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Evolution of Monetary Policy Transmission Mechanism in Malawi: A TVP-VAR Approach

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Abstract

This paper investigates the evolution of monetary transmission mechanism in Malawi between 1981 and 2010 using a time varying parameter vector autoregressive (TVP-VAR) model with stochastic volatility. We evaluate how the responses of real output and general price level to bank rate, exchange rate and credit shocks changed over time since Malawi adopted financial reforms in 1980s. The paper finds that inflation, real output and exchange rate responses to monetary policy shocks changed over the period under review. Importantly, beginning mid-2000, the monetary policy transmission performed consistently with predictions of economic theory and there is no evidence of price puzzle as found in the previous literature on Malawi. However, the statistical significance of the private credit supply remains weak and this calls for more financial reforms targeting the credit market which can contribute to monetary transmission and promote further economic growth in Malawi.

JEL classification: C49 D12 D91 E21 E44

Keywords: Monetary Policy Transmission Mechanism, Price Puzzle, Financial Reforms, Bayesian TVP-VAR.

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1 Introduction

The main objective of this paper is to investigate whether the monetary transmission mechanism has changed since Malawi adopted the financial reforms in 1980s. We investigate how and when the changes in the exogenous shocks of the monetary policy instrument of bank rate have influenced changes in the stability of inflation and output growth. Based on the Bayesian Time Varying Parameter Vector Autoregressive (TVP-VAR) techniques by Primiceri (2005) and Nakajima (2011), we empirically examine how the transmission mechanism and the monetary shocks have been varying overtime. Particularly, we evaluate whether the responses of prices and output level to bank rate, exchange rate and credit growth have been changing during and after financial reforms.[1]

Prominent work by McKinnon (1973), Shaw (1973) and Levine (1997) provide good foundations in understanding how financial reforms impact economic activities. One main goal of financial reform is to establish a vibrant financial sector that is accommodative of improved monetary policy transmission mechanism. Malawi's package of financial reforms have brought about new financial innovation with growing banking system, removal of interest rate and credit controls, opening current and capital account, adopting a managed and floating exchange rate regime, mushrooming of credit facilities and other non-financial institutions such as insurances. These policy changes have posed macroeconomic challenges for the Reserve Bank of Malawi (RBM). In tandem, we have seen an improvement of the evolution of various economic activities following these reforms. For instance, inflation declined to single digits in 2000s and the country managed to achieve a stable economic growth of about 6% on average until 2010. In addition, the country experienced interest rates and exchange rate stability with mushrooming of private sector credit. Therefore, it would be interesting to investigate whether the monetary stabilisation policy had any effects on this hard earned economic stability and how the effects have evolved overtime.

Abundant empirical work about monetary transmission mechanism focus on how the monetary policy shocks affect output, prices, exchange rates as well as other key economic variables. Most of these studies use Vector Auto-Regression (VAR) frameworks in their analysis following a breakthrough seminal work by Sims (1980). Some of the most prominent

[1] The transmission mechanism effects overtime are explained via interest, credit and exchange rate channels. The asset channel has been left out because its development is still at infancy stage.

ones include an authoritative survey by Christiano, Eichenbaum and Evans (1999) on USA, Peersman and Smets (2001) on the euro area and a recent survey by Mishra and Montiel (2012) on low-income countries. These models are based on the assumption of constant parameters and constant volatility. However, financial reform is a process and the effects may vary overtime. In addition, Franta *et al.* (2011) revealed that the reforms can affect the monetary transmission mechanism by changing the overall impact of the policy or by altering the transmission mechanism channels. Hence, the use of these models fails to evaluate how changes in the way macroeconomic economic variables respond to shocks and how the volatility of shocks hitting the economy evolves overtime. Consequently, the outcome of these models have been affected by omitted variable bias, identification problem, spurious dynamics in random coefficients and most importantly 'price puzzles' (Sims, 1992; Eichenbaum, 1992; Giordani, 2004; Bernanke, Boivin & Ehasz, 2005; Cogley & Sargent, 2005; Sims & Zha, 2006; Koop, Leon-Gonzalez & Strachan, 2009; Korobilis, 2012).

Accordingly in recent times, empirical researchers have developed the TVP-VAR models to address the issue of time varying parameter problems in the estimation of the monetary policy transmission. For instance, work by Canova (1993) followed by Cogley and Sargent (2001) considered the estimation of the TVP-VAR based on the assumption of constant volatility. However, Koop *et al*. (2009) and Cogley and Sargent (2005) argue that the transmission mechanism may not be constant overtime and the way the exogenous shocks are generated can change overtime. Primiceri (2005) confirmed the existence of both in USA. Nakajima (2011) also found the same results on Japanese economy. Another important study employing a Bayesian TVP-VAR model with stochastic volatility on transmission mechanism is by Franta *et al*. (2011) on Czech Republic.

Nevertheless, several recent studies on monetary policy transmission mechanism using the TVP-VAR with stochastic volatility framework have concentrated on developed countries. There is very limited evidence if any in Sub-Saharan Africa using the Bayesian TVP-VAR model to measure quantitatively the country's monetary transmission mechanism. A recent empirical survey by Mishra and Montiel (2012) documents studies on effective monetary transmission in Low-Income Countries and no study using the TVP-VAR framework with stochastic volatility has been included on Sub-Saharan Africa. Although not directly related to this study, the only existing studies are two recent papers by Peretti, Gupta and Inglesi-Lotz (2012) and Aye, Gupta and Modise (forthcoming) who have used a TVP-VAR model

with stochastic volatility to quantify the impact of house and stock prices on consumption and interest rate in South Africa, respectively. Thus, our paper contributes to the literature by filling this gap. The model will assist not only in analysing the effects of monetary policy transmission but also observe how the shocks and estimated parameters have evolved overtime depending on the underlying macroeconomic structure of the Malawi economy.

Previous work on Malawi monetary policy transmission mechanism has primarily focused on the estimation of aggregate money demand relations in single equation framework (Phiri, 2001), using VAR estimations (Mangani, 2010), using SVAR (Ngalawa and Viegi, 2011) and using the VECM (Lungu, Simwaka, Chiumia, Palamuleni and Jombo, 2012). From these studies, issues of parameter instability and 'price puzzle' are commonly found. However, the models are based on the assumption of constant volatility of the exogenous monetary policy shocks and estimated parameters. By employing a TVP-VAR model with stochastic volatility, this paper accommodates the possibility of the changes in the transmission mechanism and the changes in the variances of the exogenous shocks. Our preliminary findings show that the transmission mechanism in Malawi changed markedly following the financial reforms. First, the change in the monetary transmission mechanism is not clear and provides more puzzles than answers before the financial reforms. Second, the transmission mechanism changes became volatile during the financial reform. Third, the changes in the transmission became clear during the post period of financial reform. Importantly, we found clear variety of shocks to bank rate and exchange rate with weak transmission mechanism through the credit channel.

The rest of the paper is structured as follows. In section 3.2, we provide a brief review of the monetary policy and other stylized facts about the transmission mechanism in Malawi. In section 3.3, we propose a benchmark Bayesian TVP-VAR with stochastic volatility model in order to estimate whether the transmission mechanism changed overtime and whether the generated shocks are also changing overtime. In section 3.4, we discuss the empirical results and section 3.5 concludes.

