An Empirical Analysis of Exchange Rate Pass-Through on Prices in South Africa (2002-2015)

by

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Abstract

The South African Reserve Bank (SARB) adopted an inflation targeting monetary policy in 2000 in a bid to achieve price stability. The band is that of 3% to 6%. However, the monetary policy stance faces high random monthly inflation and other provincial inflation rates that are sometimes going outside the upper band of the target. Finding the duration taken by the price indices responding to exchange rate fluctuations took a central role to this research and also to find the magnitude of the exchange rate fluctuations that are passed on to different prices. This research contacted a comparative analysis from a Structural VAR and Recursive VAR to investigate exchange rate pass-through (ERPT) to tradable prices in South Africa. Using monthly data, both estimations find the producer prices contributing highly to inflation with an average of 22% of fluctuations passed to prices. The argument of high pass-through in producer prices is mainly because of the high volumes of intermediate goods that are imported by the South African producers for local production. The results also reveal that the Impulse Response Functions IRFs are weak but the prices do not take long to respond to exchange rate changes. We find that prices respond within 2 months to fluctuations in exchange rate. It takes between 3 to 4 months for other price indices to respond to import prices. Large and persistent ERPT especially on import and producer prices accompanied by high wage demands and a depreciating currency are worrying factors for South Africa. Policy makers are advised to put in place targeting measures on the exchange rate if inflation could be kept under control. Since inflation expectations play a pivotal role, it is also wise for the upper band to be increased probably by 1% so that high inflation expectations that are influenced by inflation that is sometimes going outside the upper band can also be held down.

Key: *Inflation Targeting*, *Exchange Rate Pass-Through*, *Recursive*, *Monetary policy*

Section: one

Introduction

The monetary policy exchange rate channel is of paramount importance mostly for small and open developing countries like South Africa. The country was hit by a series of rand depreciations mainly from around 2009 whilst there were other incidences like lost confidence in the political leaders of the country (series of vote of no confidence in the president), also a series of corruption scandals from government parastatals and government ministries. Also the country witnessed a series of changes in the finance ministry and the shuffles took place more than 3 times for the duration covered by the study. All these issues might have somewhere somehow contributed to the rand losing value through loss of confidence in the country's policies and leadership. The conventional wisdom assumes that depreciation of a currency makes the imports to be more expensive and the exports to be more competitive on the international market. However, for the exchange rate channel to be more efficient in operation there is an assumption that the exporting country will have to adjust the selling price of the good or service so that the quantity demand of products become more or less the same as compared to the period before depreciation. The country that is exporting can do so by slashing profits (mark-up adjustment) and also by adjusting the production costs.

The transmission or consideration of the exchange rate changes to prices is what is called Exchange Rate Pass-through (ERPT) depending on the asymmetric behaviour of price adjustments (Choudhri and Hakura 2015). Aron et al., (2014a) defined ERPT as the degree to which exchange rate variations influence trade prices and through them to other domestic prices. However, Kabundi and Schaling, (2013) defined it alternatively as the link between nominal effective exchange rate and import prices (first stage) and finally as a link between import prices, producer price inflation and consumer inflation (second stage).

The magnitude of ERPT is determined by a number of factors between the exporters and importers. For instance the exporters can set prices in order to match the prices of domestic goods (goods in South Africa), this implies that there is no pass through (zero). Gaulier *et al.,* (2006), argue that there is low sensitivity of import prices to changes in exchange rate and this is linked to the fact that exporting firms would have adjusted their prices in a manner just to maintain their level of competitiveness in the destination market. The price adjustments can be only done when the price elasticity of demand is high but when it is low, the exporters can be reluctant to adjust the mark-ups. If the exporter absorb all the exchange rate changes (zero pass through) and partial pass through when a portion of the exchange rate changes are covered by the exporter. ERPT can be divided in two stages, the first stage which is the transmission form exchange rate to import prices and second stage pass through which comes from the import prices to other prices down the pricing chain. On the other hand, the type of an industry can determine the size of pass through. Different type of industries determine pass through because levels of competition differ from one industry to another also the market share between imports and local produce differs from one industry to another. Dornbusch, (1987), states that, the elasticity of import or export supply and demand, product substitutability and differentiation also play a major role in determining pass through. Industries with imperfect competition happen to have large shares of imports and as a result of not being perfectly competitive as well, they may experience a wide range of pricing responses subscribing to changes in the exchange rate leading to great pass through effects (Reyes, 2007). When imports control a bigger part of the domestic market, the scenario of exchange rate pass through will be very high since imports constitute a large portion of the consumption basket. This theory mostly affects net importers or economies that are failing to sustain their local demand. Another type of economy to be affected by this theory is an economy that has a growing manufacturing sector relying on imported inputs. A good example of this kind of economy is South Africa where industries like car manufacturing rely on imported inputs to assemble the cars for both the local market and the export market. Most of the factors that determine ERPT can be summerised into market conditions and macro-economic environment of an economy in the importing country and their effect on the exporter's costs of exchange rate changes.

Knowledge of exchange rate pass-through is very important for a number of reasons. Firstly, the level of ERPT is an approximation of international macroeconomic transmission and thus has implications for the timing of monetary policy intervention. Hence, the degree and speed of pass-through is important for forecasting inflation and formulating monetary policy responses to inflation shocks. In addition, the adoption of inflation targeting demands knowledge of the speed and size of ERPT on inflation. Also, understanding ERPT at the macro and microeconomic levels gives insights into the strength of the international market power of domestic industries vis-à-vis their international counterparts. In the case of South Africa and many other countries that adopted inflation targeting as a way of trying to monitor inflation, it is because of that inflation targeting monetary policy with its reliance on inflation forecasting, that huge interest in Exchange Rate Pass-Through (ERPT) has been generated. Lastly, volatility in the exchange rate and persistent trade imbalances worldwide are a galvanizing point increasing interest in the investigation of the role of ERPT in prices and monetary policies. Much of the literature on ERPT is for the developing economies, the USA in particular and there is also a significant quantity for Asia but there is a handful for

Africa and South Africa to be precise, a gap this paper aims to fill. Also this paper capture the period when the economy was on the spotlight with corruption allegations and mining workers unrest.

This paper will focus on investigating ERPT to South Africa using monthly data for the period January 2002- December 2015. The focus of the paper will be on both the first stage (exchange rate to import prices) and second stage ERPT (import prices to producer, export and consumer prices). Although there are a number of other exogenous factors that can affect the pricing of producer and consumer prices , the assumption in a VAR framework assume that all the variables are endogenous. The remainder of this paper will be structured as follows, section 2 will cover the empirical literature, section 3 will provide the methodological issues whilst section 4 will cover the results. Section 5 will be the conclusion and the policy recommendations.

Section: two

Empirical literature on ERPT

The first category consists of the studies which looked on the effects of ERPT on consumer prices. (Sanusi, 2008) and (Mirdala, 2014) both study the effects of a percentage change in the exchange rate to consumer prices holding other things like domestic labour and non-traded costs like transport constant (Sanusi, 2008) used quarterly observations of consumer prices of Ghana from 1983 Q3 to 2006Q3 and as he used SVAR, found out that ERPT was very large or substantial and at the same time incomplete at 0.88 or 88%. On the other hand, researching about the Euro Area, (Mirdala, 2014) used monthly data from 2000 M1 to 2012 M12 using the Vector Auto-regression (VAR) and realized that there are different patterns of exchange rate pass through according to the baseline period as well as the exchange rate regime.

