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Understanding Inflation in Malawi: A Quantitative Investigation

by Dong Frank Wu

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Understanding Inflation in Malawi:

A Quantitative Investigation[1]

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Abstract

This paper focuses on the role of the pass-through of the exchange rate and policy-determinants in driving inflation. Using linear and nonlinear frameworks, the paper finds: (i) after the switch to a floating exchange rate regime in 2012, nonfood prices not only directly influence headline inflation, but also have an significant impact on food inflation via second round effects; (ii) the pass-through of the exchange rate to headline inflation has jumped from zero to 11 percent under the floating regime, after controlling for other factors; (iii) the improved significance of T-bill rates in shaping inflation flags its importance in Malawi's monetary framework although the monetary transmission mechanism needs further strengthening; (iv) the increased impact of broad money underscores the necessity for fiscal discipline and central bank independence.

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Keywords: Inflation, Exchange Rate, Pass-through, Regime Switch

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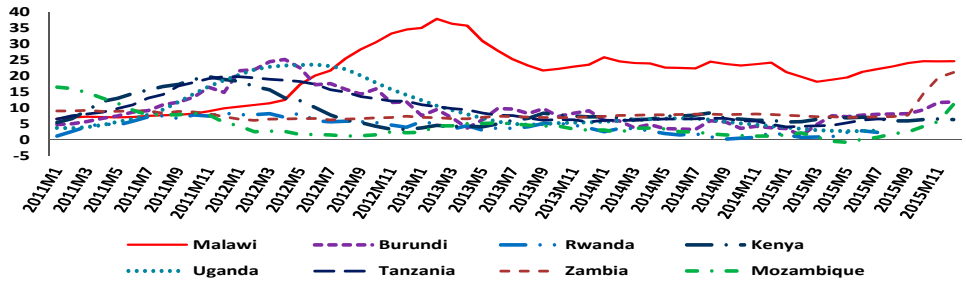
I. INTRODUCTION

1. **Malawi's inflation has remained above 20 percent since 2012, persistently higher than that of neighboring countries (Figure 1).**[2] Part of it is attributed to the dramatic changes in the institutional framework and climate-related shocks. In May 2012, Malawi switched from a fixed to a floating exchange rate regime[3] that was subject to classic overshooting and further compounded by a sudden stop in external budget support following the large-scale theft of public funds called the "cash-gate scandal". Financing the fiscal deficit in the aftermath of the scandal was done through printing money and by issuing government securities to the private sector. In 2015, a combination of droughts and floods resulted in a sharp reduction in the maize harvest and contributed to a sharp increase in food inflation.

Figure 1. Headline Inflation: Malawi vs Neighboring Countries



Source: IMF WEO.

2. **The purpose of this paper is to examine the inflation dynamics in Malawi quantitatively, with a focus on the pass-through of exchange rate and policy-related determinants of headline inflation.** Malawi's economy is dominated by rain-fed agriculture which accounts for 30 percent of GDP, and food inflation displays strong seasonal patterns. By contrast, nonfood inflation has been influenced by factors, such as import prices and the exchange rate. The paper first explores the feedback relationship between food and non-food inflation. Furthermore, the paper examines the pass-through of exchange rate to headline inflation and studies how it evolves before and after the regime switch.[4] Lastly, the paper investigates the possible drivers for headline inflation in Malawi. Key results of the paper are: (i) after the regime switch, nonfood prices not only directly influences headline inflation, but also has an significant impact on food inflation via second round effects; (ii) the pass-through from the exchange rate to headline inflation has jumped from zero to 11 percent under the floating exchange rate regime, after controlling for other factors; (iii) the improved significance of T-bill rates in shaping inflation underscores its importance in Malawi's monetary tools although the monetary transmission mechanism needs further strengthening;

[2] The annual averages of y-o-y monthly inflation from the years of 2012M5 to 2015M9 were 27.7 percent, 28.6 percent, 23.7 percent, and 20.9 percent, respectively. (Figure 1).