2 Brief Overview of Monetary Policy and Stylized Facts in Malawi

Ngalawa and Viegi (2011) provide a thorough overview of monetary policy in Malawi over the last two decades. The monetary policy analysis is also properly explained through the demand for money function by Munthali, Simwaka and Mwale (2010). Thus, we only

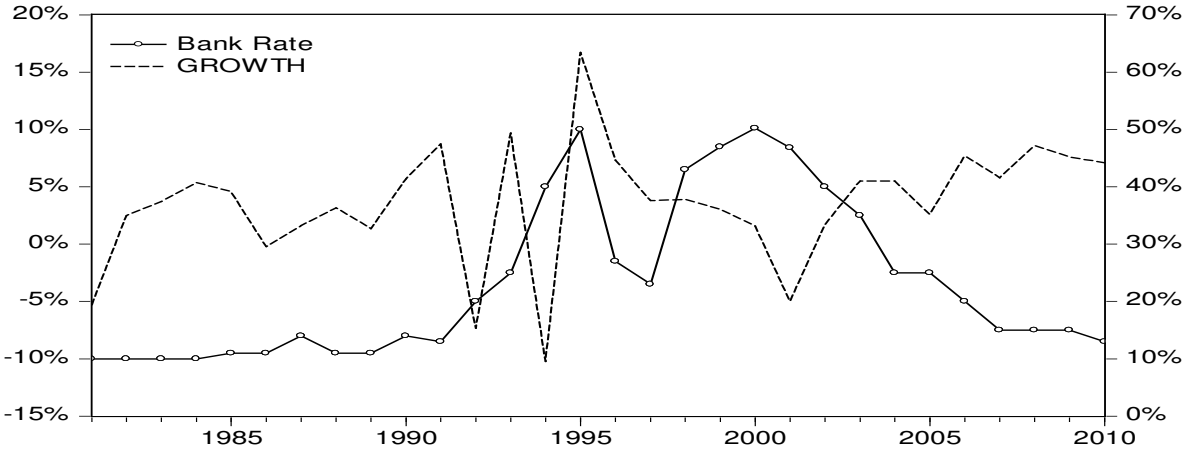
provide an overview of monetary policy in Malawi. In general, the monetary framework can be categorised under three broad regimes: the repression period (1964-1986), the financial and liberalisation reform period (1987-1994) and post period of financial reform (1995-2010). Several monetary policy reforms emerged during these periods which included: changing the fixed exchange rate regime to the managed and floating one, removing direct controls on credit and deregulation of market interest rates, moving away from direct to indirect tools of monetary control, reviewing the legal and regulatory framework of the banking system, and removing the capital controls to the liberalisation of the stock market and other external flows. All these policy changes and implementation happened at different time periods.

Officially, the Reserve Bank of Malawi (RBM) uses reserve money and the bank rate as monetary policy targets. Recently, Ngalawa and Viegi (2011) have evidently evaluated the performance between these two targets and the bank rate has been found to be more effective tool of monetary policy than reserve money. The study also demonstrates that the bank lending, exchange rates and aggregate money supply contain important addition information in the transmission mechanism process of monetary policy shocks in Malawi. The study also found that the effects of transmission mechanism became strong and unambiguous during the post period of financial reforms. In particular, the role of exchange rate, interest rate and credit channels in transmitting monetary policy impulses was enhanced in the post period of financial reforms.

In addition, with changes in Government in 2004, both fiscal and monetary policy changed direction coupled with resumption of donor assistance. Adherence to international monetary fund programme also helped Malawi achieve fiscal and monetary consolidation after 2006 until 2010. As shown in Figure 10 and 11, inflation rates historically declined to single digits and economic growth hovered around 6% on average. Specifically, Figure 10 shows that episode of high and low bank interest rate are associated with stagnation and robust economic growth, respectively. However, the relationship between bank rate and growth is not clear during the financial reform period because the period was mild with volatility in growth emanating from high inflation, drought and shift in government policies. On the other hand, movements of inflation seem to have followed the bank rate (see Figure 10). The relationship between the bank rate, economic growth and inflation seems to be very clear during the post era of financial reforms. The IMF country reports have shown that macroeconomic and all

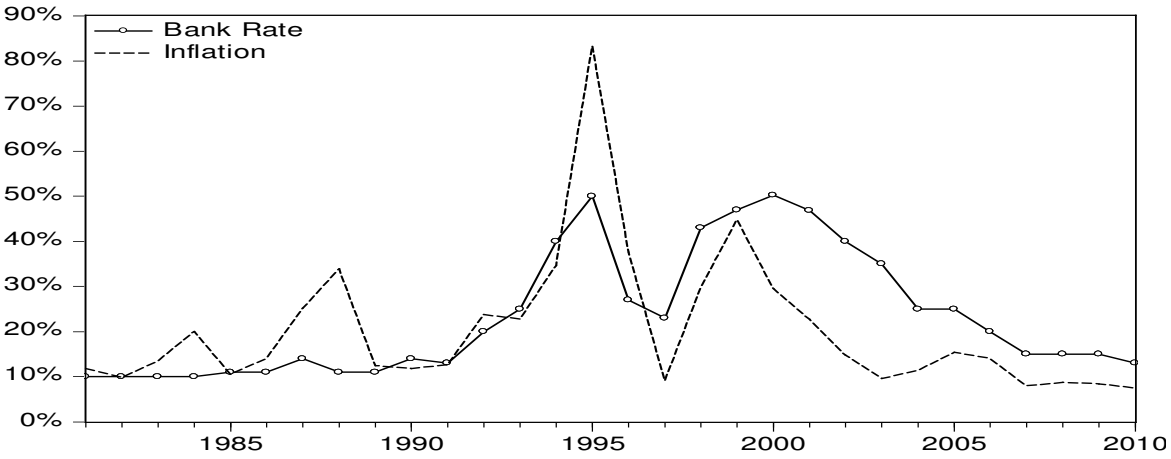
other financial and fiscal targets were almost kept on target as programmed with the IMF based on the economic fundamentals during this period (IMF, 2010).

Figure 1: Trend of Bank Rate and Growth



Source: International Monetary Fund-International Financial Statistics from Quantec Easydata

Figure 2: Bank Rate and Inflation in Malawi

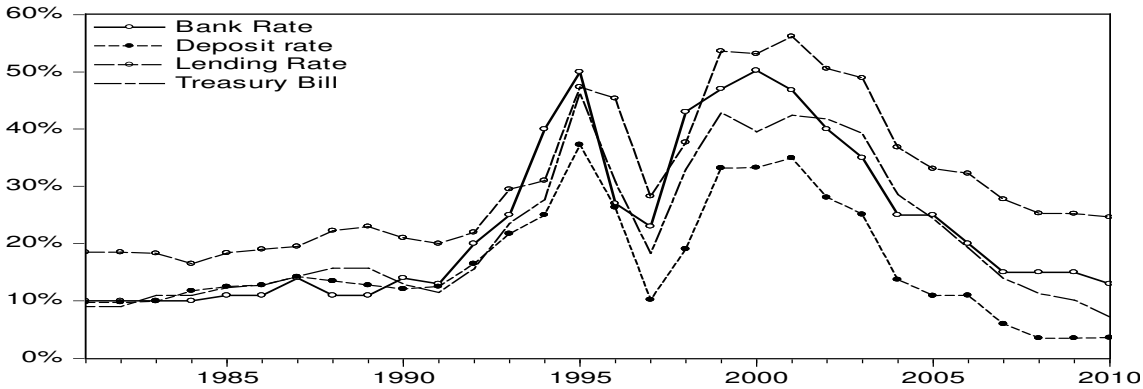


Source: International Monetary Fund-International Financial Statistics from Quantec Easy Data

According to the interest channel, the monetary transmission mechanism is based on the innovations in the bank rate. The RBM bank rate is administratively set and signals to the market the expected movements in the market interest rates (Simwaka, Ligoya, Kabango and Chikonda, 2012). In particular, movements in the bank rates are only effective to the extent they influence the Treasury bills, deposit and lending rates and thereby possibly economic activity. This is well demonstrated in the co-movements of market interest rates with the bank rate as shown in Figure 12. The weak link of transmission of interest rates is also affected by the possibility of having large informal credit markets in Africa which is the case for Malawi

(Chipeta and Mkandawire, 1991; Ngalawa and Viegi, 2010). For instance, Christensen (2011) argue that tighter monetary policy divert demand to large informal credit sector and so lead to the sharp rise in cost of credit. Therefore, tighter monetary policy is associated with short-run rise in inflation because of considerable lag in demand effects in the large informal sector leading to ineffectiveness of monetary policy in stabilising the economy.