Another category is for the multi-country researches mainly focusing on the developing and emerging markets. These works employed different methodologies to estimate and analyse the effects of exchange rate pass through on different countries they looked on. (Mihaljek and Klau, 2008), (Shambaug, 2008), (Ibrahim and Erden, 2015), (Aron *et al.*2014a), (Ghardach, 2014), (Barhoumi, 2008), (Aleem, 2014), (Hakura, 2015). On these multi-countrt researches, there are three which used the Vector Auto-regression (VAR) in estimating the effects of ERPT on developing countries. (Shambaug, 2008), used VAR and quarterly data for 1973 to 1994 and found out that supply and nominal shocks are larger in developing nations while the effect of demand shock is look weaker in well industrialised economies. Also using VAR, (Wang, 2011) employed monthly producer prices (PPI), consumer prices (CPI) and import prices (IMP) to estimate ERPT. His findings saw him concluding that, ERPT is very high for IMP than PPI and CPI. The estimates he found were 88% (IMP), 27% (PPI) and 10% (CPI). Incomplete also seem to be common in developing countries as far as his findings are concerned. On the other side, (Hakura, 2015) also analyzing exchange rate pass through, used quarterly data from 1979 to 2012 and he adopted using the VAR and OLS models to estimate the effects of ERPT in developing nations. His findings were that, ERPT is high for small economies and also he concurred with a lot of researches when he found out that IMP if higher that EXP. He found average pass through for developing countries as between 35-70%.

(Bussiere and Peltonen, 2008) also adopted an OLS equation approach to measuring both short run and long run pass through. It was not clear whether they introduced any lags in their analysis but they used quarterly data of import prices form Q1 1980-Q2 2006. It was also a multi country analysis since they were analysing the effects of exchange rate changes on both export and import prices. Their analysis on estimating pass through brought fair results which were in line with the general expectations of pass through because pass through for developing nations like South Africa were within the range since they discovered that effects of pass through on PPI were somewhere

(Ito *et al.* 2005) and (Gosh and Rajan, 2008) investigated about exchange rate pass-through (ERPT) in Thailand and Korea in different years using different models. (Ito *et al.*2005) used first differenced model with a lag of effective exchange rate upto 4 period whilst (Gosh and Rajan, 2008) used an OLS model adopted from (Stock and Watson, 1993). The research by (Ito *et al.*2005) used import and consumer prices to estimates ERPT in Korea and they found out that CPI pass through was 26% for Thailand and 13% for Korea.

On African context there were findings from the researches of (Oyinlola and Babatunde, 2009) who checked the effects of pass through in Nigeria using aggregate data of import prices. Using the UECM-Bound tests by (Pesaran *et al.*2001) they found out that short-run ERPT is lower than long-run pass through. The short-run ERPT was two times smaller than the long-run pass

through which was at 24%. In addition, (Boamah 2012) looked on the West African Monetary Zone using monthly data of import data and his findings concluded that there is varying degrees of ERPT between countries mainly because of different monetary policies adopted by those different countries.

Section: Three

ERPT IN SOUTH AFRICA

In the case of South Africa, there are a number of studies worth considering although they used different methodologies and variables and they have been conducted by (Aron *at al* 2014a), (Edwards and Garlick, 2008), (Karoro et al.2009), (Jooste and Jhaveri, 2014), (Razafimahefa, 2012) and (Parsley, 2012). (Aron *et al*.2014b) analysed the inflationary effects of inflation targeting and currency invoicing on import prices in South Africa. Using single equation models and systems to check the pass through of import price pass through, they discovered that depreciations and volatilities of the exchange rates can increase the options of hedging and foreign currency invoicing because of uncertainties. The moment exporters price their goods in producer currency that is going to increase the level of pass through to prices in South Africa considering the volatilities and depreciations of the exchange rate. Also they found the openness of trade and that of the current account as culprits in increasing the pass through.

Aron *et al.*(2012) estimates a Johansen Co-integration model and single equations for short-run Exchange Rate Pass-Through (ERPT) using monthly data of import price indices for 1980:1 to 2009:12. He reports an average pass through which he said was incomplete and it was 50% within a year and 30 % in 6 months. He also found long-run pass through as 55%. Edwards and Garlick, (2008) focused on an analysis of trade flows and exchange rate pass-through in South Africa basically the relationship between the nominal effective exchange rate (NEER) and trade flows and they also used a Johansen co-integration approach in investigating that. Their empirical evidence actually supports the positive relationship between the balance of trade and a real depreciation of the rand. This means that import or trade prices respond to changes in the exchange rate. After they used quarterly data from 1980 to 2005, they found out that pass through to export prices had an estimation of 0.85 (85%) and that of import prices was at 0.89 (89%).

Karoro *et., al.* (2009) in a way to also investigate longrun-pass through in the republic of South Africa, employed the VECM. They checked equibrium pass through using the Johansen technique and it was based on a VAR including two lags and they seemed very short for monthly data. They used various proxies for the exporter's costs of production and that resulted in long-run pass-through measurements to vary in the range of 0.75(75%) and 0.82(82%). Their findings about the equilibrium pass-through to import prices appeared to be higher for depreciations at 0.72 (72%) than that of appreciations 0.64 (64%). They also found no significant asymmetry in the ERPT of large a small changes in the exchange rate.

One of the recent studies was done by Jooste and Jhaveri, (2014) using a time varying VAR as they investigated the effects of time varying ERPT in South Africa. The methodological approach adopted in this empirical study made use of the monthly import, export and consumer prices in South Africa since 1980 to 2011. Their results showed that, pass through is high in the first period of the year than later but the long term pass through is always higher than the short term. Export pass through in the first period was 6% and 7 % in the 12^{th} period, the import pass through was 3% in the first period and 7% in the 12^{th} period. This concurs with researches by Parsley, (2012) who also concluded that long-run pass through is higher than short-run.

Parsley (2012) did a research on which he estimated the effects of exchange rate changes to import prices and services in the republic of South Africa using panel data of goods and services at the dock using disaggregated homogenous import units. This study found low pass through to the final consumer goods prices and it was between 14-27% in two years after an exchange rate change. There was an unusual phenomenon as it was found from this research that pass through of services is higher than that of goods. Under normal circumstances, services are domestic oriented hence they are not much affected by exchange rate changes. This study saw the decline in pass through maybe as a result of changes in the consumptions baskets of people, including more goods which are not affected by the exchange rate changes therefore low ERPT and the researcher see the decrease as not linked to changes in the monetary environment or pricing behaviors of the firms.

Razafimahefa, (2012) checked on the asymmetries of the pass through in South Africa using exchange rate data. They investigated the effects of the rand depreciation for 4 quarters and 8 quarters. Using the sign restricted VAR, they found out that, pass through is less asymmetric after 4 quarters (13%) than after 8 quarters (16%). This means that prices respond much to

a depreciation than an appreciation and it also depend with the size of the depreciation. If it is high them exporters may choose put mark ups on their prices but if it is small they may choose to just absorb the change so that they will protect their market share. It also depends with the level of completion and availability menu costs or costs of changing prices.

Section: four

Methodology and data issues

Variables description and Data issues

The empirical work will use monthly data for both the Structural VAR and the Recursive VAR as outlined by Ouliaris et al., (2016) as they argued that SVAR is better specified using disaggregated data than yearly data. The period captured in this research is motivated by the need to check the contribution of exchange rate changes within the period of the inflation targeting regime and by so doing it will cover the year 2002 January up to 2015 December. The primary source of the data is Quantec, a data house that gathers data from all over the world and makes it available to researchers at a cost. This makes the data more reliable since it comes from a recognised source. Below is a list of variables to be used in the model.

Output gap-The output gap is the difference between potential output of South Africa and the actual output produced in a given year. If the actual output is greater than the potential output it is inflationary but when potential output is greater than actual then it is deflationary to the economy.

Petrol prices-Petrol prices will be entered into the model representing the world oil price shocks. The oil prices represent the supply shocks in the model. South Africa is a net importer of oil so the increase of oil prices is expected to be inflationary to the economy

NEER- Is the nominal effective exchange rate which is a proxy for the exchange rate. This is the geometric weighted average exchange rates of the main trading partners of South Africa, the BRICS community and also the Euro area. The base year index of the nominal exchange rate used is 2012=100.

IMP-the import price index is used as a proxy to represent the prices of the goods and services imported by the country. The import price index is found from Quantec who get the data from the reserve bank of South Africa. The index is also seasonally adjusted and the base is 2012=100.

PPI- is the producer price index of South Africa, (also offered by the reserve bank of South Africa with a base of 2012=100). It is the average weighted value of index of the goods and services produced for domestic use or international market consumption excluding the imports.

