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. It is becoming clear from literature that financial reforms can change the monetary transmission by changing the overall impact of the policy or by altering the transmission channels overtime. Therefore, the impact of monetary policy on price stability and output growth can vary and portray delayed effects overtime. The paper finds that inflation and real output responses to monetary policy shocks changed over the period under the review. Importantly, beginning mid-2000s, the monetary transmission performed consistently with predictions of economic theory partly due to stable macroeconomic conditions and positive structural changes in the economy. 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.

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

JEL classification: C49, D12, D91, E21, E44

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 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.

* We would like to thank the anonymous referee for valuable comments. All remaining errors are our own.
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.\(^1\)

Prominent work 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 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 percent 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 Auto-Regression (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 et al. (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. (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 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, and spurious dynamics in random coefficients (Sims, 1992; Eichenbaum, 1992; Giordan, 2004; Bernanke et al., 2005; Cogley and

\(^1\) 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.
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. Empirically, Primiceri (2005) confirmed the existence of both in USA. Benati and Mumtaz (2005) and Baumeister et al. (2008) found the same results on the UK and Euro economies, respectively. Nakajima (2011) also found the time-varying structure of the Japanese economy. Another important study employing a Bayesian TVP-VAR model with volatility on transmission mechanism is by Franta et al. (2013) 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, 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, the only existing studies are two recent papers by Peretti et al. (2012) and Aye et al. (2015) 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, 2011), using SVAR (Ngalawa and Viegi, 2011) and using the VECM (Lungu et al., 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. The change in the monetary transmission mechanism is not clear and the transmission mechanism changes became volatile during the financial reform. In addition, 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 chapter 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. The description of data used in this paper is discussed under Section 4. In Section 5, we discuss the empirical results and Section 6 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 money demand function for Malawi as in Lungu et al. (2012). Thus, we only provide a brief 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 the bank rate and reserve money as monetary policy targets. Recently, Ngalawa and Viegi (2011) have evidently evaluated the performance of these two targets and found the bank rate to be more effective tool of monetary policy than reserve money. 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.

In addition, with change 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 1 and 2, inflation rates historically declined to single digits and economic growth hovered around 6 percent on average. Specifically, Figure 1 shows that episode of high and low bank interest rate are
associated with stagnation and robust economic growth. In addition, we observe that the relationship between bank rate and growth is not clear during the financial reform period. There is also high volatility of growth which can partly be explained by high observed inflation, drought and shift in government policies during this period (Mangani, 2011). 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 as programmed with the IMF based on the economic fundamentals during this period (IMF, 2010).

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 et al., 2012). In particular, movements in the bank rates are only effective to the extent they

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

**Figure 2.** Bank Rate and Inflation in Malawi
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 Viegi, 2013). 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 Quanpec Easy Data)

Prior to financial reforms, RBM used instruments such as priority sector lending targets, especially to the agriculture sector. 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 began 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 the lending to the private sector in the post period of financial reforms as shown in Figure 4. Quantitatively, annual credit growth reached an extent of 106 percent in September 2008 - April 2009 from 38 percent realised in January 2005 - September 2008 and was one of the highest in Africa (Christensen, 2011). The BID 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 tame rising inflation. The big question now arises whether this buoyant credit growth had any transmission effects in achieving economic

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2 The details of the financial reforms in Malawi are documented by Chirwa and Mlachila (2004) and Ngalawa and Viegi (2011).
growth and price stability.

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

In Figure 5, 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 the exchange rate channel is particularly important in a flexible exchange rate system (Christensen, 2011). The paper 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 monetary conditions and inflation pressures. This condition seemed to have existed when Malawi devalued its currency by more than 50 percent in 2012; inflation skyrocketed from single digits in 2006 to 2010 to around 30 percent 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.

3. EMPIRICAL METHOD

Following Primiceri (2005), Koop et al. (2009) and Nakajima (2011), the empirical approach used is TVP-VAR model with stochastic volatility. This method is becoming a popular technique in assessing the dynamic changes in the estimation of monetary policy transmission mechanism over time. The TVP-VAR model with stochastic volatility is derived from the basic structural VAR.\(^3\) We specify the reduced form VAR model as follows:

\[ y_t = c_t + \beta_{11} y_{t-1} + ... + \beta_{1p} y_{t-p} + A_t^{-1} \sum \epsilon_t. \]  

(1)

In matrix form, Equation (1) is specified as follows:

\[ y_t = X_t B_t + A_t^{-1} \sum \epsilon_t, \quad t = p+1,...,n, \]  