Figure 3: Bank Rate and Key Market Rates in Malawi

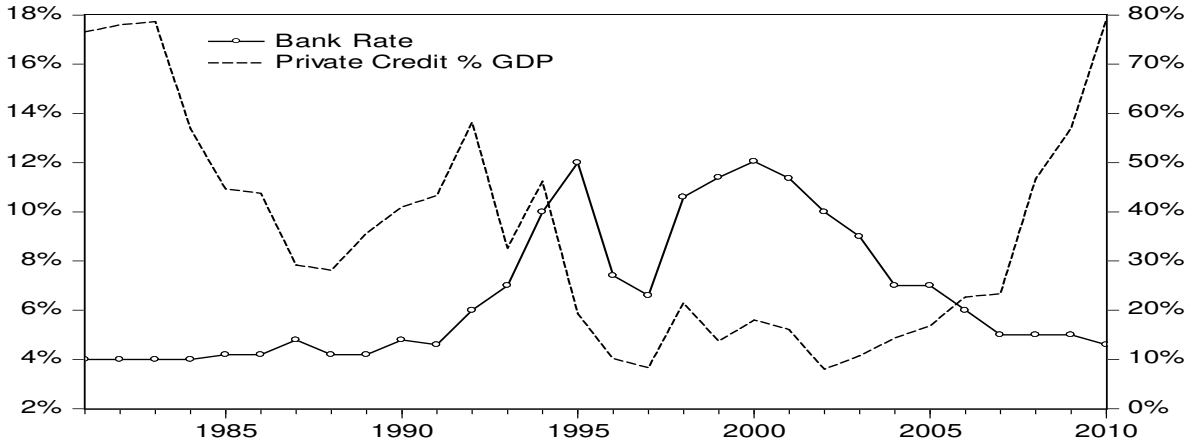


Source: International Monetary Fund-International Financial Statistics from Quantec Easy Data

Prior to financial reforms, RBM used instruments such as priority sector lending targets, especially to the agriculture sector[2]. In addition, the government introduced cash reserve ratios in the initial stage of financial reforms which trended upwards until 2003. The Malawi economy is agricultural based and government saw it fit to target agriculture to achieve development goal of price stability and economic growth. With the introduction of financial reforms, RBM started phasing out credit ceilings in 1988 but counter effect with the introduction of upward trending of liquidity reserve requirement. However, we have seen rapid expansion of lending to the private sector in the post period of financial reforms as shown in Figure 13. Quantitatively, annual credit growth reached an extent of 106% in September 2008- April 2009 from 38 % realised in January 2005 – September 2008 and was one of the highest in Africa (Christensen, 2011). The BIS study by Christensen (2011) also explains that growth fuelled in part by large capital flows and monetary policy that in case was too accommodative to stem rising inflation. The big question now arises whether this buoyant credit growth had any transmission effects in achieving economic growth and price stability.

[2] The details of the financial reforms in Malawi are documented by Chirwa & Mlachila (2004) and Ngalawa & Viegi (2011).

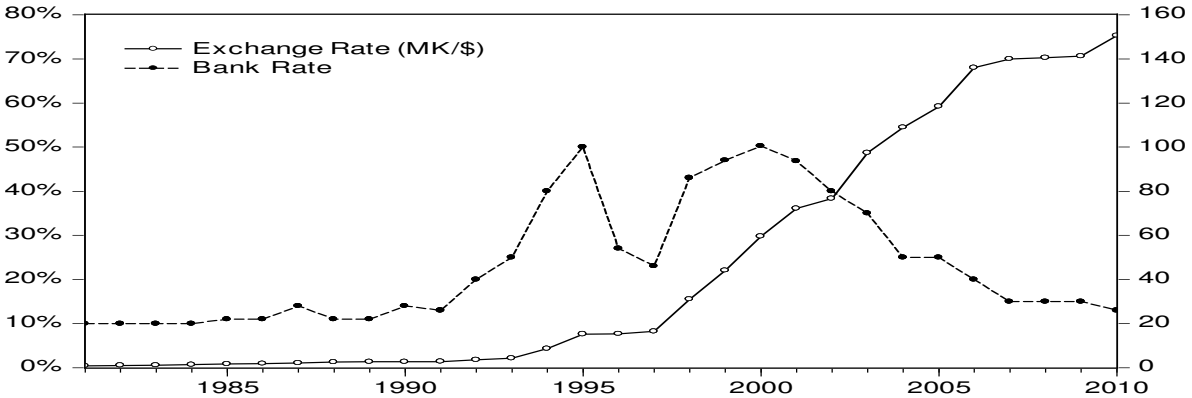
Figure 4: Trend of Bank Rate and Private Credit



Source: International Monetary Fund-International Financial Statistics from Quantec Easy Data

In Figure 14, movement in the Malawi Kwacha per US dollar seems to have followed the bank rate until 2004. However, low interest rate tends to be followed by a depreciation of the local currency since 2003 and this runs against the theoretical understanding of positive relationship between interest rate and exchange rate. Researchers have argued that the local currency was deemed overvalued to the exchange rate as explained by Munthali *et al.* (2010). Empirically, it has been found that exchange rate channel is particularly important in a flexible exchange rate (Christensen, 2011). For instance, the paper argue that monetary expansion would tend to reduce the real interest rate and lead to the devaluation of the currency, which would increase exports , reduce imports and thereby boost aggregate demand. Compounded with limited timely statistics and information about the health of the economy, devaluation has been shown to be an early indicator of monetary conditions and inflation pressures. This condition seems to exist when Malawi devalued its currency more than 50% in 2012, inflation has been skyrocketing from single digits in 2006 – 2010 to around 30% in 2012. This recent outcome shows that exchange rate shocks can have a strong effect on inflation in Malawi and volatility in the shocks may likely change overtime. Therefore, expansion of broad money in line with nominal GDP and exchange rate stability are significant factors to curb inflation in Malawi.

Figure 5: Bank Rate and Exchange Rate in Malawi



Source: International Monetary Fund-International Financial Statistics from Quantec Easy Data

3 Econometric Methodology

A survey by Mishra and Montiel (2012) reveals that the VAR methods have commonly been used to investigate the monetary transmission mechanism in low-income countries including Malawi. Thus, we start by presenting the basic structural VAR model that describes the Malawi economy as follows:

$$Ay_t = Q_1 y_{t-1} + ... + Q_p y_{t-p} + u_t, \quad t = p+1,...,T. \tag{1}$$

In Equation 1, y_t presents a $n \times 1$ vector of observed Malawian variables, A and $Q_1,...,Q_p$ are $n \times n$ matrices of parameters, and $u_t \sim N(0, \Sigma_u)$ is a $n \times 1$ vector of structural shocks whereby

$$\Sigma = \begin{bmatrix} \sigma_1 & 0 & \cdots & 0 \\ 0 & \sigma_2 & \ddots & \vdots \\ \vdots & \ddots & \ddots & 0 \\ 0 & \cdots & 0 & \sigma_n \end{bmatrix} \tag{2}$$

We specify the simulations relation of the structural shock by recursive identification, assuming that A is a lower triangular matrix with the diagonal elements equal to one:

$$A = \begin{bmatrix} 1 & 0 & \cdots & 0 \\ \alpha_{2,1} & 1 & \ddots & \vdots \\ \vdots & \ddots & \ddots & 0 \\ \alpha_{n,1} & \cdots & \alpha_{n,n-1} & 1 \end{bmatrix} \tag{3}$$

Literature reveals that Equation 1 has problem of uniquely determining the value of the parameters in the model because the coefficients are unknown and the variables may have contemporaneous effects on each other (Bredin and O'Reilly (2004). To allow estimation of the parameters, we re-specify Equation 1 as the reduced form VAR model as follows:

$$y_t = B_1 y_{t-1} + ... + B_p y_{t-p} + A^{-1}\Sigma_t \varepsilon_t, \quad \varepsilon_t \sim N(0, I_n) \tag{4}$$

In Equation 4, $B_i = A^{-1}Q_i$ for, $i = 1,..., p$. Further, we define B as a stacked row of $B_1, \ldots, B_n$ to obtain a reduced form representation:

$$y_t = X_t B + A^{-1}\Sigma\varepsilon_t \tag{5}$$

where $X_t = I_n \otimes \left[1, y_{t-1}^{'}, \ldots, y_{t-p}^{'}\right]$ and $\otimes$ is the Kronecker product. All parameters do not vary overtime.