[3] The kwacha was devalued by 33 percent from 165.9 in April 2012 to 248.5 in May 2012.

[4] Adopting the floating exchange regime, combined with the automatic energy price adjustment mechanism, means a significant structural break for economic activities.

(iv) and the increased impact of broad money highlights the necessity of fiscal discipline and central bank independence.

3. **The paper is organized as follows:** Section II presents the background information about Malawi's economy followed by a brief literature review in Section III. Section IV introduces the data and methodology. In Section V, dynamic properties of inflation are highlighted and the interaction between food inflation and nonfood inflation investigated. Section VI compares the pass-through of the exchange rate before and after the regime switch through Autoregressive Distributed Lag (ADL) and estimates the time-varying pass-through via a non-linear framework. Section VII employs the SVAR framework to explore the drivers of headline inflation. Section VIII concludes the paper with policy implications.

II. BACKGROUND

4. **Economic growth in Malawi is quite volatile, reflecting heavy aid-dependence and reliance on rain-fed agriculture.** Although the average real growth for the past ten years was 5.8 percent, the economy which suffers from a narrow export base has experienced high output volatility due to weather-related factors and other external shocks. Aid inflows have also proven to be quite volatile, declining from a peak of 12 percent of GDP in 2012 to a low of 6 percent of GDP in 2015 following the suspension of budget support after the cash-gate scandal.

5. **Prior to 2012, Malawi operated a de facto pegged exchange rate regime.** The official exchange rate was overvalued and subject to period devaluations: the kwacha depreciated by about 13 percent, 12 percent, 7 percent and 10 percent between 2004 to 2011. Even though the authorities reiterated that one objective was to implement a flexible exchange rate regime, they actually kept the Kwacha fixed against the U.S. dollar. Expansionary fiscal and monetary policies, combined with increased private sector demand, led to the drop in official reserves and weakened Malawi's external position. Prior to 2012, there were several periods of foreign exchange shortages and rationing, and private import payment arrears, which substantially undermined confidence on the de facto peg and fostered the black market for foreign exchange.

6. **In order to address the country's chronic balance of payments problems, the authorities adopted a floating exchange rate regime and automatic fuel pricing mechanism in 2012.** The specific measures implemented included:[5] (i) devaluing the exchange rate from K167 to K250 per U.S. dollar (a 33 percent devaluation), and the adoption of a floating exchange rate regime; (ii) allowing banks and foreign exchange bureaus to set the rate at which they buy and sell foreign exchange; (iii) removing the requirement for foreign exchange earnings to be surrendered to the Reserve Bank of Malawi (RBM); (iv) cancelling the requirement for banks to submit to the RBM any application for external payments exceeding US$50,000; (v) adopting an automatic fuel pricing mechanism.

[5] See *Malawi Article IV Staff Report of 2012*.

7. **At the operational level, the monetary policy framework still maintains monetary targeting of reserve money although the revised RBM Act of 1989 specifies a large but conflicting set of objectives as the bank's mandate on monetary policy, rending it almost impossible for the RBM to achieve all of them.** To achieve its operational target, the RBM implements a large range of monetary policy instruments, including: (i) the bank rate (policy rate); (ii) a liquid reserve requirement (LRR) for banks; (iii) open-market operations (OMOS); (iv) a loan facility (discount window/Lombard facility) for banks; (v) a rediscount facility, and (vi) sales and purchases of foreign exchange. While the policy rate is adopted as an anchor to interest rates, the reserve money target is achieved with OMOs, discount window operations, and LRR. Due to the segmentation of financial markets in Malawi, the policy rate has limited signaling effect on the market-based rates, which leads to the choice of T-bill rates as an effective indicator of market response to monetary stance.

