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Rand volatility and inflation in South Africa

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ABSTRACT

The floating exchange rate regime, coupled with a more open trade policy and the growth in imports, leaves South Africa vulnerable to the effects of exchange rate behaviour on import, producer and consumer prices, which all contribute to inflation. Given the central role that inflation targeting occupies in South Africa's monetary policy, this paper examines the effect of exchange rate shocks on consumer prices using monthly data covering the period January 1994 to December 2013. Consistent with developing countries story, results show a modest exchange rate pass-through to inflation, although inflation is mainly driven by own shocks. The variance decompositions also reveal that foreign exchange rate shocks (REER) contribute relatively more to inflation than money supply shocks (M3). This suggests that South African inflation process is not basically influenced by money supply changes. The practical implication is that that the volatility of the rand is not a serious threat to inflation. The SARB should therefore focus on price stability and not be unduly worried about the volatility of the rand.

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1.0 Introduction

Since 1980, South Africa has experienced three distinct monetary policy regimes. During the first period (1980 to 1989), monetary policy was not successful in containing inflation. The second period (1990 to 2000) saw a significant improvement in the pursuit of a lower inflation rate. The third period (2000 till present), also sees the South African Reserve Bank (SARB) in pursuit of low inflation. However, unlike during the second period, the SARB is now pursuing an official and explicit inflation target (Burger and Marinkov, 2008).

In February 2000, the South African Reserve Bank announced its aim to adopt an explicit inflation targeting monetary policy as an official target regime. Under this approach, the CPIX (the overall consumer price index, excluding the mortgage interest cost) basket was introduced as the targeted inflation measure, as this excludes the direct impact of monetary policy, namely interest rates. The inflation target aims to achieve a rate of increase in the CPIX of between 3 and 6 percent per year (van der Merwe, 2004).

Unlike in the period of implicit inflation targeting, where the SARB protected both the internal and external value of the rand, with explicit inflation targeting, only the internal value of the rand is protected. This was done with the view that low and stable inflation will, without the need for policy intervention, translate into a stable exchange rate. In the inflation targeting era, the SARB abandoned its pre-commitment of protecting both the internal value (interest rate parity) and external value of the rand(exchange rate parity).It was only protecting the internal value of the rand, thus the exchange rate was left to be determined by market forces, making it more volatile (Ncube and Ndou, 2011). The floating exchange rate regime, coupled with a more open trade policy and the growth in imports, leaves South Africa vulnerable to the effects of exchange rate behaviour on import, producer and consumer prices, which all contribute to inflation (SARB, 2001; Karoro, 2008). The transmission of exchange rate fluctuations to import prices, producer prices and finally to consumer prices, is referred to as exchange rate pass-through (Karoro, 2008).

Though there is a large and growing body of empirical literature on the extent and magnitude of ERPT, much focus is on industrialized nations such as the USA, the UK and other members of the European (Woo, 1984; Feinberg, 1989; Goldberg and Knetter 1997; Kim, 1998; Gagnon and Ihrig, 2001; Campa and Goldberg, 2002; Yang et al., 2004 and Campa et al., 2005). Menon (1995) conducted a comprehensive survey of some 43 empirical studies on exchange rate pass-through in both industrialized and developing countries. However, the majority of the surveyed studies focus on the USA. This study will therefore help to deepen literature on developing countries and also to indirectly contribute to the current strong debate on the usefulness of inflation targeting monetary policy framework in South Africa. To this end, this paper analyses the impact of an exchange rate shocks on consumer prices in South Africa, using the Granger (non-) Causality Test, Impulse response functions and Variance decompositions within the Toda and Yamamoto's (1995) VAR procedure. Furthermore, it examines the extent and the speed of the pass through to different prices (and the key drivers thereof) and also determines the causal relationship among variables under review (inflation, real exchange rate, nominal exchange rate, real prime lending rate and money supply).

The rest of the paper is organized as follows: section 2 reviews theoretical and empirical literature. Section 3 present theoretical framework and model specification. In section 4 data sources and time domain are presented. Estimation techniques and empirical results are given in sections 5 and 6. Section 7 contains conclusions. In section 8, policy recommendations are made from conclusion drawn in section 7.

2.0 Literature review

2.1 Theoretical literature review

There are several possible channels through which exchange rate changes may affect prices (Tandrayen-Ragoobur and Chicooree, 2012). The two main channels of exchange rate pass through are direct channel and indirect channel.

The direct channel stresses that a depreciated exchange rate will imply that imported inputs have become more expensive; consequently there will be a rise in production costs. The higher production costs will then be pushed to local consumers in the form of higher prices. Alternatively, a depreciated exchange rate may also imply that imports of finished goods have become more expensive. Consumers will then have to pay higher prices on imported goods.