Following Primiceri (2005), Koop *et al*. (2009) and Nakajima (2011) and discussions in section 1 and 2, we now assume that all parameters (B, A, Σ) change overtime. Then, we re-specify Equation 4 and 5 as follows:

$$y_t = B_{1t} y_{t-1} + ... + B_{pt} y_{t-p} + e_t, \quad e_t \sim N(0, \Phi_t) \tag{6}$$

$$y_t = X_t B_t + e_t, \qquad t = p+1,..., n \tag{7}$$

where y_t is a $(k \times 1)$ vector of observed variables. $B_{1t},..., B_{pt}$ are $(k \times k)$ time varying coefficients. Φ_t is $(k \times k)$ time varying covariance matrix. Assuming a recursive identification and a decomposition of a $\Phi_t = A_t^{-1}\Sigma_t\Sigma_t A_t^{\prime -1}$ where A_t is the lower triangular matrix with diagonal elements equal to 1 and Σ_t is a diagonal matrix containing standard deviations of the structural shocks. X_t remains as defined in equation 5. All parameters do not vary overtime. B_t is also defined as a stacked row vector of $B_{1t},..., B_{pt}$, a_t is a stacked row vector of the free lower-triangular elements in A_t and define elements $x_{jt} = \log \sigma_{jt}$ for $j = 1,..., n$ in a stacked vector of $x_t = (x_{1t}, \ldots, x_{nt})$. The time-varying parameters are assumed to follow a random walk process (Nakajima, 2011; Primiceri, 2005):

$$B_t = B_{t-1} + \nu_t \qquad \begin{pmatrix} \varepsilon_t \\ \nu_t \\ \xi_t \\ \eta_t \end{pmatrix} \sim N\left(0, \begin{pmatrix} I_n & 0 & 0 & 0 \\ 0 & \Sigma_B & 0 & 0 \\ 0 & 0 & \Sigma_\alpha & 0 \\ 0 & 0 & 0 & \Sigma_x \end{pmatrix}\right) \qquad (8)$$
$$\alpha_t = \alpha_{t-1} + \xi_t$$
$$x_t = x_{t-1} + \eta_t$$

for $t = p+1,...,n$, with $e_t = A_t^{-1}\Sigma_t \varepsilon_t$ where I_n is the identity matrix of n dimensions, while Σ_B Σ_α and Σ_x are positive definite matrices. In this matrix, the shocks are uncorrelated among the time-varying parameters. The covariance matrices Σ_α and Σ_x are assumed to be diagonal. We treat the time-varying parameters as latent variables and Equations 7 and 8 form a state space specification. As in Nakajima, Kasiya and Watanabe (2009), we assume that the initial states for the time-varying parameters are $B_{p+1} \sim N(\upsilon_{\beta_0}, \Sigma_{\beta_0})$, $\alpha_{p+1} \sim N(\upsilon_{\alpha_0}, \Sigma_{\alpha_0})$ and $x_{p+1} \sim N(\upsilon_{x_0}, \Sigma_{x_0})$.

As you can see from the model, the estimation of the TVP-VAR model with stochastic volatility will involve estimating a number of parameters. In addition, the inclusion of the stochastic volatility in the model makes the estimation difficult due to the intractability of the likelihood function (Peretti *et al*., 2012). As discussed in Koop and Korobilis (2010) the concern about over-parameterisation makes it difficult to obtain precise estimates of the parameters and impulse responses. To circumvent this problem, we estimate this TVP-VAR model using the Bayesian inference methodology via the Markov Chain Monte Carlo (MCMC) methods. As argued in many studies, the Bayesian inference methodology allows the splitting of the original estimation problem into smaller ones in order to deal efficiently with high dimension of the parameter space and the nonlinearities of the model (Primiceri, 2005; Nakajima, 2011; Banerjee and Malik, 2012). By incorporating the MCMC algorithm, we are able to assess the joint posterior distributions of the parameters that are of interest under certain priors that are set in advance. Banerjee and Malik (2012) also explains that the use of MCMC avoids the issue of dimensionality because it essentially deals with recursively sampling from lower dimensional objects and helps to mitigate problems associated with parameter explosion.[3] We use the same priors as the one in Nakajima (2011), $\Sigma_\beta \sim IW(25, 0.01I)$, $(\Sigma_a)_i^{-2} \sim Gamma(4, 0.02)$ and $(\Sigma_h)_i^{-2} \sim Gamma(4, 0.02)$ where IW

[3] For full derivation of the model, the conduct of the MCMC algorithm and the choice of priors, see Nakajima (2011), Koop and Kolobilis (2010) and Primiceri (2005).

denotes the invert Wishart distribution, $(\Sigma_a)_i^{-2}$ and $(\Sigma_h)_i^{-2}$ represents the $i = th$ diagonal elements of the matrices. Finally the initial set of the time-varying parameters, we use the flat priors such that $u_{\beta 0} = u_{a0} = u_{h0} = 0$ and $\Sigma_{\beta 0} = \Sigma_{a0} = \Sigma_{h0} = 10 \times I$.

4 Data

Data used in this study were obtained from International Financial Statistics of the International Monetary Fund (IFS-IMF) under Quantec Easy Data website. Gaps in the data were filled by domestic official publication of the Reserve Bank of Malawi (RBM) and the Government of Malawi. The dataset consists of quarterly observations and the sample spans from 1981:1 to 2010:4. Data used include GDP which measures the economic activities, CPI measures the price level, the bank rate which measures the short term interest rate. Other variables include exchange rate defined as Malawi Kwacha per US dollar and private credit which measures the financial development activity. Real gross domestic product data is annually recorded hence we generated quarterly data using quarterly data on money. We take the natural logarithms of all variables except bank rate and data is seasonally adjusted using the TRAMO and SEATS as done in Ngalawa and Viegi (2011). We also factored out price effects to come up with real interest rate. List of the data and their sources are provided in Table 1.

Table 1: Key Variables Used in the Analysis

Variable	Details	Source
BR	Bank Rate	IMF-IFS, Quantec Easy Data
LP	Log consumer price index	IMF-IFS, Quantec Easy Data
LEX	Log exchange rate	IMF-IFS, Quantec Easy Data
LPC	Log private credit	IMF-IFS, Quantec Easy Data
RY	Log gross domestic product constant price	World Bank, Quantec Easy Data

As indicated in Table 2, all macroeconomic variables used in the estimation are tested for the stationarity using the Augmented Dickey- Fuller (ADF) test (1981), Phillips-Perron test (1988) and Kwiatkowski (KPSS) test (1992). The stable TVP-VAR is estimated based on 1 lag resulting from the popular lag length tests which include the sequential modified LR test statistic, the Akaike information criterion, the Schwarz information criterion, applied to the constant parameter VAR.

Table 2: Testing for Stationarity

Variables	ADF		PP		KPSS	
	Level	Differenced	Level	Differenced	Level	Differenced
Bank Rate (BR)	-1.882	-12.954***	-1.882	-12.945***	1.293	0.155***
Prices (P)	-1.036	-3.679***	-0.651	-8.632***	1.293	0.214***
Real Output (Y)	0.699	-3.169***	1.871	-3.893***	1.287	0.330***
Private Credit (PC)	-0.904	-10.947***	-0.646	-11.239***	0.285	0.050***
Exchange Rate (EX)	-0.757	-7.622***	-0.756	-7.665***	1.280	0.188***

Note: To test for unit root test, we use the intercept on bank rate, exchange rate, prices and real output with the critical value for the KPSS LM-Stat at 5% equal to 0.463 and use trend and intercept on private credit with the critical value of the KPSS LM-Stat at 5% equal to 0.146. The symbols *** denote significance at 1 % level, respectively.