III. LITERATURE REVIEW

8. **Various theoretical and empirical models have been used to analyze the interactions between the exchange rate and inflation.** McCarthy (2000) conducts the analysis on exchange rate, import prices on consumer prices in a recursive VAR framework and finds that the pass-through has some modest effect on domestic prices and it is related to the degree of economic openness. Burstein, Eichenbaum and Rebelo (2002) examine the pass-through of the exchange rate after currency devaluation and find a small impact on domestic prices. Taylor (2000) finds the declining pass-through since late 1990's is largely attributed to the low inflation environment in the U.S., which was supported by the empirical work by Takhtamanova (2008). In line with Taylor's hypothesis, Zorzi, Hahn and Sanchez (2007) also find the positive interaction between the degree of pass-through and inflation. Regarding how the pass-through is determined at the micro level, Obstfeld and Rogoff (1995) propose that the structure of the domestic economy is a major factor and a monopolistic market or imperfect competition contributes to high pass-through. Krugman (1986) claims that pricing to market is a real phenomenon that producers have to bear a part of the exchange rate changes by reducing mark-ups to keep their market share in a competitive market.

9. **In addition, a large body of empirical literature explored the sources and dynamic properties of inflation.** Barnichon and Peiris (2007) explore the sources of inflation in sub-Saharan Africa by examining the interaction among inflation, output gap, and money gap. Loungani and Swagel (2001) find that money growth and exchange rate changes are more important for developing countries with floating exchange rate regime than those with fixed regime. Caceres, Poplawski and Tartari (2011) state that imported commodity prices and government are two main sources of inflation dynamics in the Central African Economic and Monetary Community (CEMAC). Some papers analyze inflation from the perspective of monetary transmission mechanism. Mishra, Montiel and Spilimbergo (2012) focus on the effects of financial market structure on monetary transmission in low-income countries and find that the weak institutional framework undermines the effectiveness of various transmission channels. Davoodi, Dixit and Pinter (2012) investigate both reserve money and the T-bill rates as policy variables in five East African Community countries and find mixed results. Berg, Charry, Portillo and Vlcek (2013) use a narrative approach to identify the

monetary transmission channels in four members of EAC and claim that deviations can be caused by regime-related factors.

10. **There are several papers focusing on the dynamics and determinants of inflation before Malawi's exchange rate regime switch.** Mangani (2011) assessed the effectiveness of monetary policy in Malawi, and found that the exchange rate was the most important factor in price forecasting, suggesting that more attention be directed to cost-push inflation instead of demand-pull inflation. Ngalawa and Viegi (2011) compared the transmission process of monetary shocks before and after 1994, showing that the bank rate is more effective than reserve money as policy instrument. Mwabutwa et al (2013) revealed that between 2000 and 2010, private credit supply remained weak in the monetary policy transmission. Nevertheless, none of these papers analyzed the changes in the inflation dynamics before and after 2012 regime switch. Before the floating exchange rate regime was implemented, Malawi pegged its national currency to U.S. dollar and kept an overvalued exchange rate. In the meantime, price control, such as petroleum products, prevailed among domestic markets. This kind of economic arrangement stifled market mechanisms and caused undesirable price distortion. Even though certain monetary and financial reforms were launched in 1994, the implementation of these reforms was not even and underwent policy reversal to some extent in late 2000's. After the economic reform in 2012, prices and exchange rates move based on economic fundamentals, but their excessive volatilities adversely impact economic decisions.

11. **This paper aims to fill the gap and concentrates on the new properties of inflation since 2012.** In principle, the exchange rate and the production cycle could be potentially important factors for a small open economy dominated by the primary sector. In Malawi, the monetary authorities rely heavily on monetary aggregates as a policy tool although they announce a policy rate which is not always been aligned with short-term money market interest rates (Figure 2). How effective are its monetary tools in determining inflation or could its tools become the main sources of inflation volatility? In this regard, the T-bill rate and broad money are good proxy variables to investigate the impact of monetary policy.

IV. Data and Methodology

12. **This paper uses monthly data** for the CPI index, nominal effective exchange rate (NEER), a proxy for real output, broad money, T-bill rate, oil price index and food price index, which are from January 2002 to December 2015.