The direct channel arises mainly because of the "law of one price" and the purchasing power parity (PPP) in its aggregation. The relative version of PPP claims that, starting from a base of an equilibrium exchange rate between two currencies, the future of the exchange rate between the two currencies will be determined by the relative movements in the price levels in the two countries. For a given import price, changes in the exchange rate will translate directly into higher domestic prices. Therefore,

$P = E \, . P^{*}$ P

Where E is the exchange rate in terms of domestic currency per unit of foreign currency; P* represents the foreign currency price of the imported good and P is the domestic currency price of the imported good. The pass-through is only complete (=100 percent) if:
(a) Markups of prices over costs are constant and
(b) Marginal costs are constant

The indirect channel, on the other hand, stresses that a depreciated exchange rate will result in an increase in local demand for import substitutes, consequently substitute goods will become more expensive and in turn, the general (consumer) price level will increase. A depreciated exchange rate also implies that export prices have become cheaper and as a result there will be an increase in demand for exports. There will therefore be an increase in demand for labour to expand production and in turn the price of labour (wages) will increase. Producers will then be forced to push these higher costs to consumers by charging higher prices to final products.

The indirect channel of exchange rate pass-through arises because of the impact on aggregate demand. A depreciation of the exchange rate makes domestic products relatively cheaper for foreign consumers, and hence, exports and aggregate demand will rise relative to potential output, inducing an increase in the domestic price level. Since nominal wage contracts are fixed in the short run, real wages will decrease and output will eventually increase. However, when real wages return to their original level over time, production costs then increases, the overall price level increases and; output falls. Thus, in the end the exchange rate depreciation leaves a permanent increase in the price level with only a temporary increase in output (Laflèche, 1996).

2.2 Empirical literature review

Results on studies conducted for developed countries are conclusive on the idea that low exchange rate pass-through occurs during periods of low inflation.

McCarthy (2000) presents a comprehensive study of exchange rate pass-through on the aggregate level for a number of industrialized countries. Using vector autoregressive (VAR) model and data from 1976 up until 1998, he estimates ERPT to import, producer and consumer-price. In most of the countries analyzed, the exchange rate pass-through to consumer prices is found to be modest. The rate of pass-through is, furthermore, shown to be positively correlated with the openness of the country and with the persistence of and exchange rate change, and negatively correlated with the volatility of the exchange rate. Goldfajn and Werlang (2000) estimate ERPT to consumer prices for 71 countries (both developed and emerging), using panel estimation methods on data from 1980 to 1998. They report that the pass-through effects on consumer prices increase over time and reach a maximum after 12 months. The degree of pass-through is, furthermore, found to be substantially higher in emerging market economies than in developed economies.

Studies conducted on developing countries show contradicting results. Adeyemi and Samuel (2013) using the Variance Decomposition analyses within the framework a structural Vector autoregressive, estimate the pass-through effect of exchange rate changes to consumer prices in Nigeria for the period 1970 to 2008. The results show a substantial large ERPT, although it is incomplete. The findings by Tandrayen-Ragoobur and Chicooree (2012) also show that ERPT to consumer is highest, followed by producer prices, while the ERPT to import prices is lowest. Bwire et al. (2013) examines the degree of exchange rate pass through to inflation in Uganda for the period 1999Q3 to 2012Q2 using vector error correction method (VECM) and structural VAR (SVAR) models. The findings show a modest pass-through to domestic inflation, although incomplete. Ocran (2010), using impulse response functions and variance decompositions within the framework of unrestricted VAR that incorporates a distribution chain, examines the degree of ERPT to import, producer and consumer prices in South Africa for the period 2001:1 to 2009:5. The results show that ERPT to producer prices is modest (at 19 percent) and very modest to consumer prices (at 13 percent).

3.0 Estimation techniques

3.1 Theoretical framework

The model by Macfarlane (2002) is one of the earliest theories that examine the link between exchange rate volatility and consumer price inflation. It focuses on the influence of the *direct* channel of pass-through. In this context the pass-through relation can be expressed simply by the PPP relation in logs i.e.

$$p = \beta p^{*} + \lambda e \quad (1)$$

Where p *is the* log *of* the general (consumer) price level, $p*$ is the log of the foreign price and; e is the log of exchange rate.
The "law of one price" implies that $\beta = \lambda = 1$ in which case changes in the exchange rate completely pass through to the domestic price of the traded good.

3.2 Model specification

This study uses a modified version of Parsely and Popper (1998) and Macfarlane (2002) models, which embrace the Central Bank's behaviour, by including base money and interest rates. The present study uses M3 money supply as a proxy of base money. The model is presented as follows:

$$p = \beta p^{*} + \lambda_1 e_t + \lambda_2 m3_t + \lambda_3 r_t \quad (2)$$

Where $m3_t$ *is* the broad money supply and; r_t is the rate of interest.