All tests in Table 2 show that the variables are non-stationary in levels. After taking the first difference, the variables become stationary, indicating integration of order one $I(1)$. In the standard VAR, we used the variables in levels as argued by Sims *et al.* (1990). However, estimation of the TVP-VAR model uses annual growth rates of all variables except the bank rate. The VAR satisfy the stability conditions as no root lies outside the unit circle. To be consistent between the standard VAR model and the TVP-VAR model, one lag VAR estimation is used based on the stability of the two models.[4] Based on Bernanke and Blinder (1992) and Christian and Eichenbaum (1992), we order the variables in the Y vector of the VAR as $Y = (Y, P, EX, BR)$. Private credit is also augmented in the Y vector as $Y = (Y, P, PC, EX, BR)$. We place real output and prices before the policy variables in a VAR because this standard recursive identification structure has strong theoretical foundation that real output and prices are unlikely to react immediately to bank rate shocks (Hoppner, Melzer and Neumann, 2008). The bank rate changes will only affect real output and prices with a lag. This ordering was also employed by Ngalawa and Viegi (2011) in their study on the dynamic effects of monetary policy shocks in Malawi.

5 Empirical Results

This section discusses the responses to monetary policy, exchange rate shocks and effects of credit shocks. In each case, we compare the results of the TVP-VAR with stochastic volatility with the standard VAR model. First, four variables including real output (Y), prices (P), exchange rate (EX) and bank rate (BR) are estimated in a standard VAR and TVP-VAR model. Then, we augment the model with the private credit (PC) and compare the

[4] The stability test and lag length test results are available from the authors upon request.

performances of these monetary transmission channels during and after the financial reform period.[5]

5.1 Posterior Estimates for Stochastic Volatility of the Structural Shocks and Simultaneous Relationship

Table 3 shows the estimated results for the posterior means, standard deviations, the 95 per cent credible intervals, the convergence diagnostics of Geweke and the inefficiency factors which are estimated using MCMC sample. Note that in this paper we do not use confidence intervals as in the frequentist approach do, we use 95 per cent credible intervals for Bayesian inferences to describe the uncertainty of the parameters. In our estimation, we draw M = 10,000 samples with the initial 1000 samples discarded. In the estimated results the null hypothesis for the convergence of the posterior distributions is not rejected as all the Geweke results are greater than 5 per cent level of significance. The results also indicate an efficient sampling as the inefficiency factors are below 100.

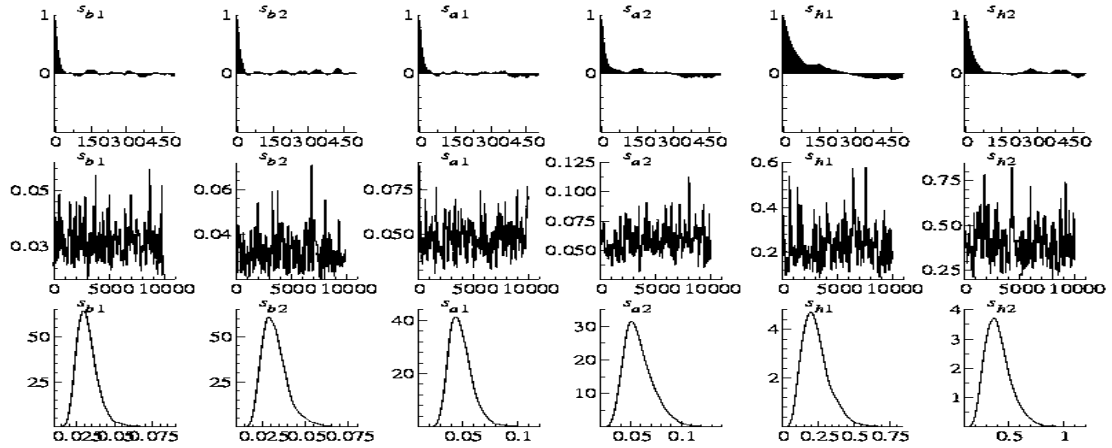
Table 3: Estimation of Selected Parameters in the TVP-VAR Model

Parameter	Mean	Stdev	95% Interval		Geweke	Inefficiency
sb1	0.0324	0.0073	0.0212	0.0491	0.065	24.97
sb2	0.0285	0.0055	0.0202	0.0417	0.266	11.78
sa1	0.0821	0.0312	0.0432	0.1619	0.169	39.34
sa2	0.0742	0.0231	0.0416	0.1290	0.157	35.78
sh1	0.5582	0.1469	0.3224	0.8864	0.248	28.29
sh2	0.5108	0.1167	0.3199	0.7751	0.945	37.75

Figure 6 shows the sample autocorrelation represented by the first panel, sample paths represented by the second panel and posterior densities for selected parameters. Discarding 1000 samples in the burn-in period, the sample paths appear stable as the sample autocorrelations drop steadily. As in Nakajima (2011), this shows that our sampling method efficiently produces samples with minimal autocorrelation.

[5] The results of the posterior estimates for stochastic volatility of the structural shocks when credit is augmented in the baseline are shown in Annex 1 and 2.

Figure 6: Sample Autocorrelation, Sample Paths and Posterior Densities for Selected Parameters

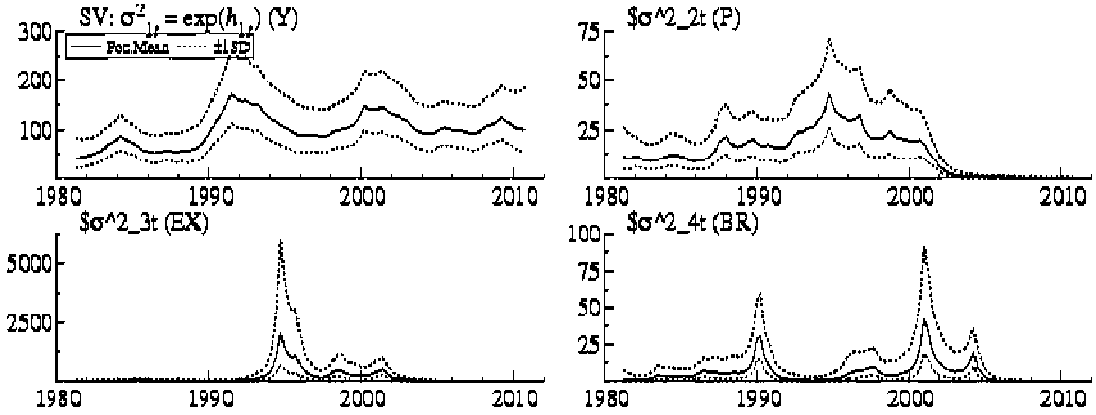


The posterior means of stochastic volatility of real output (Y), prices (P), exchange rate (EX) and bank rate (BR) changes are shown in Figure 7. The panel depicts the dynamic of the volatility over time, which differs across variables. The stochastic volatility of bank rate shows a relatively higher volatility in 1990 which started towards the end of 1980. Beginning 1987, Malawi liberalised the market interest rates which trended upwards until 1994 and 1995. In addition, between 1992 and 1994 Malawi adopted multiparty system of government which brought about changes in economic policies, such as the adoption of free floating exchange rate regime in 1994. High spike in bank rate changes were experienced after 2000, while high spikes in inflation and economic growth started much earlier. By implication, the monetary authorities reacted to the continued volatility in the inflation and sluggish economic growth.