(2)

where \( y_t \) is a \((k \times 1)\) vector of observed Malawian variables. \( B_{1t},...,B_{pt} \) are \((k \times k)\) time varying coefficients. Assuming a recursive identification and a decomposition of a \( \phi_t = A_t^{-1} \sum \epsilon_t A_t^{-1} \) where \( A_t \) is the lower triangular matrix with diagonal elements equal to 1 and \( \sum \epsilon_t \) is a diagonal matrix containing standard deviations of the structural shocks. \( \phi_t \) is \((k \times k)\) time varying covariance matrix. \( X_t = I_n \otimes [1, y'_{t-1},...,y'_{t-p}] \) and \( \otimes \) is the Kronecker product. \( \epsilon_t \) are independent identically distributed errors with \( \text{var}(\epsilon_t) = I_n \). \( B_t \) 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 \( x_t = (x_{1t},...,x_{nt}) \). As in Nakajima (2011) and Primiceri (2005), the time-varying parameters are assumed to follow a random walk process as follows:

\(^3\) For full derivation of the model see Primiceri (2005) and Nakajima (2011).
for \( t = p + 1, \ldots, n \), with \( e_t = A_t^{-1} \sum_i e_i \), where \( I_n \) is the identity matrix of \( n \) dimensions, while \( \sum_\beta \sum_\alpha \) and \( \sum_x \) are positive definite matrices. The covariance matrices \( \sum_\alpha \) and \( \sum_x \) 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 et al. (2009), we assume that the initial states for the time-varying parameters are \( B_{p+1} \sim N(\nu_{B0}, \sum_\beta) \), \( \alpha_{p+1} \sim N(\nu_{\alpha 0}, \sum_\alpha) \) and \( x_{p+1} \sim N(\nu_{x 0}, \sum_x) \).

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 nonlinearity 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.\(^4\) We use the same priors as the one in Nakajima (2011), \( \sum_\beta \sim IW(25,0.01) \), \( \sum_\alpha \sim \text{Gamma}(4,0.02) \) and \( \sum_x \sim \text{Gamma}(4,0.02) \) where \( IW \) denotes the invert Wishart distribution, \( \sum_\alpha \) and \( \sum_x \) 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 \( \nu_{B0} = \nu_{\alpha 0} = \nu_{x 0} = 0 \) and \( \sum_\beta = \sum_\alpha = \sum_x = 10 \times I \).

\(^4\) For full derivation of the model, the conduct of the MCMC algorithm and the choice of priors, see Nakajima (2011), Koop and Korobilis (2010) and Primiceri (2005).
4. DATA

Data used in this study were obtained from International Financial Statistics of the International Monetary Fund (IFS-IMF) under Quan tec 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 activity. Data on real gross domestic product (RGDP) is recorded on an annual basis and hence the series were transformed into quarterly data estimated using indices of money series (M1). In particularly, we calculated quarterly changes of M1 and use these changes to interpolate the annual RGDP into quarterly series as done in Denton (1971). With the exception of 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 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>
<thead>
<tr>
<th>Variable</th>
<th>Details</th>
<th>Source</th>
</tr>
</thead>
<tbody>
<tr>
<td>BR</td>
<td>Bank Rate</td>
<td>IMF-IFS, Quan tec Easy Data</td>
</tr>
<tr>
<td>LP</td>
<td>Log consumer price index</td>
<td>IMF-IFS, Quan tec Easy Data</td>
</tr>
<tr>
<td>LEX</td>
<td>Log exchange rate</td>
<td>IMF-IFS, Quan tec Easy Data</td>
</tr>
<tr>
<td>LPC</td>
<td>Log private credit</td>
<td>IMF-IFS, Quan tec Easy Data</td>
</tr>
<tr>
<td>RY</td>
<td>Log gross domestic product constant price</td>
<td>World Bank, Quan tec Easy Data</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Variables</th>
<th>ADF</th>
<th>PP</th>
<th>KPSS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bank Rate (BR)</td>
<td>-1.882</td>
<td>-12.954***</td>
<td>-1.882</td>
</tr>
<tr>
<td>Prices (P)</td>
<td>-1.036</td>
<td>-3.679***</td>
<td>-0.651</td>
</tr>
<tr>
<td>Real Output (Y)</td>
<td>0.699</td>
<td>-3.169***</td>
<td>1.871</td>
</tr>
<tr>
<td>Private Credit (PC)</td>
<td>-0.904</td>
<td>-10.947***</td>
<td>-0.646</td>
</tr>
<tr>
<td>Exchange Rate (EX)</td>
<td>-0.757</td>
<td>-7.622***</td>
<td>-0.756</td>
</tr>
</tbody>
</table>