13. **The CPI index is sourced from the National Statistics Office (NSO)** of Malawi which is computed by two broad categories: food price index and other price (non-food) index. Due to the absence of the price index for petroleum products, inflation in Malawi can be decomposed only into food inflation and nonfood inflation.

14. **The NEER is used to capture the price of the national currency in the foreign exchange market.** As a multilateral exchange rate, the NEER more accurately reflects the intrinsic value of the Malawi Kwacha than the bilateral exchange rate between kwacha and USD. Even when the kwacha was pegged to the US dollar, the NEER could still show the

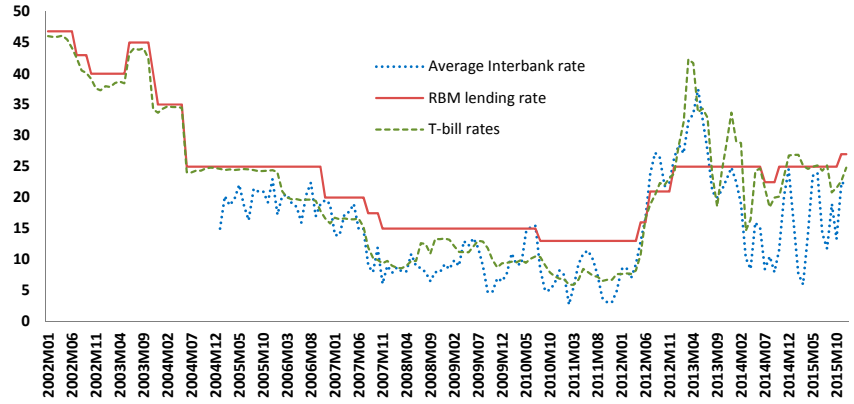
relative movement between Malawi kwacha and other currencies resulting from the strengthening or weakening of the U.S. dollar.

15. **In order to construct an economically meaningful measure of real output, monthly tax revenue was used to generate monthly GDP data**[6]. This approach proves to be consistent with annual real growth and is reflective of within-year fluctuations. There is no monthly data on GDP while a quarterly index of industrial production is only available to 2012. Although interpolation using a cubic spline technique is usually employed to serve the same purpose, it abandons information included in monthly fluctuations.

16. **Broad money and the T-bill rate**[7] **are two major intermediary variables** to capture the effects of the monetary policy stance and the market's response although there is room for the RBM to improve the alignment between the policy rate and interbank rate and further develop the interbank market (Figure 2).

17. **The monthly index for oil prices employed is the average petroleum spot price** from the World Economic Outlook and the index for global food price was obtained from the International Financial Statistics. Both indices are representative of global developments[8]

Figure 2. Interest Rates in Malawi



Source: The Reserve Bank of Malawi.

18. **All these variables were stationary and the results are summarized in Table 1**. ADL, VAR and Structural VAR are used to examine the dynamic properties of the time

[6] One question is which tax revenue variable should be used. For most of the tax revenue variables, their growing trends include an expansion in economic activity, but also the efficiency in revenue collection due to reforms. This may misrepresent the economic output within a given year. In light of this fact, the paper uses import duty to help convert yearly GDP data into monthly ones.

[7] Figure 2 presents various rates in Malawi.

[8] Admittedly, many factors influence the movement of these two price index. They, however, move broadly in line with the global economic fluctuation. When the world economy slumps, demand for oil declines, causing oil prices to drop. In addition, it is possible that some speculative motives drive up the oil prices, subjecting the world economy to an adverse supply shock.

series. Moreover, non-linear series analysis is explored to investigate the time-varying pass-through of NEER to inflation.

