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# Evolution of Monetary Policy Transmission Mechanism in Malawi: A TVP-VAR with Stochastic Volatility 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 have 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 a 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:** Transmission Mechanism, Price Puzzle, Financial Reforms, Bayesian TVP-VAR

## 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

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the 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. Specifically, 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.<sup>1</sup>

Prominent works by McKinnon (1973), Shaw (1973) and Levine (2005) 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 financial reform packages 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 both 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 in 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 regarding 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 Autoregression (VAR) frameworks in their analysis following a breakthrough seminal work by Sims (1980). Some of the most prominent 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, Horvath and Rusnak (2013) 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;

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<sup>1</sup>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.

Bernanke, Boivin and Ehasz, 2005; Cogley and Sargent, 2005; Sims and Zha, 2006; Koop, Leon-Gonzalez and Strachan, 2009; Korobilis, 2013).

In recent times, empirical researchers have developed the TVP-VAR models to address the time varying aspects 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) agree with Cogley and Sargent (2005) that the transmission mechanism may not be constant overtime and the way the exogenous shocks are generated can change overtime. Primiceri (2005), Nakajima (2011) and Franta *et al.* (2013) all confirm the changes of shocks over time and the volatility of transmission mechanism in USA, Japanese economy and Czech Republic, respectively.

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, quantitatively measuring monetary transmission mechanism using Bayesian TVP-VAR in Sub-Saharan African countries. A recent empirical survey by Mishra and Montiel (2012) documents studies on effective monetary transmission in Low-Income Countries but finds no study using the TVP-VAR framework with stochastic volatility on Sub-Saharan African countries. Although not directly related to this study, 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 rates 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's monetary policy transmission mechanism has primarily focused on the estimation of aggregate money demand relations in a single equation framework (Phiri, 2001), using VAR estimations (Mangani, 2010), using SVAR (Ngalawa and Vieg, 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 2, we provide a brief review of the monetary policy and other stylized facts about the transmission mechanism in Malawi. In section 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 4, we discuss the empirical results and section 5 concludes.

## 2 Brief Overview of Monetary Policy and Stylized Facts in Malawi

Ngalawa and Vieg (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 a brief overview of monetary policy in Malawi<sup>2</sup>. In general, the monetary framework can be categorised under three broad regimes: the repression period (1964-1986), the financial 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 the bank rate and reserve money as monetary policy targets. Recently, Ngalawa and Vieg (2011) evaluated the performance of these two targets and found the bank rate to be the more effective tool of monetary policy. In addition, the study suggests 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.

The change in Government in 2004 and the resumption of donor assistance in 2006 which had been discontinued in 2001 improved on the implementation of fiscal and monetary policy direction in Malawi. Adherence to international monetary fund programme also helped Malawi achieve fiscal and monetary consolidation after 2006 until 2010. As shown in Figure 1 and 2, inflation rates historically declined to single digits and economic growth hovered around 6%

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<sup>2</sup>For in depth details of monetary policy in Malawi since 1964 read Ngalawa and Vieg (2011).

on average. Specifically, Figure 1 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 during the financial reform period is unclear because the period was mired 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 2). The relationship between the bank rate, economic growth and inflation is very clear during the post financial reform era. The IMF country reports have shown that macroeconomic and all other financial and fiscal targets were almost kept on target based on the economic fundamentals during this period (IMF, 2010).

According to the interest channel, the monetary transmission mechanism is based on 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 3. 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 Vieg, 2013). For instance, Christensen (2011) argues that tighter monetary policy divert demand to large informal credit sector and 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.

Prior to financial reforms, RBM used instruments such as priority sector lending targets, especially to the agriculture sector<sup>3</sup>. In addition, in the initial stages of the reform government introduced cash reserve ratios which trended upwards until 2003. With the introduction of financial reforms in 1988, RBM began phasing out credit ceilings but its impact was countered by the upward trending of the liquidity reserve requirement. In the post reform, rapid expansion of the lending to the private sector occurred as shown in Figure 2. Quantitatively, annual credit growth increased from 38% revealed between January 2005 and September 2008 to 106% between September 2008 and April 2009, making it one of the highest credit growths in Africa (Christensen, 2011). 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.

In Figure 5, movement in the Malawi Kwacha per US dollar seems to have followed the bank rate until 2004. In addition, since 2003, low interest rate

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<sup>3</sup>The details of the financial reforms in Malawi are documented by Chirwa & Mlachila (2004) and Ngalawa & Vieg (2011).

tends to be followed by a depreciation of the local currency an observation that 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, Christensen (2011) found that the exchange rate channel is particularly important in a flexible exchange rate system. This study argues 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 inflation pressures and general monetary conditions. This was observed when Malawi devalued its currency by more than 50% in 2012, causing inflation to skyrocket from single digits between 2006 and 2010 to around 30% in 2012. This 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.