Notes: 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.
As indicated in Table 2, all macroeconomic variables used in the estimation are tested for the stationarity using the Augmented Dickey-Fuller (ADF) test, Phillips-Perron test and KPSS test. 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 become stationary, indicating integration of order one. The 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 and one lag VAR estimation is used based on the stability of the model. Following Bernanke and Blinder (1992) and Christiano 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 identification structure has strong theoretical foundation that real output and prices are unlikely to react immediately to bank rate shocks (Christiano et al., 1999; Hoppner et al., 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**

The first part of this section discusses the results of the stochastic volatility of the structural shocks and simultaneous relationship. While the second part analyses the estimated impulse responses to monetary policy, exchange rate and credit shocks from the TVP-VAR model. Discussions on the impulse responses results are based on two charts. The first chart shows the accumulated impulse responses at several horizons of particular variables to a specific shock and the responses are drawn in a time series manner by showing the size of the impulses for 1 to 3 year horizons over time. The second chart demonstrates how the responses 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

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

6 All the shocks are normalised to one standard deviation band to enable us compare responses across periods. An attempt was made to estimate the standard VAR but most results were found insignificant and puzzles were observed. The test results are available from the authors upon request. The results of the posterior estimates for stochastic volatility of the structural shocks when credit is augmented in the baseline are shown in Appendix.
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.

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 percent 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. 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>
<thead>
<tr>
<th>Parameter</th>
<th>Mean</th>
<th>Stdev</th>
<th>95% Interval</th>
<th>Geweke</th>
<th>Inefficiency</th>
</tr>
</thead>
<tbody>
<tr>
<td>sb1</td>
<td>0.0324</td>
<td>0.0073</td>
<td>0.0212</td>
<td>0.0491</td>
<td>0.065</td>
</tr>
<tr>
<td>sb2</td>
<td>0.0285</td>
<td>0.0055</td>
<td>0.0202</td>
<td>0.0417</td>
<td>0.266</td>
</tr>
<tr>
<td>sa1</td>
<td>0.0821</td>
<td>0.0312</td>
<td>0.0432</td>
<td>0.1619</td>
<td>0.169</td>
</tr>
<tr>
<td>sa2</td>
<td>0.0742</td>
<td>0.0231</td>
<td>0.0416</td>
<td>0.1290</td>
<td>0.157</td>
</tr>
<tr>
<td>sh1</td>
<td>0.5582</td>
<td>0.1469</td>
<td>0.3224</td>
<td>0.8864</td>
<td>0.248</td>
</tr>
<tr>
<td>sh2</td>
<td>0.5108</td>
<td>0.1167</td>
<td>0.3199</td>
<td>0.7751</td>
<td>0.945</td>
</tr>
</tbody>
</table>

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. However, the volatility of the actual data on inflation and economic started much earlier. By implication, the monetary authorities reacted to the continued volatility in the inflation and sluggish economic growth.

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

Notes: Sample autocorrelation (top), sample paths (middle), and posterior densities (bottom). The estimates of \( \sum \beta \) and \( \sum \alpha \) are multiplied by 100.

Figure 7. Posterior Estimates for Stochastic Volatility of Structural Shocks

Notes: Graphs are the posterior mean (solid line) and 95 percent credible intervals (dotted line) for stochastic volatility. The changes in the variables were multiplied by 100 during estimation.
The stochastic volatility of all variables remains stable between 2005 and 2010, coinciding with the introduction of new reforms by 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. 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 et al., 2009).

5.2. Responses to Monetary Policy Shocks

Turning now to the impulse responses, Figure 8 shows how the impulse responses of output to a one standard deviation of positive bank rate shock vary over time. Particularly, 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. Basic economic theory, based on the standard interest rate transmission mechanism (Mishkin, 1995), 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. Empirically, however, the basic standard of interest rate transmission mechanism has yielded different results (Mishra and Montiel, 2012). The positive effects on output after 2000 is supported by a decline in interest rates 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.

In terms of the effects of monetary policy shock on general price, according to the traditional Keynesian theory, an increase in interest rates will increase the cost of borrowing for consumers and investors leading to the reduction in both consumption and investment. This will result into lower aggregate demand leading to lower output and lower prices. However, results from the TVP-VAR with stochastic volatility estimations reveal that response of price to bank rate shock vary overtime and the ‘price puzzle’ disappears in the post period of financial reforms. As argued by Ngalawa and Viegi (2011), monetary factors may not be determinants of inflation in Malawi. Generally, food costs (above 50 percent) account for a large proportion in the Consumer Price Index (CPI) and hence fluctuations in food production (maize in this case) may have determined the movements in inflation other than monetary factors. As discussed in
Section 2, Malawi achieved high output growth emanating from agriculture (high increase in stable food maize) attributed to good rains and implementation of fertiliser subsidy programme. This would have increased the supply of food and hence a reduction of prices on market.