Central banks that target consumer price inflation will try to insulate prices from exchange rate movements. Neglecting the behaviour of policy variables may distort the true consequences of exchange rate variations on consumer prices. By including policy variables, the observed relationship between prices and exchange rates would take into account the central bank's behaviour rather than the direct influence of exchange rates on prices (McFarlane, 2002).

4.0 Data sources and time domain

The data consists of 240 monthly observations, covering the period from 1994m1 to 2013m12. The sample period is long enough to enable one to carry out proper cointegration analysis. The sample span is chosen so as to include both the period of single managed floating (1995 to January 2000) and an independently floating exchange rate regime (February 2000 till present).The beginning of the sample corresponds with the launch of the first South African Democratic government in 1994.

The data used are obtainable from the South African Reserve Bank (SARB) online database. The variables include foreign price (p*) is proxied by foreign exchange rate (REER), that is the real value of the rand against its 15 major trading partners. The real exchange rate is used to absorb external (foreign) shocks. Nominal effective exchange rate (NEER) is the proxy for the exchange rate. It is calculated as the trade weighted average of the country's exchange rate against other currencies and it was chosen as a measure of the exchange rate rather than the bilateral exchange rate, because countries engage in trade with more than one country, implying that one should consider not only how changes in the bilateral rate affects prices, but how changes in the currency against the currencies of its major trade partners affect consumer prices. The index therefore represents the ratio of the rand's period average exchange rate to a weighted geometric average of exchange rates of the currencies of South Africa's fifteen main trading partners. The NEER series is measured in foreign currency terms, thus an increase in this variable indicates an appreciation of the rand, while a decrease indicates depreciation thereof. The consumer price Index (CPI) is the core inflation. It is also expressed as an index. It excludes certain items that face volatile price movements. It therefore, eliminates products that can have temporary price shocks as these shocks can diverge from the overall inflation trend and give a false measure of inflation. The real prime lending rate (RPRIMRATE) is used as a proxy for the short-term interest rate. The choice of the prime rate is based on the assumption that, the series for the Central Banks repurchase rate only started in the eleventh month of 1999. The real prime lending rate is used as it is closely linked with the policy rate. Money supply (M3) is used as a proxy for base money supply. It is simply the broadly defined money supply. The seasonally adjusted time series for M3 money supply were used. Money supply and real prime lending rate are used to absorb monetary shocks.

5.0 Estimation techniques

5.1 Toda and Yamamoto (1995)'s VAR procedure

It is an improved Granger causality procedure. Unlike Johansen (1990) cointegration procedure, Toda and Yamamoto's (1995) VAR procedure or simply T-Y VAR, is a methodology of statistical inference, which makes parameter estimation valid even when the VAR system is not co-integrated.

5.1.1 Stationarity test

The first step in conducting Toda and Yamamoto (1995) procedure is testing each of the time-series to determine their order of integration, using stationarity test. The theory behind autoregressive moving average (ARMA) estimation is based on stationary time series. A series is said to be stationary if the mean and auto-covariance of the series do not depend on time.

A common example of a non-stationary series is the *random walk*:

$$y_t = y_{t-1} + \varepsilon_t \ldots\ldots\ldots\ldots \quad (3)$$

where, ε_t is a stationary random disturbance term. The series y has a constant forecast value, conditional on t, and the variance is increasing over time. The random walk is a difference stationary series since the first difference of y is stationary:

$$y_t - y_{t-1} = (1 = L)_{yt} = \varepsilon_t \ldots\ldots\ldots\ldots \quad (4)$$

A difference stationary series is said to be *integrated* and is denoted as I (d) where d is the order of integration. The order of integration is the number of unit roots contained in the series, or the number of differencing operations it takes to make the series stationary. For the random walk above, there is one unit root, so it is an $I(1)$ series. Similarly, a stationary series is $I(0)$.

Standard inference procedures do not apply to regressions which contain an integrated dependent variable or integrated regressors. Therefore, it is important to check whether a series is stationary or not before using it in a regression. The formal method to test the stationarity of a series is the unit root test.

There is a variety of tests used to test for the presence of unit root. Amongst them are the Augmented Dickey-Fuller (1979) and Phillips-Perron (1988), the GLS-detrended Dickey-Fuller (Elliot, Rothenberg, and Stock, 1996), Kwiatkowski, Phillips, Schmidt, and Shin (KPSS, 1992), Elliott, Rothenberg, and Stock Point Optimal (ERS, 1996), and Ng and Perron (NP, 2001) unit root tests. This study uses the Augmented Dickey-Fuller (ADF) and Phillips-Perron (PP) test.