### 3 Econometric Methodology

Mishra and Montiel (2012) point to the popularity of VAR methods in the investigation of monetary transmission mechanism in low income countries. Thus, we start by presenting the basic structural VAR model that describes the Malawi economy as follows:

$$Ay_t = Q_1y_{t-1} + \dots + Q_p y_{t-p} + u_t, \quad t = p + 1, \dots, T \quad (1)$$

In Equation 1,  $y_t$  presents a  $n \times 1$  vector of observed Malawian variables,  $A$  and  $Q_1, \dots, Q_p$  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

$$\Sigma = \begin{bmatrix} \sigma_1 & 0 & \dots & 0 \\ 0 & \sigma_2 & \ddots & \vdots \\ \vdots & \ddots & \ddots & 0 \\ 0 & \dots & 0 & \sigma_n \end{bmatrix} \quad (2)$$

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:

$$A = \begin{bmatrix} 1 & 0 & \dots & 0 \\ \alpha_2 & 1 & \ddots & \vdots \\ \vdots & \ddots & \ddots & 0 \\ \alpha_{n,1} & \dots & \alpha_{n,n-1} & 1 \end{bmatrix} \quad (3)$$

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:

$$y_t = B_1 y_{t-1} + \dots + B_p y_{t-p} + A^{-1} \sum \varepsilon_t, \quad \varepsilon_t \sim N(0, \Phi_t) \quad (4)$$

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

$$y_t = X_t B + A^{-1} \sum \varepsilon_t \quad (5)$$

where  $X_t = I_n \otimes [1, y'_{t-1}, \dots, y'_{t-p}]$  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 ( $B, A, \Sigma$ ) change overtime. Then, we re-specify Equation 4 and 5 as follows:

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

$$y_t = X_t B_t + e_t, \quad t = p+1, \dots, n \quad (7)$$

where  $y_t$  is a  $(k \times 1)$  vector of observed variables.  $B_{1t}, \dots, B_{pt}$  are  $(k \times k)$  time varying coefficients.  $\Phi_t$  is  $(k \times k)$  time varying covariance matrix. Assuming a recursive identification and a decomposition of a  $\Phi_t = A_t^{-1} \Sigma_t \Sigma_t' A_t^{-1}$  where  $A_t$  is the lower triangular matrix with diagonal elements equal to 1 and  $\Sigma_t$  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  $B_{1t}, \dots, B_{pt}$ ,  $a_t$  is a stacked row vector of the free lower-triangular elements in  $A_t$  and define elements  $x_{jt} = \log \sigma_{jt}$  for  $j = 1, \dots, n$  in a stacked vector of  $x_t = (x_{1t}, \dots, x_{nt})$ . The time-varying parameters are assumed to follow a random walk process (Nakajima, 2011; Primiceri, 2005):

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

for  $t = p+1, \dots, n$ , with  $e_t = A_t^{-1} \Sigma_t \varepsilon_t$  where  $I_n$  is the identity matrix of  $n$  dimensions, while  $\Sigma_B \Sigma_\alpha$  and  $\Sigma_x$  are positive definite matrices. In this matrix, the shocks are uncorrelated among the time-varying parameters. The covariance matrices  $\Sigma_\alpha$  and  $\Sigma_x$  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  $B_{p+1} \sim N(v_{\beta_0}, \Sigma_{\beta_0})$ ,  $\alpha_{p+1} \sim N(v_{\alpha_0}, \Sigma_{\alpha_0})$  and  $x_{p+1} \sim N(v_{x_0}, \Sigma_{x_0})$ .

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.<sup>4</sup> 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  $IW$  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 using 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 level of financial development. Data on real gross domestic product (RGDP) is recorded on an annual basis. Therefore, quarterly data of RGDP is generated using quarterly data on money. With the exception of the bank rate, the natural log of all other variables is used and all data is seasonally adjusted using the TRAMO and SEATS as done in Ngalawa and Viegli (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.

As indicated in Table 2, all macroeconomic variables used in the estimation are tested for the stationarity using the Augmented Dickey- Fuller (ADF) test

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<sup>4</sup>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).

(1981), Phillips-Perron test (1988) and Kwaiatkowski (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.

All tests in Table 2 show that the variables are non-stationary in levels. After taking the first difference, the variables becomes 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 satisfies 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.<sup>5</sup> Following 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  $Y = (Y, P, PC, EX, BR)$ . Real output and prices are ordered 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.

## 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 private credit (PC) and compare the performances of these monetary transmission channels during and after the financial reform period.<sup>6</sup>

### 5.1 Posterior estimates for stochastic volatility of the structural shocks

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 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

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<sup>5</sup>The stability test and lag length test results are available from the authors upon request.

<sup>6</sup>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.

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.

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.

The posterior means of stochastic volatility of 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 mechanism 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 in bank and market interest rates. The movement of exchange rates also exhibited a spike in 1990s due to changes in exchange rate policies. The adoption of a floating exchange rate regime by the government in 1994 resulted in numerous devaluations which induced instability in the exchange rate. 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).