Table 1. Results of Augmented Dickey-Fuller Test

Variable	Specification	Statistics
Real GDP growth (m-o-m, sa)	I(0): with drift, 2 lags	-8.520 **
Headline inflation (m-o-m, sa)	I(0): with drift, 2 lags	-3.033 **
Food inflation (m-o-m, sa)	I(0): with drift, 2 lags	-5.818 **
Nonfood inflation (m-o-m, sa)	I(0): with drift, 4 lags	-4.798 **
Change rate of NEER (m-o-m, sa)	I(0): with drift, 3 lags	-6.730 **
Change rate of broad money (m-o-m, sa)	I(0): with drift, 2 lags	-7.603 **
T-bill rate average	I(0): with drift, 1 lags	-2.464 **
Change rate of oil price index (m-o-m, sa)	I(0): with drift, 2 lags	-6.415 **
Change rate of food price index (m-o-m, sa)	I(0): with drift, 2 lags	-6.287 **

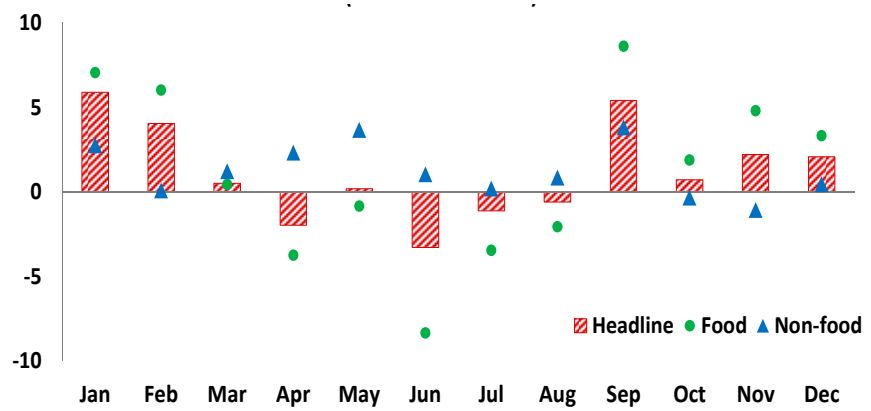
Notes:
The test statistics with * means rejecting the null hypothesis at 5 percent significant level;
The test statistics with ** means rejecting the null hypothesis at 1 percent significant level.

V. Headline Inflation Decomposition

A. Seasonality and Volatility

19. **Since the revision of the CPI basket in 2012, food prices were assigned a weight of 50.8 percent and non-food prices 49.2 percent respectively**. Given that the economy is dominated by subsistence farmers and food prices are largely shaped by the agriculture cycle and subject to strong seasonal patterns, the seasonality of headline inflation tracks closely that of food inflation (Figures 3 and 4).

Figure 3. Seasonal Factors of Inflation: Headline, Food and Non-food



Source: National Statistics Office of Malawi.

20. **All inflation series are seasonally adjusted, and the standard deviation computed for two sub-periods.** Interesting findings emerge (Tables 2 and 3)[9]: (i) nonfood inflation is more volatile than food inflation after the exchange rate regime switch; (ii) the average level of nonfood inflation is higher than food inflation before and after the regime switch; (iii) the floating regime not only increases headline inflation's volatility, but also its level.

Table 2. Inflation Volatility (m-o-m, seasonally-adjusted)

	2002.01-2015.12	Sub-period	
		2002.01-2012.04	2012.05-2015.12
Headline	0.8	0.4	0.9
Food	0.8	0.7	1.1
Non-food	0.9	0.5	1.3