Expo- is the export price index of South Africa for goods and services produced in South Africa and sold in the other countries. The export index data is also downloaded from the Quantec data providers with the producer being the South Africa Reserve Bank (SARB). The index has a base of 2012=100 and falls under line 65 of the IMF financial statistics.

CPI- is the consumer price index of South Africa representing a basket of goods and services sold to the consumers in South Africa. This Index takes care of the food prices, mortgage interest and other items that are volatile to cost structure changes in the economy with exchange rate change not spared. This index goes in line with line 64 in the financial statistics of the IMF. The CPI index has a 2012=100 base as well.

Theoretical framework

Recursive VAR Approach

McCarthy, (2000) is paper who most studies using the recursive VAR framework on ERPT borrow the concept from. The assumption of the estimation is that of a recursive ordering of the variables in which the international supply shocks in this case represented by petrol prices and demand shocks represented by the output gap enter the model first to affect all the other

variables in the model without them being affected by any other variable in the model. The supply and demand shocks are exogenous to the exchange rate in period t. These exogenous variables to the exchange rate are determined in each period by the expectations of the previous period and an error. So in the ordering of say, Petrol prices, output gap and exchange rate, then we would

a) Exclude the contemporaneous values of output gap and exchange rate from the equation of petrol prices.
b) Exclude the contemporaneous value of exchange rate from the equation of output gap
c) Exclude no variable and meaning that we include petrol prices and output gap in the equation of exchange rate.

The model has 7 variables and they are ordered in a way that the consumer prices will be affected by all the other variables in the model without it affecting any variable and that it is guided by the fact that the CPI is more of like inflation itself so we cannot allow it to affect any variable in the model.

$\pi_t^{petr} = {}_{t-1}^{E}(\pi_t^{petr}) + \varepsilon_t^{petr}$ (a)

$Y_t = {}_{t-1}^{E}(Y_t) + a_1\,\varepsilon_t^{petr} + \varepsilon_t^{y}$ (b)

$\Delta e_{t=t} - {}_{t-1}^{E}(\Delta e) + b_1\,\varepsilon_t^{petr} + b_2\varepsilon_t^{y} + \varepsilon_t^{\Delta e}$ (c)

Where petr is the world oil prices (international supply shock) to South Africa since it is a small open economy and a price taker. This shock can be inflationary if the oil prices go up and deflationary when it goes down, Y_t measures the output gap in the country and will be measured using the difference between actual output and potential output, Δe_t is the change in the exchange rate and ε_t are the respective shocks which occur at each stage. This exchange rate shock feeds into domestic inflation through the finished imported product or imported inputs by the manufacturers and then passed through to the producers and later to export and consumer prices.

$\pi_t^{imp} = {}_{t-1}^{E}(\pi_t^{imp}) + c_1\varepsilon_t^{petr} + c_2\varepsilon_t^{y} + c_3\varepsilon_t^{\Delta e} + \varepsilon_t^{imp}$ (d)

$\pi_t^{ppi} = {}_{t-1}^{E}(\pi_t^{ppi}) + d_1\varepsilon_t^{petr} + d_2\varepsilon_t^{y} + d_3\varepsilon_t^{\Delta e} + d_4\varepsilon_t^{imp} + \varepsilon_t^{ppi}$ (e)

$\pi_t^{cpi} = {}_{t-1}^{E}(\pi_t^{cpi}) + e_1\varepsilon_t^{petr} + e_2\varepsilon_t^{y} + e_3\varepsilon_t^{\Delta e} + e_4\varepsilon_t^{imp} + e_5\varepsilon_t^{ppi} + \varepsilon_t^{cpi}$ (f)

$\pi_t^{exp} = {}_{t-1}^{E}(\pi_t^{exp}) + f_1\varepsilon_t^{petr} + f_2\varepsilon_t^{y} + f_3\varepsilon_t^{\Delta e} + f_4\varepsilon_t^{imp} + f_5\varepsilon_t^{ppi} + f_6\varepsilon_t^{cpi} + \varepsilon_t^{exp}$ (g)

Other variables are: imp which is the import prices represented by the import price index for South Africa; ppi- producer price index for the national producers; exp- the export price index for goods exported by South Africa into the world market, these goods become cheap when the currency is depreciating and cheap under the periods of depreciation and finally the cpi- the consumer price index in the country formed by a basket of goods and services representing all the goods and services consumed by South Africans.

Estimation procedure

Any type of a VAR starts with a reduced form VAR and after the traditional VAR has been run all other restrictions on the model can be done. The variables in the model are arranged in the following order:

(Petrol prices, output gap, exchange rate, import prices, producer prices, export prices, consumer prices)

starting with a structural representation of linear dynamic equations of the following form:

$A_0 X_t = A(L)X_{t-1} + B\varepsilon_t$

In this case X_t will be the p(=7)- dimensional set vector housing the variables being used in the model, A_0 gives a description of the contemporaneous relationships amongst the variables in the model, A(L) is the finite-order matrix polynomial in the lag operator L and lastly ε_t is a vector of structural disturbances that can be interpreted and it is drawn from the list of equations spelling out the system with covariance matrix and the equations are those above showing the recursive structure of the model. Under lenient conditions (A_0 invertible), we can also show the p-dimensional Vector X_t in the following reduced form presentation:

$X_t = A_0^{-1}A(L)X_{t-1} + e_t$

In this case the VAR residual vector $e_t = A_0^{-1}Be_t$ is n.i.i.d. with full variance-covariance (VCV) matrix. After the above structural form equation, then we will be able to derive the relationship between the VCV matrices (unobserved) ε_t and e_t (observed):

$E(e_t e_t') = A_0^{-1}BE(\varepsilon_t \varepsilon_t')B'A^{-1}$

In this case it then holds that $\hat{\sum}_e = \hat{A}_0^{-1}\hat{B}I\hat{B}'\hat{A}_0^{-1}$. The identification demands the restrictions to be done on A and B. This ordering of the variables is best known as the Cholesky decomposition proposed by Sims, (1980), and it is the one also followed by McCarthy, (2000), Bonato and Billmeier, (2002) and others. On the issue of identification, the study used the AB model proposed by (Amisano and Giannini, 1997). As iterated previously, identification is the problem of interpreting the correlations in a model in a causal manner and that problem cannot be solved by a model itself by theoretical restrictions on the model. The number of restrictions in the model is determined by the difference between the known and unknown parameters in the model. In general terms the number of restrictions for our exact identification is $2n^2$-n(n+1)/2 on A and B matrices.

On the AB model adopted from Amisano and Giannini, (1997), the B matrix is just there to identify structural shocks to the model. In short it is called the identification matrix. The non-zero elements in the identification matrix (B) would then allow the structural shocks to affect more than a single variable in the model. By so doing the shocks will affect each and every variable in the model. Under this framework since the matrix B is the identification matrix and it has non-zero off diagonal elements then matrix A is assumed to be lower triangular. In this scheme, the identification of shocks will be depending on the variable ordering and in this context our recursive ordering of the variable is what will determine the identification of structural shocks in the model. Since all the variables are assumed to be endogenous under the VAR framework, the degree of endogineity when the variables are ordered recursively rises along the variable ordering:

$$A = \begin{pmatrix} 1 & 0 & \cdots & 0 \\ a_{21} & 1 & & \\ \vdots & & \ddots & \vdots \\ a_{n1} & a_{n2} & \cdots & 1 \end{pmatrix}, B = \begin{pmatrix} b_{11} & & \cdots & 0 \\ 0 & b_{22} & & 0 \\ \vdots & & \ddots & 0 \\ 0 & 0 & 0 & b_{nn} \end{pmatrix}$$

In the VAR modelling, the contemporaneous correlations of the variables are then reflected in the cross-equation residual correlation. After restrictions are done of the matrix A and B then the Cholesky factorisation is done to so that is sets to zero all the residual correlations amongst the variables in the model prior to causal ordering. Once the required and necessary restrictions to the model are done then a number of exercises can then be done like the impulse response functions and variance decompositions.