## 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 a 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 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 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 a 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 Viegli (2011) employing the SVAR model to analyse the dynamic effects of monetary shocks in Malawi. The existence of a price puzzle and non-effects on exchange rate cast doubts on the relevance of findings from the VAR model. One possible reason 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 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 and Mlachila, 2004), inadequate financial intermediation and a large informal financial market (Chipeta and Mkandawire, 1991; Ngalawa and Viegi, 2013).

### 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 into the prices of goods and services that uses the imported goods. While on the demand side, exchange rate movements influence demand for domestically produced goods and services and hence affects the net exports and aggregate demand. In turn, aggregate demand may influence inputs prices and wage demands. Changes in wages may result in domestic price changes. Hence through this channel, exchange rate movements affect inflation. As argued by Franta *et al.* (2013), 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 the 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.<sup>7</sup> 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

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<sup>7</sup>Vinh and Fujita (2007) provide a well-documented empirical literature about the effects of exchange rate on economic activities.

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 vary overtime. Although the responses of output still remain unclear as the impulses oscillate around the zero line overtime (see 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 which is more persistent in the post financial reforms period. 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 the 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 is more pronounced during the financial reform. Malawi adopted a free floating exchange rate regime but experienced many episodes of devaluations especially after 1994 which led to a reversion back to the fixed exchange rate. The reversion did not last long and government again adopted a managed floating exchange rate since 1998 until 2010. It is also observed that depreciation had a short lived positive effect on output and inflation pressures contrary to the good macroeconomic conditions that prevailed 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 movements. 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 Viegli (2011), Simwaka *et al.* (2012), and Lungu *et al.* (2012).

#### 5.4 Responses to Private Credit Shocks

Figure 10, Chart 1, 2 and 3 depict the dynamic responses of the 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 in output and prices. The output responses are positive after 3 quarters while 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 the findings of Ngalawa and Viegli (2011). In addition, a positive shock on credit induces exchange rate depreciation. As pointed out by Ngalawa and Viegli (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.

Chart 2 and 3 of the TVP-VAR model estimation results indicate 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 pick 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 are dampened in the later years of the sample. However, positive credit shock leads to the exchange rate appreciation in the post financial reforms period. The results in Chart 3 also demonstrate that responses varied over time. For instance, the responses of output was positive prior and during the financial reforms but became negative in the post period of the reforms. In addition, the positive shock on bank rate leads to a decline in private credit in the post period of financial reforms.

Moreover, the private loan supply effect in Malawi remains weak. 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 Vieg, 2013). 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.]

## 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 with 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. Applying Bayesian econometric techniques enabled us to estimate whether, where, when and how the transmission mechanism changed 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, the impulse response results show that in the pre financial reform period, the

transmission mechanisms are ambiguous and provide more puzzles than answers. The changes in the transmission mechanism were volatile during the financial reforms as this period was characterised by 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, with no evidence of a 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, a move which is critical for economic growth.

Lastly, this paper has argued that there were changes in the transmission mechanism in Malawi following the implementation of financial reforms and changes in the government policies emanating from changes in political regimes. To ascertain these findings, it would be interesting to assess individual transmission mechanisms in more details to assess how it has changed. This would require a more detailed and structural model such as the DSGE model which considers the theoretical aspects of the transmission mechanism than that used in this paper. We hope to address this in our future work.

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**Table 1: Key Variables Used in the Analysis**

Variable	Details	Source
BR	Bank Rate	IMF-IFS, Quantec Easy Data
P	Log consumer price index	IMF-IFS, Quantec Easy Data
EX	Log effective exchange rate	IMF-IFS, Quantec Easy Data
PC	Log private credit	IMF-IFS, Quantec Easy Data
Y	Log gross domestic product constant price	World Bank, Quantec Easy Data