A. The Augmented Dickey-Fuller (ADF) test

The standard Dickey Fuller test is carried out by estimating the following equation:

$\Delta Y_t = \propto Y_{t-1} + X_t'\delta + e_t$……………………………………………………………… (5)

Where,

$\propto = p - 1$.

The null and alternative hypotheses may be written as,

H_0:∝=0 (null hypothesis)…………………………………………………………… (6)

$H_1 = \propto = 1$ (alternative hypothesis)……………………………………………… (7)

The simple Dickey-Fuller unit root test described above is valid only if the series is an AR (1) process. If the series is correlated at higher order lags, the assumption of white noise disturbances ε_t is violated. The Augmented Dickey-Fuller (ADF) test therefore constructs a parametric correction for higher-order correlation by assuming that the y series follows a AR(p) process and adding p lagged difference terms of the dependent variable y to the right-hand side of the test regression. This is presented as follows:

$\Delta y_t = \propto y_{t-1} + x_t'\delta + \beta \Delta y_{t-1} + \beta_1 \Delta y_{t-1} + \beta_2 \Delta y_{t-2} + \beta_p \Delta y_{t-p} + V_t$……… (8)

There are two practical issues in performing an ADF test. Firstly, one should choose whether to include exogenous variables in the test regression. Therefore, one has the choice of including a constant, a constant and a linear time trend, or neither in the test regression. One approach would be to run the test with both a constant and a linear trend since the other two cases are just special cases of this more general specification. However, including irrelevant regressors in the regression will reduce the power of the test to reject the null of a unit root.
Secondly, one will have to specify the number of lagged difference terms (the lag length) to be added to the test regression (0 yields the standard DF test, whereas integers greater than 0 correspond to ADF tests). The usual (though not particularly useful) advice is to include a number of lags sufficient to remove serial correlation in the residuals.

B. The Phillips-Perron (PP) test

Phillips and Perron (1988) developed a number of unit root tests that have become popular in the analysis of financial time series. The Phillips-Perron (PP) unit root tests differ from the ADF tests mainly in how they deal with serial correlation and heteroskedasticity in the errors. In particular, where the ADF tests use a parametric autoregression to approximate the ARMA structure of the errors in the test regression, the PP tests ignore any serial correlation in the test regression.It is therefore, an alternative (nonparametric) method of controlling for serial correlation when testing for a unit root.

When performing the PP test, one should also choose whether to include a constant, a constant and a linear time trend, or neither, in the test regression.

The test regression for the PP tests is: It is therefore

$\Delta Y_t = \beta^1 D_t + \pi Y_{t-1} + \mu_t$………………………………………………………………… (9)

The Augmented Dickey-Fuller (ADF) test and the Phillips-Perron test have a null hypothesis of a unit root process of the form:

$y_t = y_{t-1} + c + \delta t + \varepsilon_t$……………………………………………………… (10)

which the functions test against an alternative model

$y_t = \gamma y_{t-1} + c + \delta t + \varepsilon_t$………………………………………………………(11)

where $\gamma < 1$. The null and alternative models for a Dickey-Fuller test are like those for a Phillips-Perron test. The ADF extends the model with extra parameters accounting for serial correlation among the innovations:

$y_t = c + \delta t + \gamma y_{t-1} + \phi_1 \Delta y_{t-1} + \phi_2 \Delta y_{t-2} + ... + \phi_p \Delta y_{t-p} + \varepsilon_t$ ……… (12)

where

- L is the lag operator: $Ly_t = y_{t-1}$.
- $\Delta = 1 - L$, so $\Delta y_t = y_t - y_{t-1}$.
- ε_t is the innovations process, whereas, Phillips-Perron adjusts the test statistics to account for serial correlation.
  There are three alternatives of both ADF test and PP test, corresponding to the following values of the 'model' parameter:
- 'AR' assumes c and δ, which appear in the preceding equations, are both 0; the 'AR' alternative has mean 0.
- 'ARD' assumes δ is 0. The 'ARD' alternative has mean $c/(1-\gamma)$.
- 'TS' makes no assumption about c and δ.

C. KPSS test

The KPSS test is an inverse of the Phillips-Perron test: it reverses the null and alternative hypotheses. The KPSS test uses the model:

$y_t = c_t + \delta t + u_t$, with

$c_t = c_{t-1} + v_t$.

Here u_t is a stationary process, and v_t is an i.i.d. process with mean 0 and variance σ^2. The null hypothesis is that $\sigma^2 = 0$, so that the random walk term c_t becomes a constant intercept. The alternative is $\sigma^2 > 0$, which introduces the unit root in the random walk, where:

μ_t is I (0) and may be heteroskedastic.

The PP tests correct for any serial correlation and heteroskedasticity in the errors u_t of the test regression by directly modifying the test statistics:
$t_\pi = 0$ and $t_\pi^{\wedge}$.