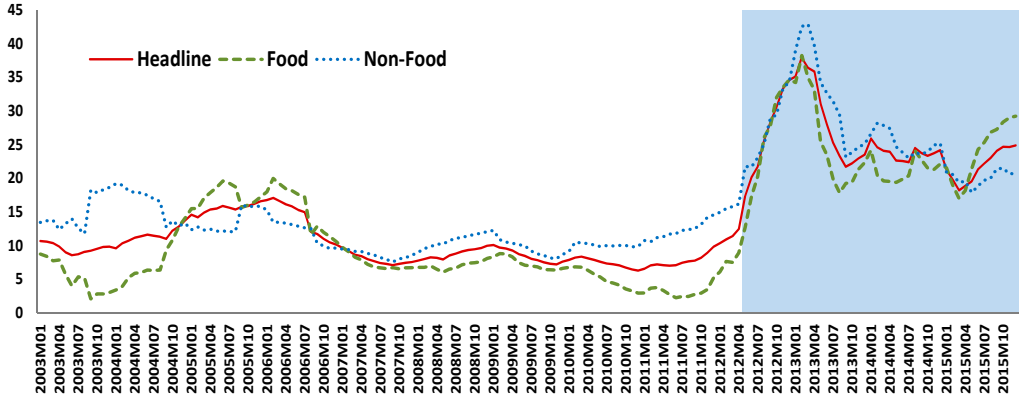
Source: National Statistics Office of Malawi.
Note: Volatility is measured as the standard deviation.

Table 3. Inflation Average (y-o-y, in percent)

	2002.01-2015.12	Sub-period	
		2002.01-2012.04	2012.05-2015.12
Headline	14.3	10.1	25.0
Food	12.8	8.4	24.0
Non-food	16.1	12.1	26.1

Source: National Statistics Office of Malawi.
Note: Inflation average is calculated on the y-o-y change rate of monthly data.

Figure 4. Inflation in Malawi (y-o-y, in percent, 2002M1–2015M12)



Source: National Statistics Office of Malawi.
Note: The shaded area is for the periods after the exchange regime switch.

[9] Please check Tables 2 and 3 for details. Also, Figure 4 depicts the same pattern.

B. Interaction Between Food Inflation and Non-food Inflation

21. **This section uses the VAR framework to study the interaction between food and nonfood inflation.** Before the econometric analysis, the paper first employs the Chow test to examine whether the structural break associated with the regime switch is statistically significant. The Chow test rejects the null hypothesis that there is no structural break at the 5 percent level. Against this background, the paper applies VAR regression with dummy variables to control for the structural break (Eq 1). Then, information criteria are employed to determine the optimal lag length. Finally, the paper applies the general-to-specific approach to eliminate insignificant variables (Tables 4 and 5).

$$Y_t = A_0 + dum_{regime} + \sum_{i}^{q} A_i Y_{t-i} + \sum_{i}^{q} AA_i Y_{t-i} dum_{regime} + \sum_{i}^{q} B_i X_{t-i} + u_t \qquad (Eq\ 1)$$

where Y_t is a 2x1 vector including food inflation and nonfood inflation;

$$Y_t = \begin{pmatrix} \pi_{f,t} \\ \pi_{nf,t} \end{pmatrix} \qquad (Eq\ 2)$$

X_t is a 3x1 vector of control variables including the change rates of oil price, broad money and NEER;

$$X_t = \begin{pmatrix} \pi_{oil,t} \\ \Delta m_{2,t} \\ \Delta NEER_t \end{pmatrix} \qquad (Eq\ 3)$$

dum_{regime}

is the dummy variable for the regime switch.

22. **For the optimal lag length of the VAR model, four information criteria[10] are employed**. Based on these criteria, this section uses 12 periods as the maximum time lag and applies the general-to-specific approach to drop insignificant regressors. The Lagrange multiplier (LM) test suggested no autocorrelation of the residuals and eigen values that remained within the unit circle indicated the model was stable.

[10] Namely AIC, BIC, SBIC and HQIC. All four indexes decline with more lags added to the VAR equations because of the significant changes of the maximized log likelihood and the negligible penalty factors associated with new variables. In this context, the paper uses 12 periods as the maximum time lag.