**Table 2: Testing for Stationarity**

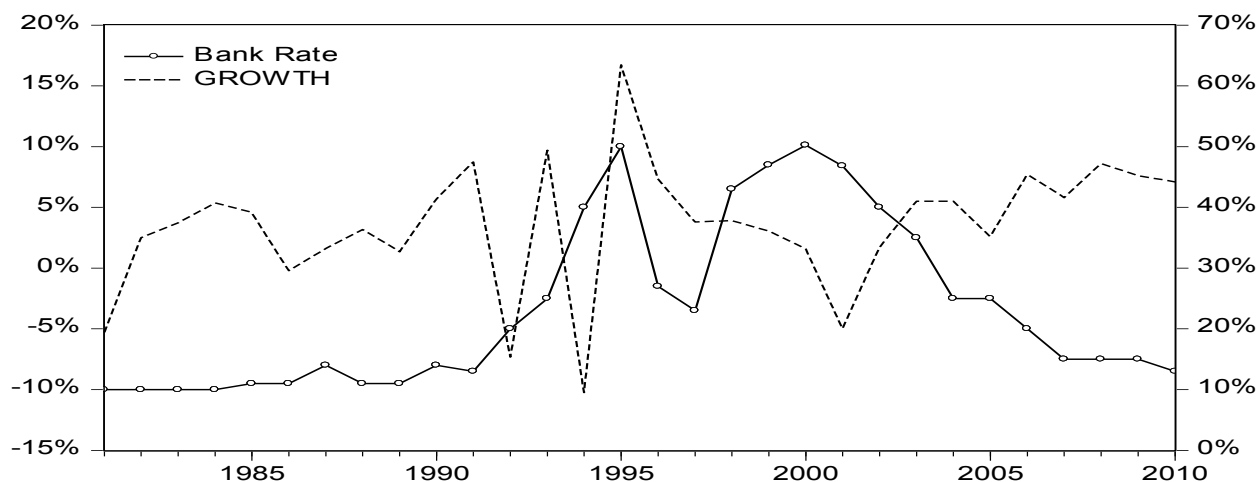
Variables	ADF		PP		KPSS	
	Level	Differenced	Level	Differenced	Level	Differenced
Bank Rate (BR)	-1.882	-12.954***	-1.882	-12.945***	0.588	0.155***
Prices (P)	-1.097	-3.750***	-0.693	-5.445***	1.293	0.238***
Real Output (Y)	0.773	-3.180***	-1.710	-3.961***	1.283	0.462**
Private Credit (PC)	-0.904	-10.947***	-0.646	-11.239***	0.285	0.050***
Exchange Rate (EX)	-2.406	-7.515***	-2.313	-7.561***	0.180	0.119**

**Note:** To test for unit root test, we use the intercept on bank 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 money, private credit and nominal effective exchange rate (NEER) with the critical value of the KPSS LM-Stat at 5% equal to 0.146. The symbols \*\*\* and \*\* denotes significance at 1 % and 5% level, respectively.

**Table 3: Estimation of selected parameters in the TVP-VAR model**

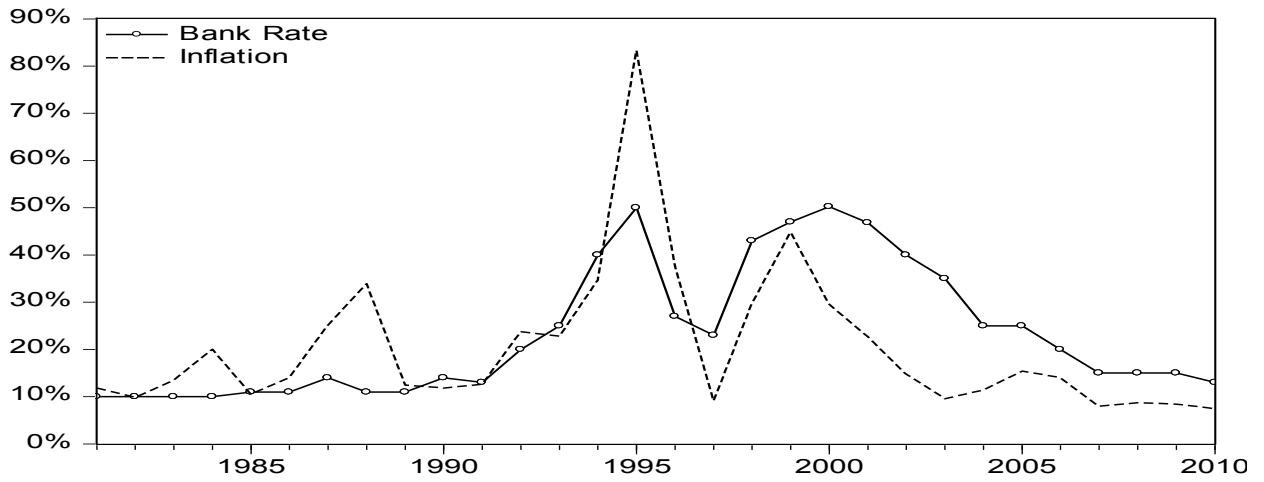
Parameter	Mean	Stdev	95% Interval		Geweke	Inefficiency
sb1	0.0321	0.0071	0.0216	0.0487	0.556	22.98
sb2	0.0324	0.0073	0.0215	0.0507	0.673	23.75
sa1	0.0486	0.0105	0.0323	0.0730	0.143	22.10
sa2	0.0582	0.0143	0.0366	0.0921	0.682	38.40
sh1	0.2358	0.0957	0.0957	0.4640	0.150	96.30
sh2	0.4055	0.1169	0.2286	0.6825	0.379	50.23