Mishkin (1995) states that “when domestic real interest rates rise, domestic dollar deposits become more attractive relative to deposit denominated in foreign currencies, leading to an increase in the value of dollar deposits relative to other deposits, that is, an appreciation of the dollar”. In this case, the value of domestic currency will increase and induce a high cost of domestic goods relative to the foreign goods. However, responses of exchange rate as a result of bank rate shock using the TVP-VAR model with stochastic volatility shows that exchange rate movements behaved differently over time period. The impulse responses reveal that there was an appreciation of the exchange rate consistent with economic theory during the post period of financial reforms.

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. (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. 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.

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

**Chart 2**: TVP-VAR impulses in 1987:Q1 (--), 1995:Q1 (-----) and 2010:Q1 (----) one Standard-deviation bands

**Notes**: Chart 1 presents the accumulated impulse responses at several horizons of particular variables to a specific shock. Chart 2 demonstrates how the responses have behaved in different periods.

**Figure 7.** TVP-VAR Impulse Response to a Positive Exchange Rate Shock

The results of the TVP-VAR model with stochastic volatility presented in Figure 9 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 1, Chart 2 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 2, also shows that the transmission mechanism through the exchange rate channel was more pronounced during the financial reform. Malawi adopted a free floating exchange rate regime which was followed by 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 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 fluctuations. Researchers have argued that the disparity comes about because of the overvaluation and management of the exchange rate (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).

5.4. Responses to Private Credit Shocks

The dynamic responses of bank rate, exchange rate, output and prices to unexpected positive credit shock are discussed based on the bank lending channel mechanism, working through the conditions of supply of banks loans as fully explained by Bernanke and Gertler (1995), Mishkin (1995) and Ireland (2005). Specifically, they argue that a monetary policy that induces an increase in bank deposits will enhance an increase in banks loans and investors will be able to borrow. Therefore, the increase in investment will lead to an increase in output. However, they have noted that credit channel does not matter currently because banks play less important role in credit markets due to evolution of other players in credit allocation. However, our study uses the lending channel because Malawi is still bank dependant and the financial system is still shallow with high cost of financial intermediation (Chirwa and Mlachila, 2004).

The estimation results in Figure 10 indicate much variation of responses following a one standard positive private credit shock. In Chart 1, 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 are dampened in the later years of the sample. However, positive credit shock leads to the exchange rate appreciation in the post period of financial reforms. The
results in Chart 2 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 a positive shock on bank rate leads to decline in credit to the private sector in the post period of financial reforms.

Figure 8. TVP-VAR Impulse Responses to a Positive Private Credit Shock

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 Viegi, 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 estimated 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 estimated a TVP-VAR model with stochastic volatility that allowed us to capture the variation of macroeconomic structure and the changes in the transmission mechanism overtime. Combined with 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 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. On the other hand, 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.

APPENDIX

Table 1A. Estimation of Selected Parameters in the TVP-VAR Model Including Private Credit

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Mean</th>
<th>Stdev</th>
<th>95% Interval</th>
<th>Geweke</th>
<th>Inefficiency</th>
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<tr>
<td>sb1</td>
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<td>0.0313</td>
<td>0.0886</td>
<td>0.491</td>
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<tr>
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<td>0.0330</td>
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<tr>
<td>sa1</td>
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<td>0.0335</td>
<td>0.0766</td>
<td>0.051</td>
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<tr>
<td>sa2</td>
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<td>0.0343</td>
<td>0.0420</td>
<td>0.1773</td>
<td>0.286</td>
</tr>
<tr>
<td></td>
<td>sh1</td>
<td>sh2</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>---</td>
<td>-----------</td>
<td>-----------</td>
<td></td>
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<tr>
<td>1</td>
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<td>86.61</td>
<td>36.12</td>
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</tbody>
</table>

Notes: Sample autocorrelation (top), sample paths (middle), and posterior densities (bottom). The estimates of the $\sum g$ and $\sum a$ are multiplied by 100.

Figure 1A. Sample Autocorrelation, Sample Paths and Posterior Densities for Selected Parameters Including Private Credit

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