5.1.2 Selection of lag-length criteria

The next step is determining the appropriate maximum lag length for the variables in the VAR. According to Brooks (2002: 335) financial theory has little to say on what an appropriate lag length used for a VAR model should be and how long changes in the variables should persist to work through the system. However, the optimal lag length selected should produce the number and form of co-integration relations that conform to all the *a priori* knowledge associated with economic theory (Seddighi *et al*. 2000: 309).

Three most popular information criteria (ICs) used to determine optimal lag length are the Akaike (1974) information criterion (AIC), Schwarz's (1978) Bayesian information criterion (SBIC) and the Hannan-Quinn information criterion (HQIC). However, these information criteria sometimes produce conflicting vector autoregressive (VAR) order selections.

The VAR model is illustrated in the following manner:

$y_t = \beta_0 + \beta_1 t^1 + \ldots . \beta_q t^q + \eta^q$…………………………………………… (13)

Where $\{\eta_t\}$ sequence is a vector autoregression with k lag length and it can be presented as:

$\eta_t = J_1 \eta_{t-1} + \ldots . J_k \eta_{t-k} + \varepsilon_t$…………………………………………… (14)

It is assumed that k is the optimal lag length and ε_t is random vector.

Accordingly, the null hypothesis is to jointly test vector J:

$H_0: J_1 = J_2 = ... J_k = 0$……………………………………………….. (15)

5.1.3 Diagnostic tests

The next step is making sure that the VAR is well-specified. This is done by conducting diagnostic tests. Diagnostic checks for serial correlation, normality and heteroskedasticity are then performed on the residuals from the VAR. These tests are most often used to detect model misspecification and as a guide for model improvement (Norat, 2005) and aid in the validation of the parameter estimation outcomes achieved by the model (Karoro, 2007).The tests include serial correlation test, heteroskedasticity test and normality test.

A. Testing for serial correlation

Testing for serial correlation helps to identify any relationships that may exist between the current values of the regression residuals (μ_t) and any of its lagged values (Brooks, 2002). Such tests can be done via graphical exploration or by using formal statistical tests such as the Durbin-Watson test or the Lagrange Multiplier (LM) test. Although the first step in testing for autocorrelation would be to plot the residuals and look for any patterns, graphical methods may not be easy to interpret (Brooks, 2002). In this study, the LM test is used to investigate residual serial correlation. According to Harris (1995), the lag order for the LM test should be the same as lag order chosen for the VAR. The null hypothesis of the LM test is that the residuals are not serially correlated, while the alternative is that the residuals are serially correlated.

B. Testing for heteroskedasticity

According to Brooks, (2002: 445), heteroskedasticity describes a scenario where the variance of the errors in a model is not constant. Thus a problem arises when errors are heteroscedastic but are assumed to be homoscedastic (constant variance). The result of such an assumption would be that the standard error estimates might be wrong (Brooks, 2002: 445). In this study, the test for heteroscedasticity is done using an extension of White's (1980) test to systems of equations. The null hypothesis of the test is that the errors are homoscedastic and independent of the regressors, and that there is no problem of misspecification. In performing the test, each of the cross products of the residuals is regressed on the cross products of the regressors, testing for the joint significance of the regression. If the test statistic produced from this process is significant, the null hypothesis of homoscedasticity (no heteroscedasticity) and no misspecification will be rejected.

C. Testing for normality

In this study, the Jarque-Bera normality test is used to ascertain whether the regression errors are normally distributed. Under the null hypothesis of normally distributed errors, the test statistic has a Chi-Square distribution with two degrees of freedom (Brooks, 2002: 181). Thus, if the Jarque-Bera statistic is not significant, that is, the p-value is greater than 0.05, then the null of normality is not rejected at the 5 percent level of significance (Brooks, 2002: 181).

5.1.4 Granger (non-) causality test

According to the concept of Granger's causality test (Granger, 1969; 1988), a time series x_t Granger-causes another time series y_t if series y_t can be predicted with better accuracy by using past values of x_t rather than by not doing so, other information is being identical.

We can test for the absence of Granger causality by estimating the following VAR model:

In the case of two time-series variables, X and Y:

$Y_t = a_0 + a_1 Y_{t-1} + ... a_p Y_{t-p} + b_1 X_{t-1} + ... b_p X_{t-p} + \mu_1$………………………….(16)

$X_t = c_0 + c_1 X_{t-1} + ... c_p X_{t-p} + d_1 Y_{t-1} + ... d_p Y_{t-p} + \mu_2$…………………………(17)

Then, testing $H_0 : b_1 = b_2 = \cdots . b_p$ against the alternative hypothesis:

H_A:' $Not\ H_0$' is a test that X *does not* Granger-cause Y.