**Figure 1: Trend of Bank Rate and Growth**



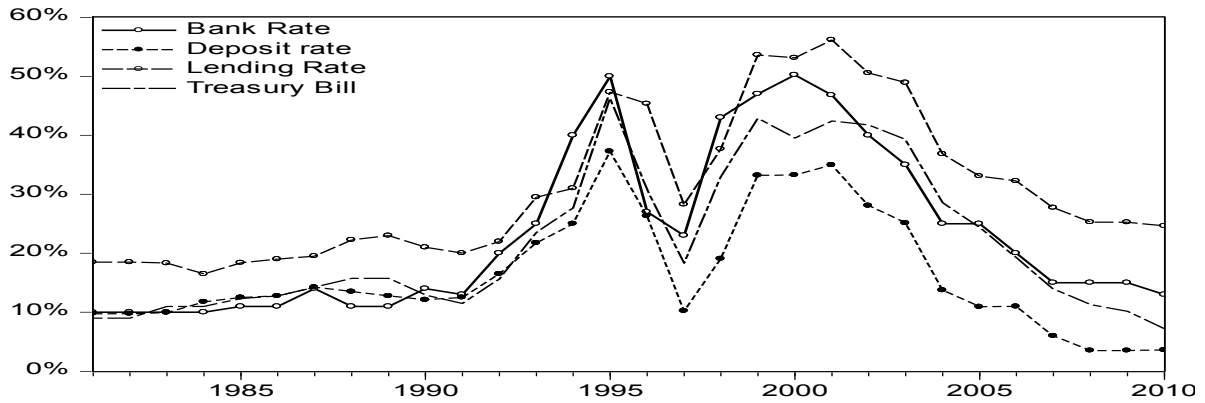
Source: International Monetary Fund-International Financial Statistics from Quantec Easydata

Figure 2: Bank Rate and Inflation in Malawi



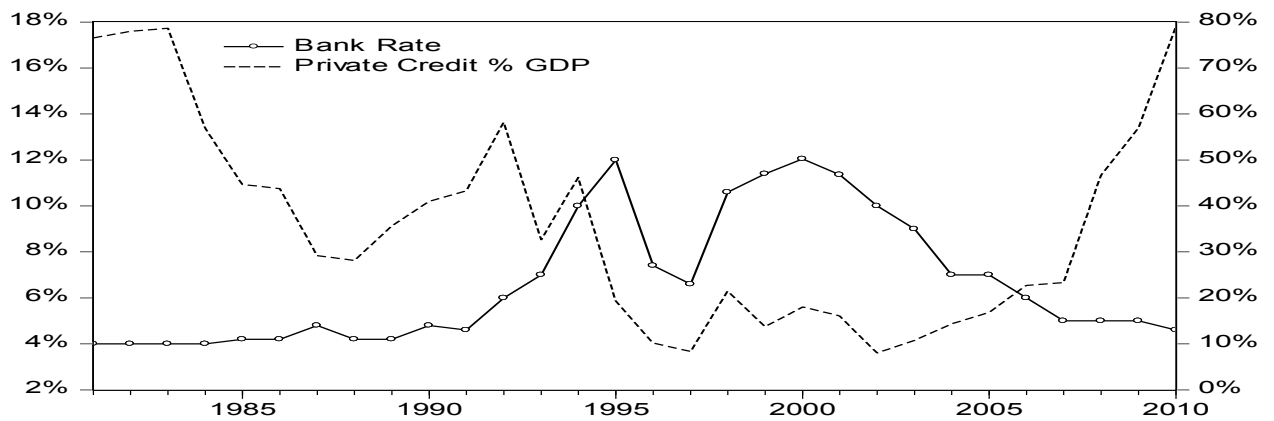
Source: International Monetary Fund-International Financial Statistics from Quantec Easy Data

Figure 3: Bank Rate and Key Market Rates in Malawi



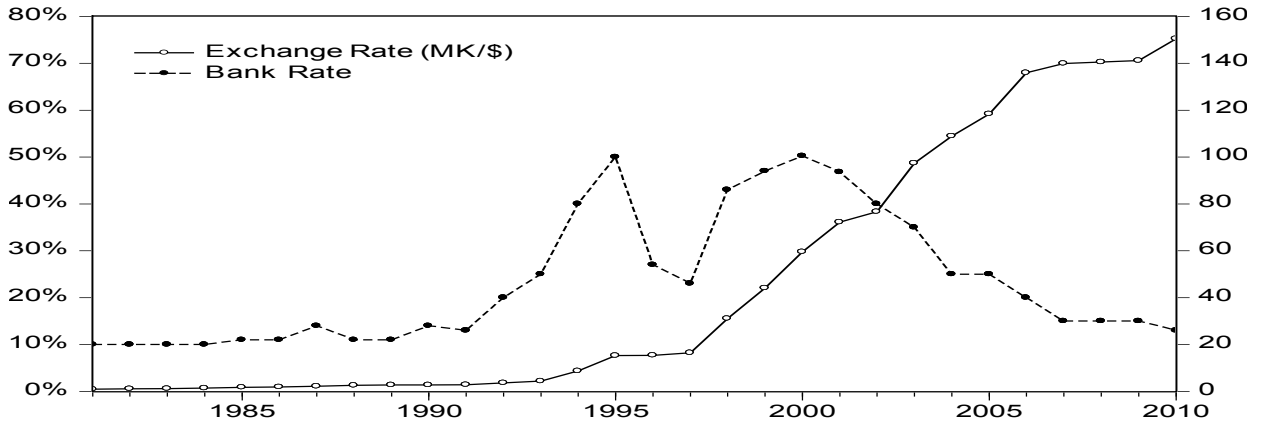
Source: International Monetary Fund-International Financial Statistics from Quantec Easy Data