The stochastic volatility of all variables remains stable between 2005 and 2010, coinciding with the new elected government in 2004. As discussed in section 2, the stability of the transmission might be explained by government successfully implementing disciplined monetary and fiscal policies. In particular, good performance in the agricultural sector emanating from good rains and the implementation of the fertiliser subsidy programme boosted economic growth and price stability. Achieving meaningful growth and stable inflation rates led to downward trends and stable bank and market interest rates. The movement of exchange rates also exhibit a spike in 1990s due to changes in exchange rate policies. Government adopted the floating exchange rate regime in 1994 and this was followed by many devaluations bringing about much exchange rate instability. Therefore, the

use of time-varying stochastic volatility will contribute to the VAR estimation and the identification of the structural shock with the appropriate variance of the shock (Nakajima, Kasiya and Watanabe, 2009).

Figure 7: Posterior Estimates for Stochastic Volatility of Structural Shocks



Note: Graphs are the postrior mean(solid) line and 95 percent crediable intervals (dotted line) for stochastic volatility.

5.2 Responses to Monetary Policy Shocks

In the standard interest rate transmission mechanism, Mishkin (1995) posits that the tightening of monetary policy leads to a rise in market interest rates which in turn raises the cost of capital, implying a decline in aggregate demand through decline in investment expenditures and hence a fall in output and general prices. Empirically, however, the basic standard of interest rate transmission mechanism has yielded different results (Mishra and Montiel, 2012). Using the standard VAR model for the case of Malawi as provided in Figure 8, Chart 1, a one standard deviation rise in the bank rate leads to the decline in output as postulated by economic theory. However, the response of output to bank rate shock is statistically insignificant at 95% confidence interval within the first 5 quarters. The effect is not immediate as it becomes significant almost after 5 quarters, indicating that the monetary policy does not have any contemporaneous effect on output as argued by Christiano *et al*., (1999), Bernanke and Blinder (1992) and Bredin and O'Reilly (2004).

In terms of the effects on general price, we observe the 'price puzzle' as generally found in many studies documented on Low-Income countries over the past two decades by Mishra and Montiel (2012). On the other hand, an increase in the bank rate in Malawi has short lived limited effect of appreciation of the exchange rate. Empirically, the VAR results are consistent with the evidence found in Lungu (2008) using a VAR model and Ngalawa and

Viegi (2011) employing the SVAR model to analyse the dynamic effects of monetary shocks in Malawi. The existence of price puzzle and non-effects on exchange rate cast doubts on the relevance of findings from the VAR model. One possible suggestion is that modelling the transmission mechanism for Malawi requires further investigation. As discussed in section 2, the economy behaved differently before and after the financial reforms. Thus, changes in the structural macroeconomic relationships and the behaviour of policy makers could have influenced transmission mechanism overtime (Catik and Martin, 2012).

The effects of a positive bank rate shock on real output and inflation was estimated using the TVP-VAR model with stochastic volatility. The impulse response functions are presented in Figure 8, Chart 2 and 3. Chart 2 represents the accumulated impulse response at several horizons of real output, price level and nominal effective exchange rate to a bank rate shock as it evolves over the estimation period. In each graph accumulated impulse responses are drawn at horizon of 1 year, 2 years and 3 years evolving over the estimation period, respectively. A one percentage point positive bank rate shock leads to non-effect in real output until 2000. However, we observe positive response of output to real bank rate changes after the post period of financial reforms. Interest rates declined during this period as reflected in the response of bank rate to its own shock. However, other factors such as changes in the institutional policies (fertiliser subsidy programme) influenced a positive increase in real output. With regard to price level responses, we observe the non-existence of 'price puzzle' and the effects of bank rate become clear in the post era of the reforms. In the case of exchange rate reaction to a bank rate shock, the TVP-VAR results reveal an appreciation of the exchange rate and the effects are more pronounced after implementing the reforms.

Chart 3 on the other hand demonstrates how the responses of output, prices and exchange rate have behaved in different periods which are chosen arbitrary to capture important episodes of economic and political events in the Malawi economy. The 1987 and 1995 captures the time when Malawi abandoned repressive monetary policies and experienced frequent devaluations following the adoption of flexible exchange rate regime in 1994, respectively. A period between 1995 and 2010 captures the post era of financial reforms and the time when new governments came into power. The results in this chart indicate that the transmission mechanism performed differently overtime. We observe that the positive bank rate shock is followed by the negative response of prices contrary to what was found in the standard VAR

and other empirical studies by Lungu (2008) and Ngalawa and Viegi (2011). The effects on prices are more prominent after the reforms reflecting the positive lag effects of financial reforms. The response on output to a positive bank rate shock is negative in all the periods as postulated by theory but more prominent in the post reform period. The positive bank rate shock leads to the depreciation of exchange rate. However, the exchange rate depreciation is minor in the post period of reforms and immediately depreciates after 1 quarter as expected. The effect of exchange rate shock on output and inflation will be discussed fully in 3.5.3.

Thus, the TVP-VAR model demonstrates that interest transmission mechanism on prices and exchange rate performed differently overtime. Although the paper finds that transmission mechanism improves with the implementation of financial reforms, the financial environment is still characterised with weak legal systems, poor governance, and insufficient financial infrastructure (RBM, 2012). These factors have contributed to high interest rate spread (Chirwa & Mlachila, 2004), inadequate financial intermediation and a large informal financial market (Chipeta & Mkandawire, 1991; Ngalawa & Viegi, 2010).

Figure 8: Standard VAR and TVP-VAR Impulse Responses to a Positive Bank Rate Shock

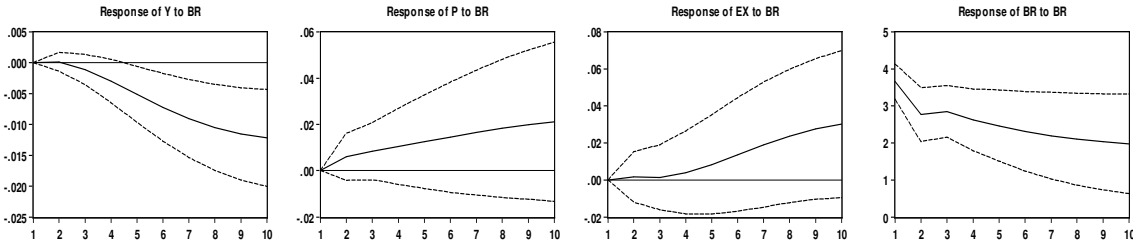


Chart 1: Unrestricted standard VAR impulses with dotted lines indicating 95% confidence intervals

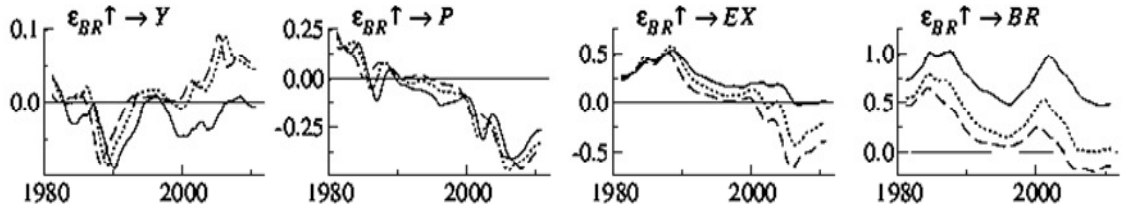


Chart 2: TVP-VAR impulses after 1 year (——), 2 years (- - - - -) and 3 years (– – –) ahead

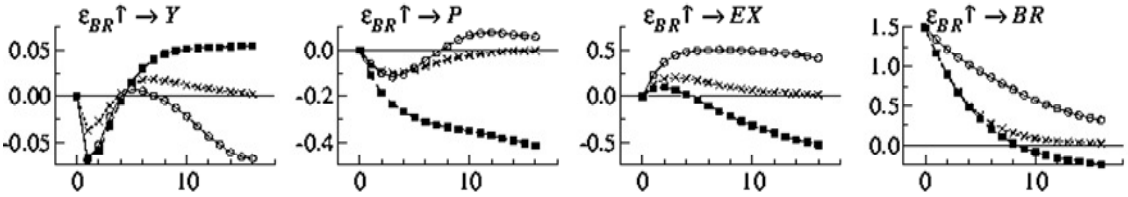


Chart 3: TVP-VAR impulses in 1987:Q1 (—o—), 1995:Q1 (- -x- -) and 2010:Q1 (—■—) one standard-deviation bands