Similarly, testing $H_0 : d_1 = d_2 = \cdots . d_p$ against the alternative hypothesis:

H_A:' $Not\ H_0$' is a test that Y *does not* Granger-cause *X*.

In each case, a *rejection* of the null implies there is Granger causality (Giles, 2011).

5.2 Impulse response and variance decomposition

The second-stage of ERPT is analyzed by estimating the impulse responses and variance decompositions of consumer prices to shocks from exchange rate changes. These tests are important in determining whether changes in the exchange rate has a positive or negative effect on the consumer prices, determining how long it would take for that effect to work through the system, as well as establishing the variables in the model that have a significant impact on the future values of each of the other variables in the system (Brooks, 2002).

5.2.1 Impulse response function

An impulse response can be described as a shock to the *i-th* variable that not only affects the *i-th* variable directly, but is also transmitted to all the other endogenous variables through the dynamic (lag) structure of the VAR. Impulse responses determine the responsiveness of the dependent variables in the VAR to fluctuations of each of the other variables (Brooks, 2002; Elder, 2003:1). Thus, for each variable from each equation, a unit shock to the error is analyzed in order to determine the effects upon the VAR system over time (Brooks 2002). In the case of this study, the impulse response function will be able to reveal the sign, size and persistence of shocks from the exchange rate to consumer prices. Two approaches are commonly used in econometrics literature to estimate impulse responses. These are the generalized impulse response and the Cholesky decomposition. The main advantage of the generalized impulse response is that it does not require orthogonalization of innovations and is invariant of the ordering of the variables in VAR (Pesaran and Shin, 1998: 17 in Aziakpono, 2006: 8).

However, similar to Kiptui *et al.* (2005), this study uses the Cholesky decomposition because, unlike other approaches, it incorporates a small sample degrees of freedom adjustment when estimating the residual covariance matrix used to derive the Cholesky factor (Lutkepohl, 1991).

5.2.2 Variance decomposition

Variance decompositions highlight the proportion of the movements in the dependent variables which are a result of their own shocks, versus shocks from the other variables. Brooks (2002: 342) notes that in practice, self or own series shocks explain most of the (forecast) error variance of the series in a VAR.

6.0 Empirical tests results

6.1 Unit root tests

We use the traditional Augmented Dickey-Fuller test, supplemented by the Phillips-Peron (PP) tests which are structured under the null hypothesis of a unit root against stationarity alternative to check for the unit root in each variable and thereby determine the order of integration. Both tests indicate that some the variables are stationary at levels, that is, they are integrated of order 0 or *I (0),* whereas others are stationary after first differencing, which I (1) is.

In this chapter, assumption 1 was selected, which presupposes that there is no deterministic trend but intercept in the data. Therefore, unit root tests shows the results of the variables with intercept only.

Table 1: Augmented Dickey Fuller test

Variable	5% calculated t-statistic(at level)	t*value (at level)	5% calculated t-statistic I (1)	t*value *I* (1)
CPI	-2.874	-4.958*I(0)*	-2.874	-6.460*I(1)*
NEER	-1.339	-2.873*I(0)*	-2.873	-15.296*I(1)*
M3	-2.874	1.927	-2.874	-10.621*I(1)*
Rprimrate	-2.873	-1.339	-2.874	-9.819*I(1)*
FOIL	-2.461	-2.874*I(0)*	-6.460	-2.874

Table 2: Phillips-Perron test

Variable	5% calculated t-statistic (at level)	t*value (at level)	5% calculated t-statistic I (1)	t*value *I* (1)
CPI	-2.873	-13.428 I(0)	-2.873	-8.621I(1)

NEER	-2.873	-13.691 I(0)	-2.873	-23.756I(1)
M3	-2.873	-1.117	-2.873	-29.6701(1)
rprimrate	-2.873	-3.249 I(0)	-2.873	-8.621 I(1)
FOIL	-2.873	-103.469 *I(0)*	-2.873	-13.691 I(1)

6.2 Selection of lag order criterion

The LR, FPE and AIC indicate lag order selection at level 4, whereas SC and HQ selects lag 2, which is lower. The Akaike Information Criterion (AIC) and Schwarz Information Criterion (SC) are the two commonly used criteria as they give appropriate lag order. Lag 2 is therefore selected in this study, as it is selected by the Schwarz criteria (SC) and is the lowest selected lag order.