Figure 4: Trend of Bank Rate and Private Credit



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

Figure 5: Bank Rate and Exchange Rate in Malawi



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

Figure 6: Sample autocorrelation, sample paths and posterior densities for selected parameters

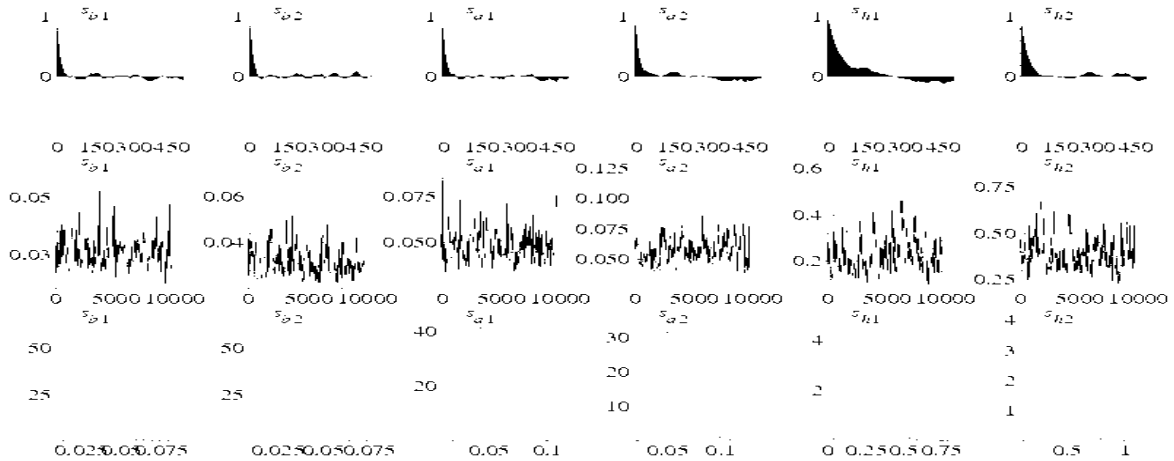
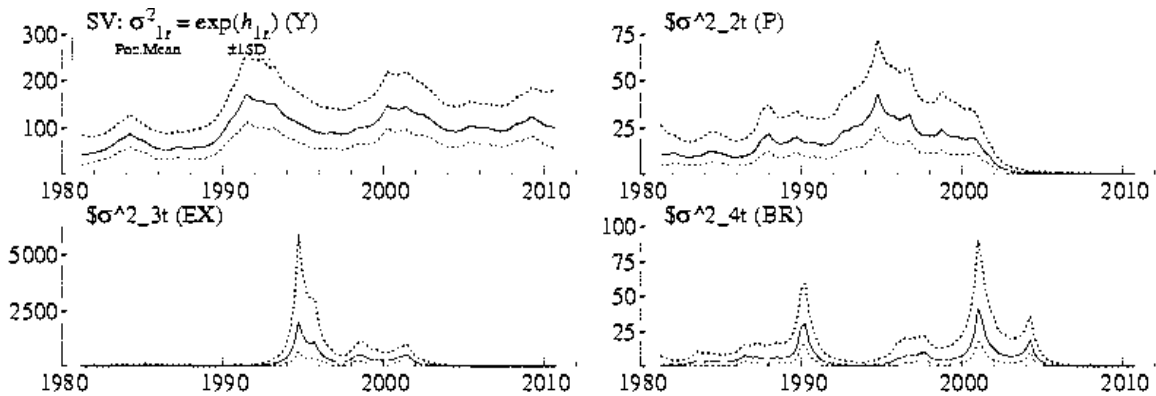
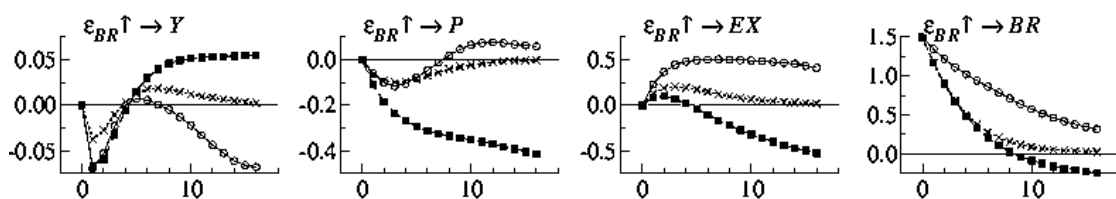
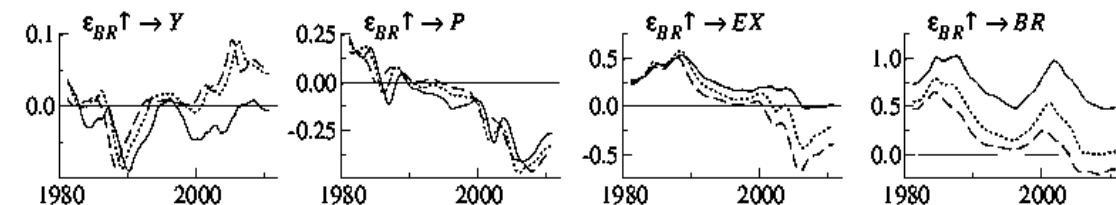
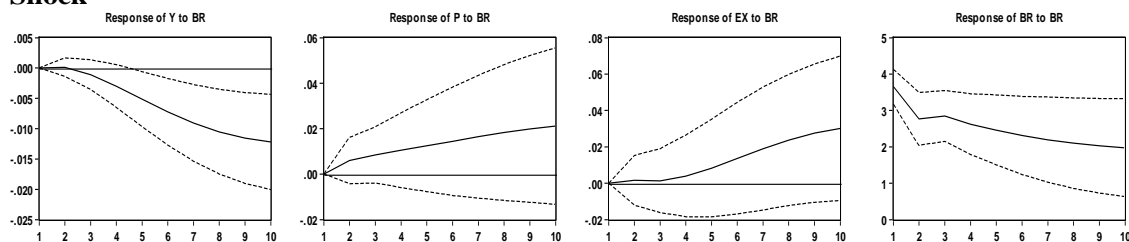