Structural VAR estimation

The estimation of Structural Vector Autoregressions (SVARs) starts from the reduced form Vector Autoregression (VAR). According to Gottschalk (2001), the SVAR was modelled from the dynamic simultaneous equation models that were designed for policy analysis and also simulations. Basically the SVAR is better than the reduced form VAR because of the different puzzles the reduced form VAR most produce. There are the empirical puzzles that exist such as the exchange rate puzzle; liquidity puzzle and price puzzle (Gottschalk, 2001). Through identification, the SVAR is a better methodology for interpreting the effects of unexpected shocks into the model and that is why it provides better results as compared to a reduced form VAR. Hence there is need for theoretical restrictions to be done to the model. Without the identifying restrictions there cannot be any conclusion in regards to the parameters that can be obtained from the data, the reason being that a variety of different structural models produce the same reduced form.

Structural VAR methodology

P^{th} order reduced form VAR

$Y_t = A_1 Y_{t-1} + \ldots\ldots + A_p Y_{t-k} + e_t$

Y_t – nX1 vector of endogenous variables

A_1 – the coefficient vector of lagged variables Y_{t-p}

e_t – the vector of serially uncorrelated reduced form errors with $(e_t e_t')=\sum$

Below is the more compact form of the reduced form:

$A(L)Y_t = e_t$

A(L) – is the matrix polynomial in the form of a lag operator L

The following stage shows the structural for of a VAR:

$B(L)Y_t = u_t$

Therefore B(L) – a p^{th} order matrix polynomial in the lag operator

$B(L) = B_0 + B_1 + B_1L - B_2L^2 - \ldots - B_pL^p$

U_t – nX1 vector of structural innovations, with:

$E(u_t u_t') = \Omega$

The following equations show the relationship between the structural and reduced model.

$B_0A(L) = B(L)$

$$B_0 e = u$$

$$\sum = (B_0^{-1})\Omega(B_0^{-1})$$

Structural VAR Identification

The SVAR laid out above in a primitive line of equations will not be directly estimated because of the deep-rooted feedback in a VAR process (Enders, 2004). However, the information in the VAR system can be recovered by the estimation of a reduced form VAR in the lag operator as shown below:

$Ay_t = \partial + \emptyset(L)y_{t-i} + B\mu_t$

where $\emptyset(L)$ is an $(n\ X\ n)$ finite order matrix polynomial in the lag operator L.

Pre-multiplying a reduced for VAR equation by A^{-1} give the reduced form VAR of order p, which in standard form matrix can be written as:

$y_t = \psi_0 + \sum_{i=1}^{p} \psi_i y_{t-i} + \varepsilon_t$

For the restrictions to be sufficient for identification, a total of $2n^2$ unknown elements must be identified since matrices A and B are all $(n\ X\ n)$ and upon which $n(n+1)/2$ restrictions are then imposed by equation (29) above. In order to make the make AB identified, this therefore means that , at least $2n^2 - n(n+1)/2$ or $n(3n-1)/2$ supplementary restrictions will be required. There are several ways to make the AB matrices to be identified but this research is only going to talk about two of them. The first approach is the recursive identification or factorisation which is based on the Cholesky decomposition of matrix A and this was developed by (Sims 1980). This approach assumes that all the elements of the A matrix are recursively related meaning to say that the variables to be run in the reduced form VAR will be recursively ordered in their way of causation and therefore matrix A will be lower triangular.

This approach's identification of structural shocks is dependent on the ordering of the variables with the most endogenous variable ordered last (Ngalawa, 2009). This then means that in the ordering of the variables, the first variable will have no contemporaneous relationships with all the variables in the model meaning that its reduced form shock is the same as its structural shock. The second variable will have contemporaneous interactions only with its own and the previous structural shock. Going on the third variable, this variable is contemporaneously affected by its own shock and then the two previous structural shocks and the chain goes like that up until to the seventh variable. The first approach will make the system to be exactly or just identified (Ngalawa, 2009).

The second approach uses structural factorisation as an identification tool and most recent literature on SVAR have used this approach. This approach uses relevant economic theory to impose the restrictions on the elements of matrices A and B (Sims and Zha, 1998, Sims, 1986 and Ngalawa, 2009). The SVAR model will be identified using the assumption of orthogonality of

the structural shocks μ_t ; simultaneous feedback in the opposite direction is allowed for in the model and the imposition of restrictions on the model reflects the exchange rate transmission mechanism followed by the monetary policy makers.

The SVAR will be have seven variables which include output gap (gap), nominal effective exchange rate (Ner), consumer price index (cpi), petrol prices (ptr), producer price index (ppi), export price index (exp01) and import price index (imp). Output gap and the petrol prices will enter the model as policy variables representing the demand shocks and the supply shocks in the economy. The other five variables will enter the model representing the exchange rate transmission mechanism. According to the second approach to identification, the structural shocks in the equation below equation will be identified in the following way:

$$A = \begin{pmatrix} 1 & 0 & 0 & 0 & 0 & 0 & 0 \\ a_{21} & 1 & 0 & 0 & 0 & 0 & 0 \\ a_{31} & a_{32} & 1 & a_{34} & a_{35} & a_{36} & a_{37} \\ a_{41} & a_{42} & 0 & 1 & 0 & 0 & 0 \\ a_{51} & a_{52} & 0 & 0 & 1 & 0 & 0 \\ 0 & 0 & 0 & a_{64} & 0 & 1 & 0 \\ 0 & 0 & a_{73} & a_{74} & a_{75} & a_{76} & 1 \end{pmatrix} \qquad \varepsilon_t = \begin{pmatrix} \varepsilon_t^{gap} \\ \varepsilon_t^{ptr} \\ \varepsilon_t^{ner} \\ \varepsilon_t^{cpi} \\ \varepsilon_t^{imp} \\ \varepsilon_t^{ppi} \\ \varepsilon_t^{exp01} \end{pmatrix}$$

$$B = \begin{pmatrix} b_{11} & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & b_{22} & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & b_{33} & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & b_{44} & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & b_{55} & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & b_{66} & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & b_{77} \end{pmatrix} \qquad \mu_t = \begin{pmatrix} \varepsilon_t^{gap} \\ \varepsilon_t^{ptr} \\ \varepsilon_t^{ner} \\ \varepsilon_t^{cpi} \\ \varepsilon_t^{imp} \\ \varepsilon_t^{ppi} \\ \varepsilon_t^{exp01} \end{pmatrix}$$

From the matrices A and B, the non-zero coefficients a_{ij} and b_{ij} in their respective manner show that any residual j in these matrices ε_t and μ_t in the same manner has an immediate impact on variable i. The first two equations are modeled to capture the external shocks that can affect exchange rate shocks and then the exchange rate shocks to the prices will be quantified by the variance decompositions and the impulse response functions. The issue of modelling responses of exchange rate to others variables in an SVAR is now a standard across a wide range of studies especially those that are investigating the transmission mechanisms. These studies include Ngalawa, (2009), Cheng, (2006), Becklemans, (2005), Borys and Horvath, (2007) and (Piffanelli, 2001).

SVAR, stationary and Cointegration

The data will be tested for stationarity to see if variables are stationary in levels or not because for a research study to use any type of a VAR, the variables should be integrated of the same order (Sims, 1980). However, if the variables are seen to be nonstationary in their levels, the research is going to proceed to run a Structural VAR in levels since useful information can be lost when data is being transformed to stationarity through differencing. This idea is borrowed from the canonical paper of (Sims, Stock and Watson, 1990). The paper demonstrates that the common practice of transforming models to stationarity by difference or Cointegration operators is unnecessary because most monetary variables like exchange rate and prices mostly have distributions that are not affected by nonstationary especially when one is using high frequency data and not a very long sample size. This then means that all the hypotheses can be tested without starting by transforming the data to stationarity. In this research, the main issue is not about the integration of the data but to see whether the coefficients we are estimating have a nonstandard distribution if in fact the variables we are regressing on each other are integrated.

In the SVAR literature, the Sims, Stock and Watson idea has been largely accepted by many researchers with a study from Germany by Bernake and Mihov, (1997, p.1037) clearly stating that we can include output, prices and reserves in levels despite having observed that they are nonstationary. Their motivation for running the model in levels is based on the fact that, levels specification yields consistent and reliable estimates even if Cointegration exists or not. They go on to say that a differences specification is inconsistent if some variables are cointegrated. Since some information is lost in the process of transforming data to be stationary, the situation can be worse especially with the imposition of restrictions on the model to make it identified.