Table 3: VAR lag order selection criteria

Lag	LogL	LR	FPE	AIC	SC	HQ
0	-5503.693	NA	2.90e+14	47.48873	47.56301	47.51869
1	-4330.572	2285.564	1.46e+10	37.59113	38.03683	37.77088
2	-4204.737	239.7360	6.11e+09	36.72187	37.53899*	37.05141*
3	-4175.756	53.96581	5.91e+09	36.68755	37.87608	37.16687
4	-4148.979	48.70576*	5.82e+09*	36.67223*	38.23218	37.30134
5	-4132.596	29.09360	6.29e+09	36.74652	38.67788	37.52542
6	-4111.432	36.67226	6.52e+09	36.77959	39.08236	37.70827
7	-4095.074	27.64007	7.06e+09	36.85408	39.52828	37.93256
8	-4087.581	12.33665	8.26e+09	37.00501	40.05062	38.23327

* 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.

6.3 Diagnostic tests

a. AR Roots

The reported inverse roots of the AR polynomial have roots with modulus less than one and lie inside the unit circle, indicating that the estimated VAR is stable (stationary). This is a very favorable result because if the VAR were not stable, certain results, such as impulse response standard errors, would not be valid making the model results and conclusions questionable.

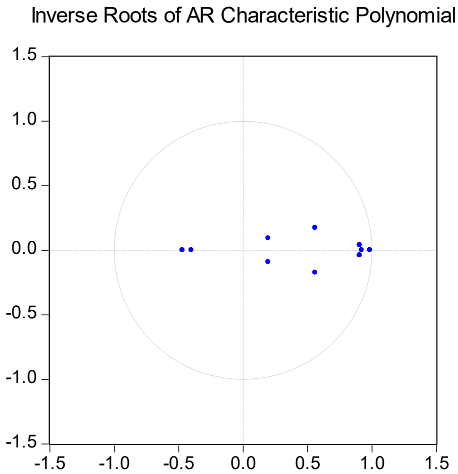

Figure 1: AR Roots

b. Serial Autocorrelation test and normality test

Most of the p-values are greater than 0.05 at the 5% level of significance, therefore we cannot reject the null hypothesis that the residuals are not serial correlated. Thus, we conclude that misspecification does not exist, that is the model is well specified. In case of normality test as the p-value of the Jacque-Bera test is less than 0.05, we therefore reject the null hypothesis that normal distribution does not occur. Therefore, there is normal distribution.

Table 4: Serial Autocorrelation LM test and normality test

Panel A: Autocorrelation LM test Ho: No serial correlation at lag order.			Panel B: Jarque-Bera test			
Lags	LM-Stat	Prob	Component	Jarque-Bera	df	Prob.
			1	47.47232	2	0.0000
1	62.88407	0.0000	2	30883.61	2	0.0000
2	55.52037	0.0004	3	28.58675	2	0.0000
3	33.47199	0.1197	4	337.2948	2	0.0000
4	20.23011	0.7347	5	192.5373	2	0.0000
5	38.86774	0.0380	Joint	31489.50	10	0.0000
6	25.45159	0.4373				
7	28.54878	0.2832				
8	32.84909	0.1349				
Probs from chi-square with 25 df.						

6.4 Granger (non-) causality test

The results from table 9 show a unidirectional causality, running from M3 to CPI, from NEER to CPI and from REER and CPI. The causal relationship between NEER and CPI and between REER and CPI reflects the presence of exchange rate pass through to consumer inflation.

Table 5: Results of Granger causality between CPI and selected variables (M3, RPRIMRATE AND REER)

Direction of Causality	Chi-sq	(df)	Prob.
NEER does not Granger cause CPI	5.130914	2	0.0769
CPI does not Granger cause NEER	0.900986	2	0.6373
M3 does not Granger cause CPI	5.526629	2	0.0631
CPI does not Granger cause M3	1.199259	2	0.5490
RPRIMRATE does not Granger cause CPI	0.907484	2	0.6352
CPI does not Granger cause RPRIMRATE	49.39967	2	0.0000
REER does not Granger cause CPI	5.734570	2	0.0569
CPI does not Granger cause REER	0.289661	2	0.8652

6.5 Impulse response function (IRF) and variance decomposition

The Table below shows the response of price to a *structural* one standard deviation shock to each of the variables. According to the table, the immediate effect of a shock to money supply (M3) at month 8 is about 19 percent increase in the price level. . The results are consistent with that of Ocran (2010), which also reveal that ERPT to consumer prices was about 13 percent for the period 1998m1 to 2009m5. However, the effect of exchange rate shock (REER) is modest, at about 22 percent. The results show low average pass-through for nominal than for real shocks.

Consistent with the IRFs discussed above, the results of variance decomposition show that foreign exchange rate (REER) contribute relatively more to inflation (about 44 percent) than money supply shocks (M3), at about 38 percent. This suggests that South African inflation is not basically influenced by money supply changes. Specifically, while money supply shocks account for only 0.6 to 42 percent of the variations of the price level, exchange rate changes and interest rate account for about 0.8 to 54 percent at the same horizon respectively.