Figure 7: Posterior Estimates for Stochastic Volatility of Structural Shocks

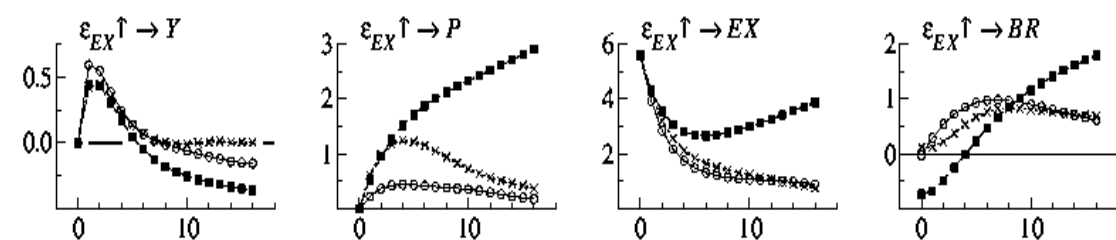
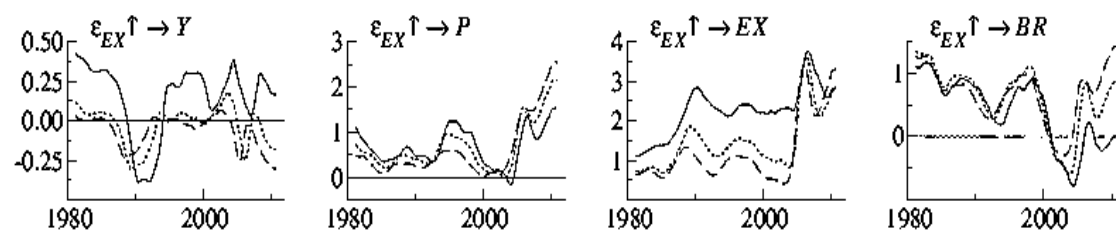
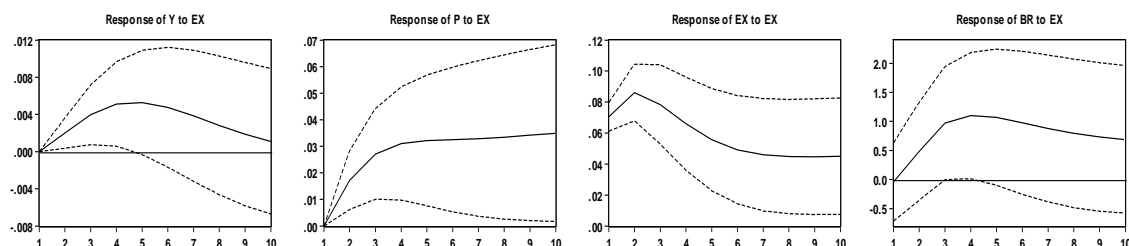


Note: Graphs are the postrior mean(solid) line and 95 percent credible intervals (dotted line) for stochastic volatility. The changes in the variables were multiplied by 100.