In the case that false restrictions to the model are made, the inferences will be highly inaccurate and this situation can be worsened if the data is transformed through differencing. Some of the studies that followed the same approach of estimating the SVAR in levels when the variables are, Brischetto and Voss, (1999), Ramaswamy and Sloek, (1998), Sims, (1992), kim, (1999), Ngalawa, (2009), Dungey and Pagan, (2000), Piffaneli, (2001).

On the other hand there is a large number of other studies that have used SVAR with differenced data with the most common factor being that they were worried about the long-run implication of their models. This will be done by putting Cointegration restrictions on the VAR depending with the Cointegration equations in the model and the restrictions per equation will be done according to the number of Cointegration equations in the model. This mean to say that is a researcher finds out that the model gave 2 Cointegration equations, 2 restrictions per equation will be done, and if there are 3 Cointegration equations then 3 restrictions to the VAR will be done (Ngalawa, 2009). In being rationale to the issue Haug et al., (2005), concurred that for the long-run implications of any VAR model, the Vector Error Correction Model (VECM) will be the best model to adopt. This study is concerned about the short-run implications of the model. Haug et al however, made it clear that for the short run it is best to run the VAR since its parameters are estimated consistently by least squares with variables in levels without unleashing cointegrating restrictions available in the data. However, when faced with cointegration analysis in the data, a VAR can do accurate and precise modelling with non-stationary variables when the researcher is concerned about the long run implications of the model through cointegration restrictions to the model (Johansen, 1988). In identifying long run relationships in a model there are some other papers that have used cointegration analysis for identification in a linear cointegrating model with variables that are differenced ones for example; King et al., (1991) , Lutkepohl and Wolters, (1998), Ehrmann, (1998), Garratt et al., (2003).

While the debate on whether to transform the non-stationary data by differencing or by using cointegration operators when running a SVAR has mostly followed Sims, Stock and Watson (1990), there are other studies and researchers who are still following the traditional way of first transforming the data to make it stationary through differencing without putting a difference whether the motive for research is short run or long run implications of the model taking for example (Enders 2004, Sanusi, (2006), Aleem, (2014), Nogueira, (2008) among more others.

Section: five

Results analysis

Unit root tests

Each and every variable was tested for stationarity using the Augmented Dickey fuller(ADF) tests to show if the variables are stationary in their levels of after they are differenced. The results of the unit root tests indicates that all the variables were non-stationary in levels and get stationary after the first difference I(1) mostly at 1% level.

variable	model @ 1%	ADF (levels)		ADF (Diff)		
		cr value	t stat	Cr Value	Tstat	conclusion
Output gap	Trend and intercept	-3.469	2.718	-3.47	-4.501	Nonstationary
	Intercept	-4.013	1.975	-4.014	-11.745	Integrated of
	None	-2.578	3.111	-2.579	-4.373	order 1
Petrol prices	Trend and intercept	-3.47	-1.053	-3.47	-9.323	Nonstationary
	Intercept	-4.014	-4.111	-4.014	-9.292	Integrated of
	None	-2.57	0.814	-2.579	-9.22	order 1
Ner	Trend and intercept	-3.47	-1.461	-3.47	-2.796	Nonstationary
	Intercept	-4.014	-3.303	-4.014	-2.619	Integrated of
	None	-2.579	-1.044	-2.579	-2.751	order 1
PPI	Trend and intercept	-3.469	-0.978	-3.47	-7.165	Nonstationary
	Intercept	-4.013	-0.08	-4.014	-7.216	Integrated of
	None	-2.578	-0.14	-2.579	-7.183	order 1
EXPO	Trend and intercept	-3.469	-0.532	-3.469	-12.335	Nonstationary
	Intercept	-4.013	-1.984	-4.014	-12.311	Integrated of
	None	-2.578	2.152	-2.578	-12.056	order 1
IMP	Trend and intercept	-3.469	0.395	-3.469	-11.598	Nonstationary
	Intercept	-4.013	-1.689	-4.014	-11.687	Integrated of
	None	-2.578	1.946	-2.578	-11.411	order 1
CPI	Trend and intercept	-3.469	2.32	-3.469	-11.51	Nonstationary
	Intercept	-4.013	-0.943	-4.014	-11.943	Integrated of
	None	-2.578	10.798	-2.579	-2.761	order 1

Johansen Cointegration Test results

The results show that there is a long run relationship amongst the variables in the model and there are 2 cointegrating equations according to the Trace statistic results and one cointegrating equation using the Max Eigen results. This paper is adopts the results from the Trace statistic since it is assumed to be the most powerful compared to the Max Eigen.

Null	Trace statistic	5% C.V	Max Eigen	5% C.V
r=0	152.5993	125.6154	53.84199	46.23142
r<=1	98.75732	95.75366	36.24792	40.07757
r<=2	62.50940	69.81889		

Estimation Results

Impulse response functions (Recursive VAR)

Impulse responses identify the responsiveness of the endogenous variables in the VAR when a shock is put to the error term such as *u1* and *u2* on the equations in the system (Ngalawa, 2009). A unit shock of the exchange rate is applied to each of the above mentioned variables to see its effect on the VAR system. According to McCarthy (2000), in the calculations of the impulse response functions, ordering of the variables is important and this study has adopted the Cholesky degrees of freedom that are adjusted in Eviews 9.5.

An unexpected shock in the exchange rate corresponding to an unanticipated 1 percent change in the exchange rate is not immediately felt by the import prices in the South African economy. The shock is mostly felt between 4 to 6 months then its impact become less and less as time goes by. This means that the import prices respond to exchange rate changes with a lag. Import prices respond positively after a shock in the petrol prices also showing no immediate response. The petrol price shock is mostly felt by the import prices between 2 to 4 months then its impact goes down with time. There is an immediate negative response in the import prices as a result of an unexpected shock in the output gap between 0 to 2 months. In the fourth month is when the import prices respond positively to a shock in the petrol prices. Import prices respond positively at an increasing rate from the 10^{th} month onwards.

The impact of an unexpected import price shock down the pricing chain is immediately felt by the producer prices and the export prices with the impact fading away after 2 years in the export prices. Producer prices show a constant negative response with the shock felt considerably after one year but then the impact goes down with time at a constant rate. Consumer prices respond sluggishly to a shock in the VAR coming from the import prices. The shock will increasingly be felt in the consumer prices after a year (12 months) as it goes on increasing with time.

Variance decompositions

The fluctuations in import prices are largely accounted for by own shocks of cause but shocks to the exchange rate accounts for the highest percentage fluctuations in the import prices. After a shock to the exchange rate, the import prices respond by 17.27% after only 6 months. The effect of a shock into exchange rate will increase the fluctuations in the import prices to 27.54% after one year. These results confirm or agree with the findings from studies by Parsley (2010) and (Aron et al., 2014). They found that the import prices were being accounted for by the exchange rate by the same magnitude. The effect of a shock to exchange rate on prices will increase as time goes by but at a decreasing rate after one year. This can be observed by a steady increase in the fluctuations from 15 months to 21 months since the fluctuations increased from 29.66% to 31.27% respectively. After 24 months the shock to the exchange rate will contribute to a 31.30% fluctuation in the import prices. This then means that the effect increases with time and its effect will be felt mostly after 2 years with half of the effects experienced 6 months after the shock has taken place. It should be a worrying factor for the monetary policy makers because the arguments in the literature suggest that pass-through decreases with time but from the look of these results ERPT is not decreasing meaning to say that it will continue to cause more pressure on the average inflation figures.

Petrol prices are not spared since they account for quite significant fluctuations in the import prices. A shock to the petrol prices leads to a 7.24% change in import prices after only 1 month meaning that the shock to import prices is immediately felt in the South African economy because the percentage is quite big and very significant. The fluctuations will then increase by more than 100% after 6 months increasing from 7.24% to 17.98% after only 3 months. The fluctuations after a shock to the petrol prices are immediate and they are quickly influential on the prices the South African importers pay. This is basically because petrol or oil prices are one of the main production and operation costs that are immediately felt by any producer and that will force producers to quickly adjust their prices to remain making profits in business. However, the effect will be increasing at a decreasing rate over 6 months, 12 months, 18 months and finally 24 months (17.94%, 19.96%, 21.27% and 21.59% respectively).