Table 6: Impulse response function

Period	CPI	NEER	M3	RPRIMRATE	REER
1	0.545741	0.000000	0.000000	0.000000	0.000000
2	0.810116	0.003656	0.021787	0.013868	-0.056549
3	0.901487	-0.000165	0.108580	0.021752	-0.111143
4	0.900674	0.003637	0.161794	0.024088	-0.164740
5	0.850391	0.008225	0.195271	0.019897	-0.198049
6	0.779533	0.017751	0.206049	0.011330	-0.217822
7	0.702714	0.027840	0.203268	0.000380	-0.224779
8	0.628129	0.038646	0.192083	-0.011118	-0.224311
9	0.559018	0.048434	0.176891	-0.021955	-0.218808
10	0.496515	0.057078	0.160355	-0.031442	-0.210781

Table 7: Variance decomposition

Period	S.E.	CPI	NEER	M3	RPRIMRATE	REER
1	0.545741	100.0000	0.000000	0.000000	0.000000	0.000000
2	0.978774	99.59518	0.001395	0.049548	0.020074	0.333799
3	1.339886	98.41287	0.000746	0.683129	0.037066	0.866184
4	1.631079	96.90261	0.001001	1.444947	0.046822	1.604625
5	1.860484	95.37120	0.002723	2.212180	0.047425	2.366471
6	2.039465	93.97591	0.009842	2.861663	0.042552	3.110037
7	2.178496	92.76871	0.024956	3.378667	0.037297	3.790374
8	2.286748	91.73845	0.051211	3.771921	0.036213	4.402203
9	2.371437	90.85996	0.089332	4.063728	0.042245	4.944736
10	2.438161	90.10202	0.139314	4.276904	0.056595	5.425170

7.0 Conclusion

This chapter analyzed the impact of exchange rate volatility on inflation (exchange rate pass-through to prices) in South Africa for the period 1994m1 to 2013m12, using Granger (non-) causality test within the framework of Toda-Yamamoto (1995) VAR procedure. Impulse response functions and variance decomposition of consumer prices to shocks from exchange rate changes are also estimated.

The results from Granger causality test show a unidirectional causality, running from M3 to CPI, from NEER to CPI and from REER and CPI. The causal relationship between NEER and CPI and between REER and CPI reflects the presence of exchange rate pass through to consumer inflation. The IRFs results show that ERPT to consumer prices was modest during the period under review. The immediate effect of a shock to the exchange rate (REER) at month 8 is about 0.22 (22 percent) increase in the price level. This is consistent with literature on developed countries, which suggest that exchange rate pass-through (ERPT) in an environment of low inflation is more subdued. Since the implementation of inflation targeting monetary policy in February 2000, the South African Reserve Bank was able to contain inflation within the target range most of the times.

Consistent with other studies for developing countries, the variance decomposition results show a modest exchange rate pass-through to inflation, although inflation is mainly driven by own shocks. This is consistent with Bwire *et, al.* (2013). The variance decompositions also reveal that foreign exchange rate shocks (REER) contribute relatively more to inflation than money supply shocks (M3).This suggests that South African inflation process is not basically influenced by money supply changes.

8.0 Policy recommendations

Low pass-through into consumer prices has important policy implication for the adoption of inflation targeting by the South African Reserve Bank. Floating exchange rate system is the requirement for a well- functioning inflation targeting regime because in a world of capital mobility, independent monetary policy cannot coexist with a pegged exchange rate regime.

The adoption of flexible exchange rate regime in mid-1990’s, in conjunction with inflation targeting monetary policy in 2000 has raised question of exchange rate volatility and resulting fear of exchange rate pass-through into consumer price inflation. Therefore, the evidence of low inflation regime since 2000 and the associated low ERPT for the period under review support the adoption of an inflation targeting regime in South Africa. This implies that the volatility of the rand does not pose any serious threat to inflation. It is therefore suggested that the SARB focus on its commitment to protect he internal value of the rand (price stability) and allow the rand to float freely. As foreign exchange rate shocks contribute relatively more to inflation than money supply shocks, this implies that money supply changes have insignificant impact on inflation in South Africa. There is therefore no need for monetary surveillance in South Africa.

The present study only focuses on ERPT to consumer prices and ignores other types of inflation (import and producer prices).From the third quarter of 2012 to early 2014, the country witnessed a significant decline in exports due to the ongoing labour unrest, which led to production stoppage in mines. Consequently, many mines were forced to shut down, consequently, a sharp drop in exports occurred. A decline in exports implied that the country had to depend on imports. Consequently, import prices surged relative to export prices. The present framework that we proposed can be extended to incorporate import and producer prices. Another interesting avenue of future research would be to conduct a model of two disaggregated periods (pre-2000 and post-2000).

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