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



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



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

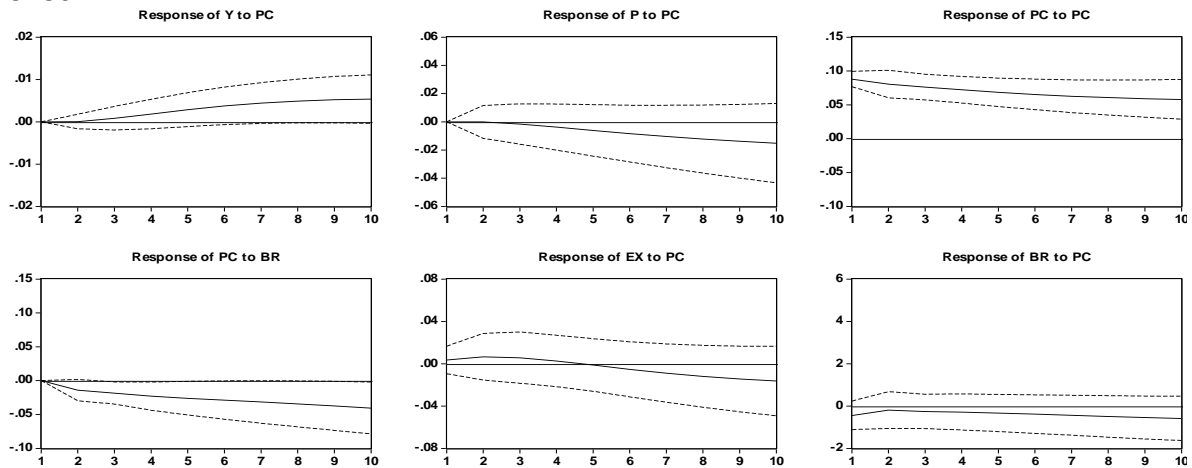


Chart 1: Unrestricted standard VAR impulses with dotted lines indicating 95% confidence intervals

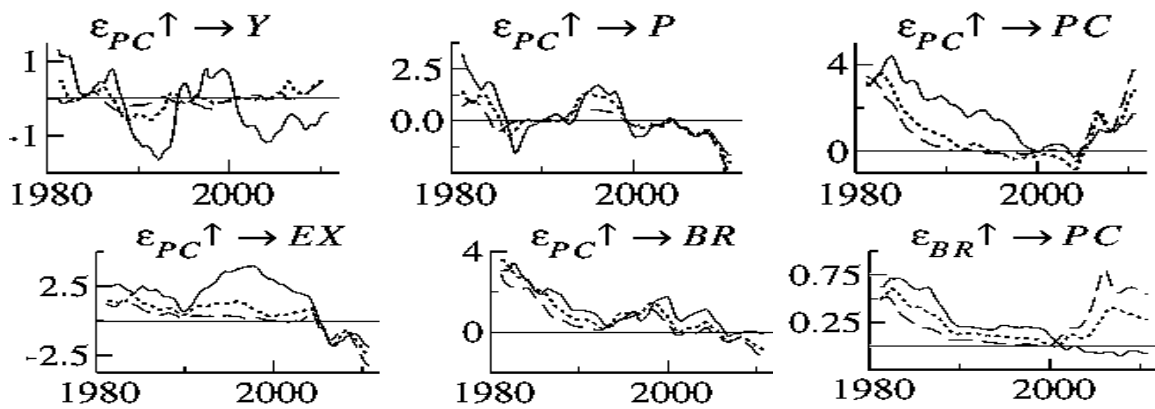


Chart 2: TVP-VAR impulses after 1 year (—), 2 years (-----) and 3 years (- - -) ahead

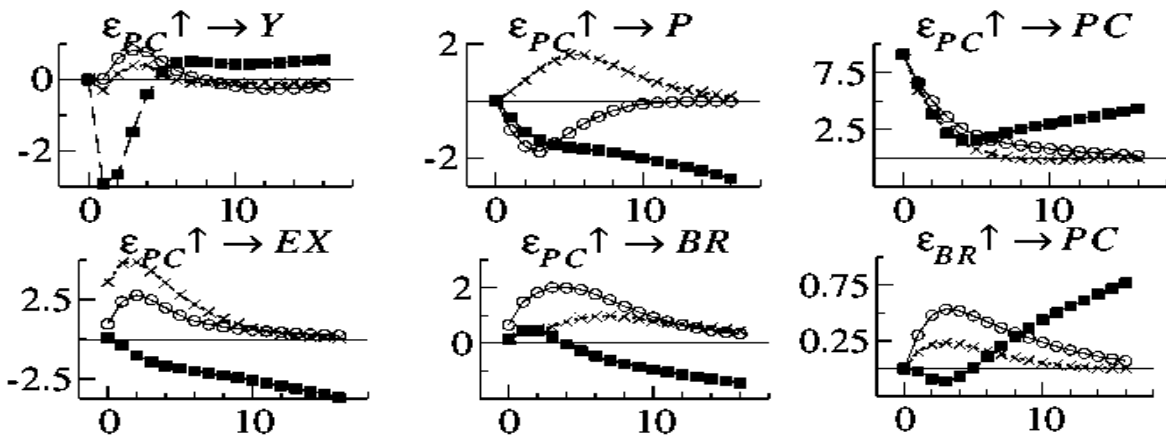


Chart 3: TVP-VAR impulses in 1987:Q1 (—○—), 1995:Q1 (---x---) and 2010:Q1 (—■—) one standard-deviation bands

## Appendix

### 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