A shock to import prices accounts for 31.47% fluctuations in the producer prices only one month after the shock meaning that the producer prices in South Africa quickly respond to changes in the import prices. However, although the effects are immediate, they decrease at almost a decreasing rate as time increases up to one year before it starts to increase again. This is observed by a decrease in the fluctuations in the producer by 23.94% after 3 months down from 31.47% after one month. After 6 months the shock in the import prices will account for 19.78% changes in the producer prices down from 23.94%. After one year the impact of the import price shock will account for 20.45%, after 18 months 21.64 and 21.09% meaning that the effect increased from 12 months up to 18 months although at a constant rate. After 24 months the effect starts to increase as well.

The producer prices were assumed to be a big contributor to the changes in export prices but from the results import prices are contributing the most. Unexpected shocks in the Producer prices account for 3.05% after a month but the impact goes down to 1.34% after six months before it goes further down to 0.73% in 12 months' time and 0.58% after 2 years. Although the effect of the shock as if it is immediately felt in the export prices it is its magnitude which is a worrying factor but the reason could be the fact that producer prices have not been changing much because of the low commodity demand on the world market and the adjustment of the prices especially for a small economy like South Africa not being easy to adjust.

It is within the researcher's expectations to see that all the variables in the model are contributing to the fluctuations in the consumer prices. Since the model used a recursive approach, all the variables in the model have an effect without them being affected much by the fluctuations of the consumer prices. Direct ERPT is significant for consumer price increases as time elapses as can be observed from table 5.5.7 above. As a result of an unexpected shock in the exchange rate, the consumer prices respond by 0.51% after one month before they fluctuate by 1.36% after 3 months. The exchange rate accounts for a 5.49% fluctuation in the consumer prices after 6 months then by 11.55% after a period of 12 months (1 year). It can be observed that the effect of the shock increases as time increases. In the 24^{th} month, the fluctuations in the consumer prices as a result of a shock to the exchange rate rise 13.25%. This confirms previous work of previous researchers on South Africa as they have also

seen the effects of exchange rate changes to consumer prices at around the same range for example Razafimahefa, (2012), Rigobon, (2007) and Aron,et al. (2014) who found ERPT to CPI as 12%, 13% and 10% respectively.

On the consumer prices the producer prices were expected to have made a mark but from the look of things the producer prices have got a paltry effect of 0.21% after one year, 0.89% after six months, 0.63% in the period up to one year and only an increase to 1.29% after two years. The assumption behind this is either that the producer prices takes time to have an effect in the consumer prices or either the prices are sticky in South Africa especially after the changes in the exchange rate. There is quite a lot of competition amongst the local producers in South African and goods that are coming from abroad. The need for survival in the case of local producers is what might make the prices sticky and not being passed on much to the consumer prices which means that the consumer and export prices are being shaped by other variables in and outside this model.

SVAR results

Identification assumptions

- Industrial production and inflation of the small open economies is deeply impacted by the world or outside shocks
- Output and prices do not respond contemporaneously to changes in domestic monetary policy variables.
- Production responds to domestic price and exchange rate with a lag
- Inflation is affected by world shocks and the current state of the industrial production
- Exchange rate is one of the most volatile variables in the model and is quick to react to almost all shocks be they from outside or inside, nominal or real
- Every variable in the model is affected by the petrol price shocks

The assumptions above were adapted from the work of Ngalawa (2011) in his paper on monetary transmission mechanism for Malawi. The reseacher added some assumptions that are appropriate for South Africa.

Restrictions made to the SVAR according to the above mentioned assumptions:

$$A = \begin{pmatrix} 1 & 0 & 0 & 0 & 0 & 0 & 0 \\ C_1 & 1 & 0 & 0 & 0 & 0 & C_{18} \\ C_2 & 0 & 1 & C_{10} & C_{13} & 0 & 0 \\ C_3 & C_7 & 0 & 1 & 0 & C_{16} & 0 \\ C_4 & 0 & 0 & C_{11} & 1 & 0 & 0 \\ C_5 & 0 & 0 & 0 & C_{14} & 1 & 0 \\ C_6 & C_8 & C_9 & C_{12} & C_{15} & C_{17} & 1 \end{pmatrix} \qquad \varepsilon_t = \begin{pmatrix} \varepsilon_t^{gap} \\ \varepsilon_t^{ptr} \\ \varepsilon_t^{ner} \\ \varepsilon_t^{cpi} \\ \varepsilon_t^{imp} \\ \varepsilon_t^{ppi} \\ \varepsilon_t^{exp01} \end{pmatrix}$$

Matrix B was just an identity matrix just like in the Recursive VAR situation

Impulse response functions

Drawing an analysis from the results from the non-recursive VAR, the impulse responses of the import prices do not look much different from those of the recursive VAR, the only difference being that, the impact moves more quickly from negative to positive than it does under the recursive estimation. In the recursive it comes back steadily but never comes back to zero but under the non-recursive it comes to zero after 20 months. This means that the identification of the shocks under the non-recursive is a bit strict and tight as compared to the sluggish response shown under the non-recursive. The impact of an unexpected shock in the VAR to consumer prices according to figure 5.6 is also not different from the recursive because it behaves in the same for 2 years and fluctuates in the same manner. The only difference noticed between the responses of consumer prices to an exchange rate shock is that under the non-recursive the consumer prices fluctuate a lot but look steady and calm in the recursive estimation for the entire 2 years. Looking at the impact of the exchange rate shock to the export prices, under the recursive the impact looks steady and negative for the entire period of 2 years but under the non-recursive identification the impact quickly comes back to positive after 20 months and stays positive above zero with time.

Producer prices and import prices are expected to have a positive relationship. As import prices goes up because of exchange rate depreciations, the producer prices will also respond by going up. However, that situation has not been happening across the globe especially in the context of exchange rate pass through. Producers were not very willing to pass through the changes of sudden exchange rates to their customers mainly because of low commodity demand across the globe. The response of the

producer prices to a shock in the import prices is slightly different for the two estimations. Although having a negative response for both estimations in the first 10 months, under non-recursive it fluctuates more than it does under recursive. Between 10 months and 14 months the impact fluctuates between zero and positive before it goes back to negative and fluctuates back to positive in periods after 24 months. This means that the adjustment of producer prices does not respond instantly to changes in import prices but they will adjust when the producers have seen that the depreciation is persistent. Under the recursive, it looks like coming back to positives but it does that sluggishly meaning it will take more than 2 years to come to positive.

There is a difference in the way the consumer prices are impacted by a shock to the import prices under both estimations. Under the recursive, the impact is positive throughout the entire period of 24 months meaning that the consumer prices do not take time to respond to changes in the import prices. The impact of the shock or the response to the import price shock is small under the recursive estimation whilst it is bigger and positive though volatile under the non-recursive. Export prices follow the pattern of the export prices in the sense that the pricing by the firms does not happen instantly but the exporters wait and see if the fluctuation in the import prices caused by exchange rate fluctuations is a one-time depreciation or appreciation before they respond positively to changes in import prices after 20 months falling into 2 years.