5.3 Responses to Exchange Rate Shocks

On the supply side, exchange rate shocks tend to feed directly into domestic prices of imported goods and services and indirectly through to the prices of goods and services that uses the imported goods. While on the demand side, exchange rate movements influences demand for domestically produced goods and services and hence affects the net exports. In turn, aggregate demand is affected and this impact the uptake of production inputs such as wages. Hence through this channel, exchange rate movements affect inflation. As argued by Franta *et al*. (2011), exchange rate movements affects output through expenditure switching which affects net exports and also through real interest rate changes which affects investment expenditure and hence real output. However, the importance of this exchange rate channel in the monetary transmission mechanism depends on the nature of exchange rate regime, the market structure and product substitutability (Vinh and Fujita, 2007; Aleem, 2010). Therefore, empirical investigations have revealed mixed reaction of inflation and output following exchange rate shocks. A paper by Vinh and Fujita (2007) provide a well-documented empirical literature about these effects. Accordingly, for the case of Malawi where the exchange rate regime has remained de facto coupled with capital controls and the monetary authorities have some room of intervention, we expect high mixed responses of output and inflation following a positive exchange rate shock.

The standard VAR model results in Figure 9, Chart 1 show that output increases significantly following a depreciation of the exchange rate and the effects on prices are significant. The results of the TVP-VAR model with stochastic volatility presented in Figure 9, Chart 2 and 3 show that the effects of positive exchange rate shock on output and inflation varied overtime. Although the responses of output still remain unclear as the impulses oscillate around zero line overtime in Chart 2, Chart 3 indicates that output increases following a depreciation of exchange rate in Malawi. Depreciation is also inflationary and there is high exchange rate pass through to prices and is more persistent in the post period of financial reforms. Malawi depends heavily on imports mainly fertiliser and oil used in the production process and as a landlocked country transport costs are also very high. Thus, depreciation shocks on exchange rate will immediately feed into the prices of goods and services that use imported inputs. Most interestingly, the effects on prices are prominent in all horizons after the reform period.

Chart 3, also shows that the transmission mechanism through the exchange rate channel was more pronounced during the financial reform. Malawi adopted the free floating exchange rate

regime which was followed by many episodes of devaluations especially after 1994 which led to government reverting to the fixed exchange rate. However fixed exchange rate did not last long and government adopted a floating exchange rate again in 1998. It is also observed that depreciation had short lived positive effect on output and inflation pressures contrary to the good macroeconomic condition in the country during the later years of post-financial reform period (2004Q1-2010Q1). The country experienced high economic growth and stable nominal exchange rate fluctuations. Researchers have argued that the disparity comes about because of the overvaluation and management of the exchange rate (see IMF, 2012; Munthali *et al.*, 2010). Nevertheless, the result shows that the exchange rate pass-through is relatively strong and quick in Malawi agreeing with findings by Ngalawa and Viegi (2011), Simwaka *et al*. (2012), and Lungu *et al*. (2012).

Figure 9: Standard VAR and TVP-VAR Impulse Response to a Positive Exchange Rate Shock

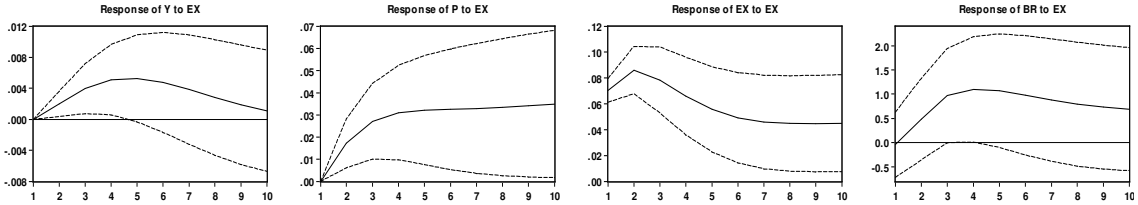


Chart 1: Unrestricted standard VAR impulses with dotted lines indicating 95% confidence intervals

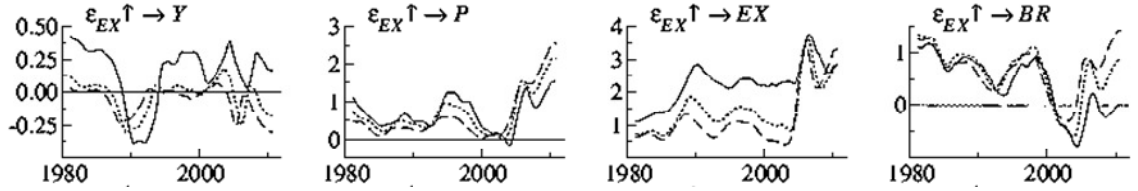


Chart 2: TVP-VAR impulses after 1 year (———), 2 years (- - - - -) and 3 years (– – –) ahead

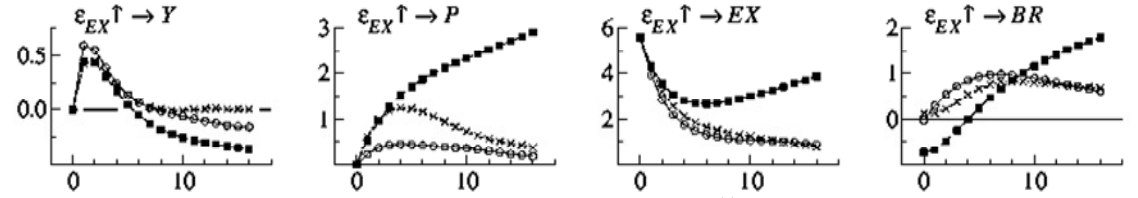


Chart 3: TVP-VAR impulses in 1987:Q1 (—⊖—), 1995:Q1 (- -x- -) and 2010:Q1 (—■—) one standard-deviation bands

5.4 Responses to Private Credit Shocks

Figure 10, Chart 1, 2 and 3 depict the dynamic responses of bank rate, exchange rate, output and prices to unexpected positive credit shock in a standard VAR and TVP-VAR model, respectively. Discussions are based on the bank lending channel mechanism, working

through the conditions of supply of banks loans as fully explained by Bernanke and Gertler (1995) and Ireland (2005). In the standard VAR model in Chart 1, a positive shock on credit does not lead to immediate positive reactions on output and prices. The responses on output are positive after 3 quarters and prices respond negatively to credit shock. However, the responses are not significant and the negative response on prices to one standard positive credit shock contradicts what was found by Ngalawa and Viegi (2011). In addition, a positive shock on credit induces exchange rate depreciation. As pointed out by Ngalawa and Viegi, 2011, Malawi depends heavily on fertiliser and fuel imports in the production process. Hence, the increased credit might have increased demand for imports which might have influenced exchange rate depreciation.

Nevertheless, Chart 2 and 3 of the TVP-VAR model estimation results tell us much variation of responses following a one standard positive private credit shock. In Chart 2, response of output is positive in one year ahead as expected but the effects diminish with time. The effects picks up in the latter part of the sample with minor positive effects on output in the long run period. A positive private sector credit shock is inflationary but the effects vary over time. The effects on prices dampen in the later years of the sample. However, the exchange rate appreciates in the post period of financial reforms inconsistent with theoretical expectations. The results in Chart 3 also demonstrate that responses varied over time. In particular, the responses become clearer in the latter years of post-financial reforms, though with limited effects.