Variance decompositions (Recursive VAR and SVAR compared)

Direct ERPT (Non-recursive)					**Direct ERPT (recursive)**			
IMP to NER	**PPI to NER**	**CPI to NER**	**EXP to NER**	**Months**	**IMP to NER**	**PPI to NER**	**CPI to NER**	**EXP to NER**
1.63	18.47	2.06	0.01	**1**	1.14	0.14	0.51	0.24
1.68	27.60	2.91	0.43	**3**	6.28	0.08	1.35	2.71
1.07	30.87	2.82	1.56	**6**	17.27	0.05	5.44	6.76
1.74	26.87	2.06	3.20	**12**	27.54	0.07	11.55	14.50
13.29	15.16	12.38	8.20	**24**	31.30	0.52	13.25	20.07

Under the non-recursive SVAR, the response of the import prices to a shock in the VAR coming from the exchange rate is sluggish with the import prices responding with 1.63% one month after the shock. The situation does not increase up to the 15th month where import prices fluctuate by 1.59% before the shock starts to be significantly felt in the economy when it fluctuates by 6.13% after 18 months, 11.77% after 21 months and finally by 13.29% after 2 years or 24 months. This then means that the import prices also respond slowly after a change in the exchange rate. With the way the rand devaluated with in the covered period between 2002 and 2015, the import prices were expected to have fluctuated with a huge margin but things did not happen like that. The argument behind such kind of developments is attributed to the structure of the South African economy which has an oligopolistic kind of set up. So it is not easy for prices to just change. Also, the issue of competition in other importing sectors can cause the prices to become sticky and then adjust later when the impact of the shock is insistent in the economy.

The Variance decompositions of the producer prices to a shock in the exchange rate show an instant significant fluctuation in the first month after the shock with a 18.47% , fluctuation. The producer prices fluctuate most after 6 months, fluctuating by 30.87% before the impact goes down to 26.87% after one year then the effect on the economy is steadily lessened and after 2 years the fluctuation is reduced by 15.16%. The response of the producer prices after an exchange rate shock is consistent with the expectation of the researcher because the producers are significantly affected by the value of the foreign currency when the rand depreciates. Producers bring in intermediate goods from the international market in order to produce and that is how their prices are affected.

Consumer prices slowly respond to an exchange rate shock in the first 15 months after the shock. However, the weight of the impact starts to increase 18 month the exchange rate shock. The impact is almost constant in the first year of the shock with the fluctuations not exceeding 3% for the entire year. The consumer prices are expected to behave in that manner because they are not really affected directly by the exchange rate. Their fluctuations are mostly caused by the shocks in the import prices and the producer prices. Also the export prices behave in the same way as the consumer prices are responding. They start by responding by a very small and slow fluctuation until after 9 months of the shock. From the 1st month to the 9th month after the shock, the fluctuation of the export prices does not exceed 2% before the impact of the exchange rate starts to increase in the 12th month fluctuating by 3.20%. Although the impact of the shock is bigger after 2 years, it shows that the exporters are not going to quickly adjust their prices as soon as the rand depreciates. The pricing system in the world market is determined by a wide

range of factors that include menu costs, competition, the Chinese effect and the low world commodity prices that have been hampering the dreams of many economies when it comes to export led growth. It is either business settle for something less than getting nothing on the international market, hence adjusting prices is not easy.

In the second stage exchange rate pass-through for South Africa, Aron et al., (2014) assert that the producer prices are expected to have a higher pass through followed by either export prices or the consumer prices. However, from the results harvested from the non-recursive SVAR it looks like the empirical wisdom is defied as time goes. In the first month after the shock the expected trend is followed by the variables as we see the producer fluctuating by 1.71%, consumer prices fluctuate by 0.19% and finally, the export prices responding by 0.005%. As time went on the trend is broken because after 12 months the producer prices respond by 4.36%, export prices fluctuate by 32.17% and consumer prices become volatile by 42.92%. After 24 months the pattern does not change its structure but the impact of the shock increases with time for export and consumer prices and the producer prices are slow is their fluctuation with 4.22% response, 31.07% for export prices and a fluctuation of 51.61% for consumer prices. This is assumed to be caused by the fact that producer prices are sluggish in responding to anything to do with exchange rate volatilities. Also the justification for the consumer price behaviour is assumed to be high percentage of goods and services that respond significantly to changes in the exchange rate via the changes in the import prices.

In the first stage or direct ERPT, the import prices look sluggish within 12 months after the exchange rate shock in the non-recursive regime with the impact of the shock causing a lot of fluctuation after 18 months. However, under the recursive estimation the fluctuations after 3 months are quite significant and the impact of the shock is showing higher pass through under recursive although not complete. So there is a similar pattern being followed by the import prices in both estimations just that the impact of the shock is felt faster under the recursive approach.

The direct ERPT on the producer prices responds insignificantly under the recursive regime with the fluctuations insignificant, but it is shocking to observe that under the non-recursive the identification of the ER shock to the producer prices is very high and significant although not too volatile and the ERPT for producer prices is incomplete for both estimations though higher under the non-recursive regime.

The export prices show a pattern of response to the exchange rate shock similar to that of the import prices. They respond sluggishly in the first few months after the shock and then have a bigger impact later i.e. after 6 months under recursive and after 18 months in the other estimation.

On the other hand the consumer prices' response to the exchange rate shock in the VAR was completely the opposite. The fluctuation as a result of the shock is huge in the first few months under the recursive with the impact felt smaller and smaller as time went by unlike the situation under the non-recursive identification where the impact is small within the first few months before it grows in the later months for example after 18 months.

Section: six

Policy recommendations and conclusion

The pressure from the depreciating rand on prices is causing a significant contribution to the average inflation in the country. However, several policy issues can be derived from the findings of this study. First, monetary policy authorities in South Africa need to keep track of the contribution of the exchange rate volatilities on prices. Although the Inflation targeting framework succeed during the early years from its inception, the past 3 years have seen inflation in the upper band and outside the stipulated band for most parts of the year. This means that targeting inflation is currently not really working and the target is frequently missed. In the event that the current situation persists the following suggestions should be considered by the policy makers. The suggestions are that, either they need to scale up the band a bit to the right potential of the economy although this can have effects on the inflation expectations from the agents but the fact that the band is being missed is a worrying factor.

Also, the bank needs to extend its objectives from solely price stability but also to exchange rate stability since it is evident that targeting inflation only is not really of much help to the South African situation right now. If the Bank could adopt a managed float, that could help to stabilise the exchange rate and prices since it is evident enough that exchange rate changes are contributing highly to inflation. Achieving exchange rate stability will enable businesses to plan and when circumstances are certain in an economy most sectors can respond positively and the economy can attain some significant growth patterns.

Areas for Future and Further Research

The study analysed the pass-through of exchange rate changes to import, producer, export and consumer prices in South Africa. However, the variables used were in aggregate terms leaving a gap for disaggregated data. It has been argued that the import prices respond highly to exchange rate changes but it is not yet known which specific goods respond most to changes in the import basket. Also in the consumer price level basket, there are certain items like meat, bread and cereal, electricity that are thought to cause more trouble in terms of inflation but the magnitude of their contribution to headline inflation is not yet known.

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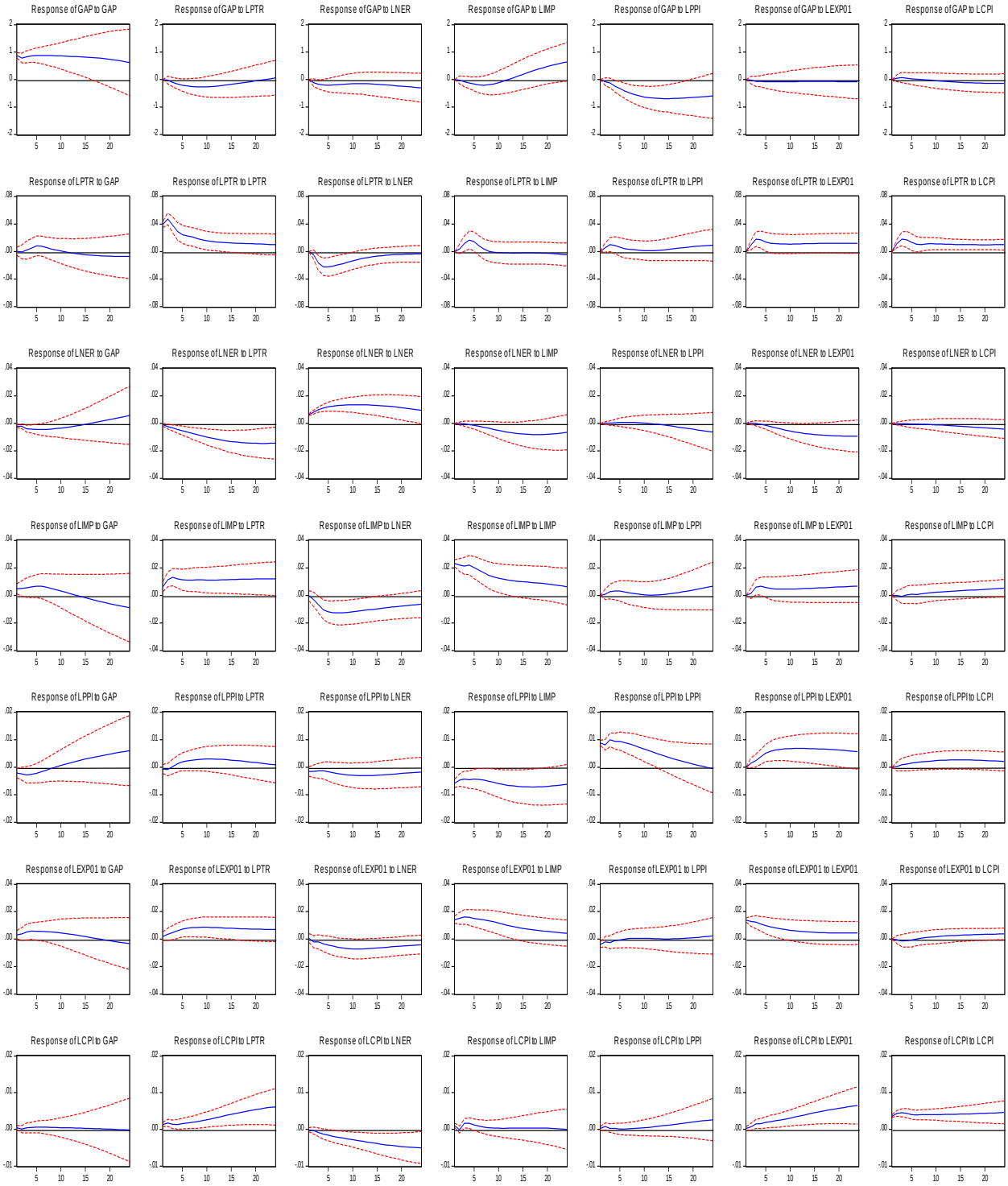
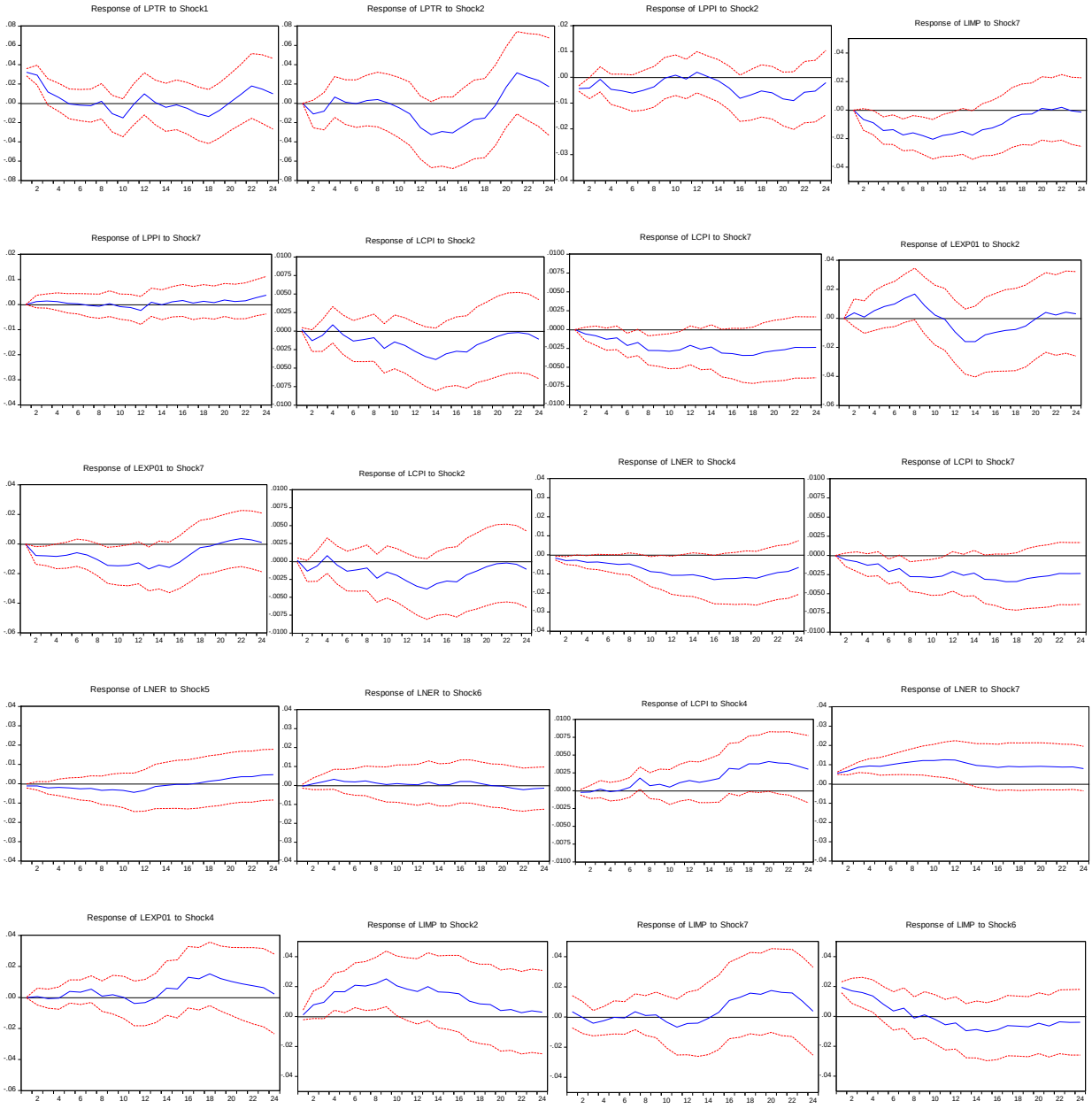
Appendix

Recursive VAR Impulse response Functions



Impulse response function for the SVAR



Johansen Cointegration

Date: 09/26/16 Time: 15:57
Sample (adjusted): 2002M05 2015M12
Included observations: 164 after adjustments
Trend assumption: Linear deterministic trend
Series: GAP LCPI LEXP01 LIMP LNER LPPI LPTR
Lags interval (in first differences): 1 to 3

Unrestricted Cointegration Rank Test (Trace)

Hypothesized No. of CE(s)	Eigenvalue	Trace Statistic	0.05 Critical Value	Prob.**
None *	0.279857	152.5993	125.6154	0.0004
At most 1 *	0.198302	98.75732	95.75366	0.0306
At most 2	0.143188	62.50940	69.81889	0.1665
At most 3	0.122449	37.16546	47.85613	0.3398
At most 4	0.071756	15.74378	29.79707	0.7302
At most 5	0.021140	3.532208	15.49471	0.9376
At most 6	0.000172	0.028150	3.841466	0.8667

Trace test indicates 2 cointegrating eqn(s) at the 0.05 level
* denotes rejection of the hypothesis at the 0.05 level
**MacKinnon-Haug-Michelis (1999) p-values

Unrestricted Cointegration Rank Test (Maximum Eigenvalue)

Hypothesized No. of CE(s)	Eigenvalue	Max-Eigen Statistic	0.05 Critical Value	Prob.**
None *	0.279857	53.84199	46.23142	0.0065
At most 1	0.198302	36.24792	40.07757	0.1269
At most 2	0.143188	25.34394	33.87687	0.3621
At most 3	0.122449	21.42167	27.58434	0.2515
At most 4	0.071756	12.21157	21.13162	0.5269
At most 5	0.021140	3.504058	14.26460	0.9076
At most 6	0.000172	0.028150	3.841466	0.8667

Max-eigenvalue test indicates 1 cointegrating eqn(s) at the 0.05 level
* denotes rejection of the hypothesis at the 0.05 level
**MacKinnon-Haug-Michelis (1999) p-values