Moreover, results show that the private loan supply effect remains weak in Malawi. As explained in section 2, the importance of the credit channel for monetary transmission has been negatively affected by the upward trend in liquidity reserve requirements during the financial reform period. In addition, the economy is characterised with large informal credit markets (Chipeta and Mkandawire, 1991; Ngalawa and Viegi, 2010). Hence tighter monetary policies might divert demand to the large informal credit sector and so lead to a sharp rise on the cost of credit. Other important issue to note is the beneficiaries of credit. The results show that private sector credit drives demand other than production because the effects on real output are limited. In addition changes in the financial structure are still limited. For instance, the banks are still not offering facilities such as credit cards. Thus, the effects of credit shocks seems to be less persistent overtime and this calls for more financial reforms targeting the

credit market which can contribute to monetary transmission and promote further economic growth in Malawi.

Figure 10: Standard VAR and TVP-VAR Impulse Responses to a Positive Private Credit Shock

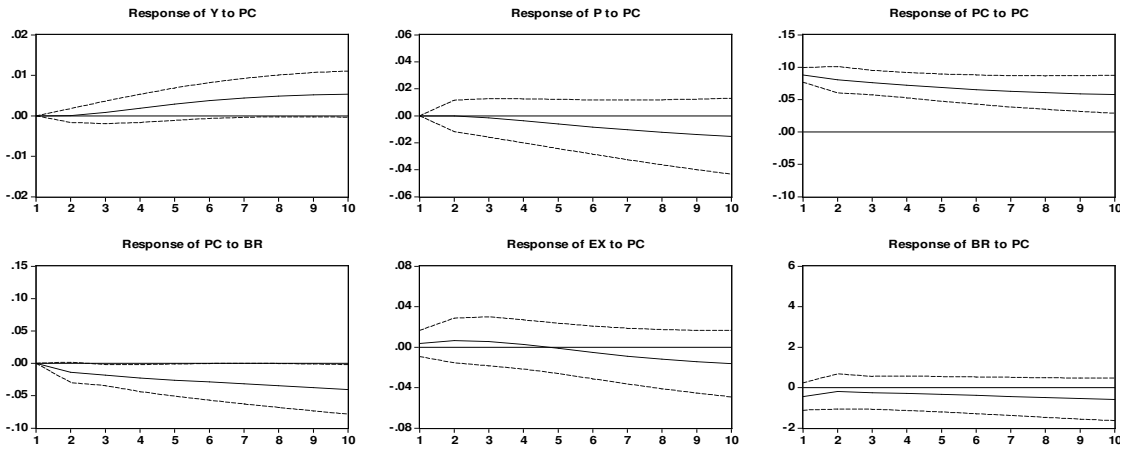


Chart 1: Unrestricted standard VAR impulses with dotted lines indicating 95% confidence intervals

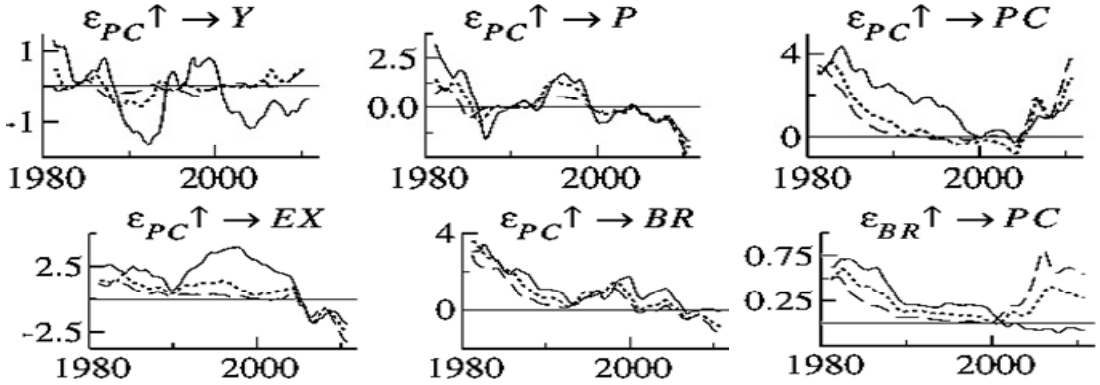


Chart 2: TVP-VAR impulses after 1 year (——), 2 years (- - - - -) and 3 years (– – –) ahead

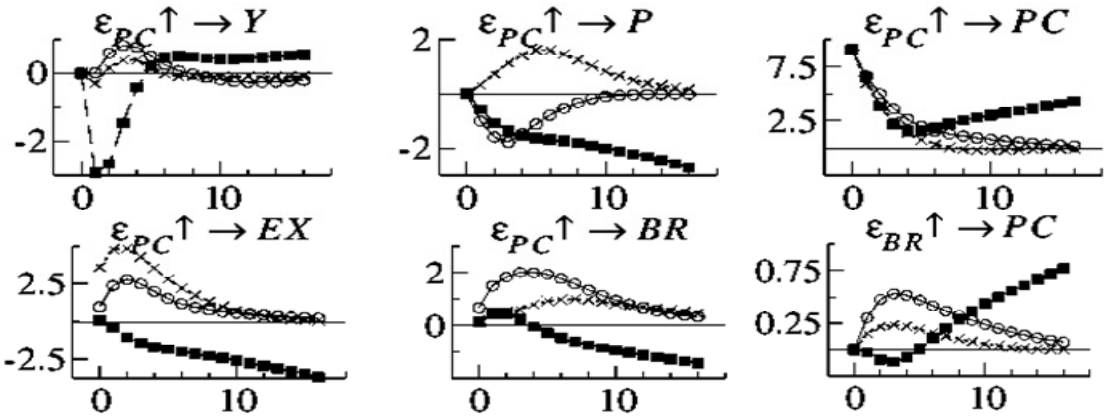


Chart 3: TVP-VAR impulses in 1987:Q1 (—o—), 1995:Q1 (--x--) and 2010:Q1 (—■—) one standard-deviation bands

6 Conclusion

This paper has attempted to estimate an empirical macroeconomic model of Malawi that generates changes in output and price level in response to bank rate, exchange rate and private credit shocks. On the understanding that Malawi implemented financial reforms between 1988 and 1994 and continued efforts in improving the financial sector until 2010, we estimate a TVP-VAR model with stochastic volatility that allows us to capture the variation of macroeconomic structure and the changes in the transmission mechanism overtime. Combined with Bayesian econometric techniques enable us to estimate whether, where, when and how the transmission mechanism has been changing over time. In particular, this model is used to estimate and calculate the impulse responses of output and price level to financial and monetary policy shocks overtime.

Using the TVP-VAR model results, the paper demonstrates that the transmission mechanism changed markedly following the financial reforms. In particular, our empirical results of the impulse response show that in the prior years of the financial reforms, the transmission mechanisms are not clear and provide more puzzles than answers. The changes in the transmission mechanism were volatile during the financial reforms as this period was also faced with high inflation, natural shocks and political changes. However, the changes in the transmission mechanism became clear starting from 2000. Specifically, the monetary policy transmission performed consistently with predictions of economic theory and there is no evidence of price puzzle as found in the previous literature on Malawi. However, the transmission mechanism through the credit channel remains weak and this calls for more financial innovation, especially in improving the credit market system that is viable for economic growth.

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Annex 1: Estimation of selected parameters in the TVP-VAR model including private credit

Parameter	Mean	Stdev	95% Interval		Geweke	Inefficiency
sb1	0.0522	0.0148	0.0313	0.0886	0.491	33.09
sb2	0.0582	0.0175	0.0330	0.1003	0.460	34.17
sa1	0.0506	0.0128	0.0335	0.0766	0.051	23.68
sa2	0.0845	0.0343	0.0420	0.1773	0.286	81.44
sh1	0.2506	0.1001	0.0990	0.4678	0.470	86.61
sh2	0.4562	0.1276	0.2560	0.7620	0.655	36.12

Annex 2: Sample autocorrelation, sample paths and posterior densities for selected parameters including private credit