Table 4. Regression Results for the Pass-Through of Non-food to Food Inflation		
Variable	Coefficient	Statistics
Food inflation (-1)	0.25	3.43**
Food inflation (-2)	0.20	2.40*
Nonfood inflation (-1)	0.18	2.27*
Nonfood inflation (-5)	0.19	2.65**
Nonfood inflation (-10)	0.19	2.89**
Nonfood inflation (-12)	0.50	5.60**
Dummy for regime	0.37	1.71
Dummy for regime X Food inflation (-2)	-0.43	-2.75**
Dummy for regime X Food inflation (-7)	0.34	3.05**
Dummy for regime X Food inflation (-8)	-0.33	-2.47*
Dummy for regime X Nonfood inflation (-12)	-0.75	-6.84**
Constant	-0.76	-3.35**
Note: Coefficients for other control variables are not reported.		

Table 5. Regression Results for the Pass-Through of Food to Non-food Inflation		
Variable	Coefficient	Statistics
Food inflation (-1)	0.18	3.21**
Food inflation (-10)	0.19	3.76**
Nonfood inflation (-1)	0.27	2.95**
Nonfood inflation (-6)	0.13	1.74
Nonfood inflation (-11)	0.20	2.94**
Nonfood inflation (-12)	-0.29	-4.32**
Dummy for regime	3.37	13.24**
Dummy for regime X Food inflation (-2)	-0.55	-5.17**
Dummy for regime X Food inflation (-4)	0.42	4.53**
Dummy for regime X Food inflation (-5)	-0.70	-6.67**
Dummy for regime X Food inflation (-8)	-0.52	-4.48**
Dummy for regime X Food inflation (-11)	0.45	4.78**
Dummy for regime X Food inflation (-12)	0.53	5.50**
Dummy for regime X Nonfood inflation (-1)	-0.75	-6.90**
Dummy for regime X Nonfood inflation (-6)	-0.18	-1.96
Dummy for regime X Nonfood inflation (-9)	-0.33	-4.71**
Dummy for regime X Nonfood inflation (-11)	-0.41	-4.91**
Dummy for regime X Nonfood inflation (-12)	-0.75	-6.84**
Constant	-0.30	-1.55
Note: Coefficients for other control variables are not reported.		

23. **With control for the effects of exchange rate, broad money and oil prices, key findings are:** (i) after the exchange rate regime switch, the long-term pass-through of nonfood inflation to food inflation is 31 percent; (ii) the long-term pass-through of food inflation to nonfood inflation is approximately zero[11]. The almost-zero pass-through of food inflation could be explained by the substitution effect of nonfood consumption between domestically produced or imported goods. For example, suppose that the exchange rate is constant, when higher domestic food prices push up inflationary expectations on nonfood consumption, agents would import more nonfood items from abroad and keep its prices unchanged.

[11] Before the regime switch, the long-term pass-through of nonfood to food inflation is 192 percent while that of food to nonfood inflation is 54 percent.

VI. Pass-Through of The Exchange Rate to Inflation

24. **This section explores the pass-through of the NEER to headline inflation.** Both Autoregressive Distributed Lag (ADL) models and non-linear frameworks are employed to cross check the robustness of results. Following the similar procedure as above, structural break tests are employed before regression analysis is conducted (Equation 4). The Chow test is used to check the significance of parameters after the regime shift. The results show that the null hypothesis is rejected at 1-percent significance level that there is no structural break for the pass-through of the NEER on headline inflation, implying a structural break for the impact of the NEER on inflation. Therefore, the section conducts the ADL regression with dummy variables to control the structural break. Moreover, the lag length is chosen based on information criterions and the general-to-specific approach applies to pin down the final regression specification.

$$\pi_t = a_0 + aa_0 * dum_{regime} + \sum_{i}^{q} A_i Y_{t-i} + \sum_{i}^{q} AA_i Y_{t-i} dum_{regime} + \sum_{i}^{q} B_i X_{t-i} + u_t \quad (Eq\ 4)$$

where π_t is headline inflation and the change rate of NEER.

$$Y_t = \begin{pmatrix} \pi_t \\ \Delta NEER_t \end{pmatrix} \quad (Eq\ 5)$$

and X_t includes change rates of global oil prices and broad money for control effects.

$$X_t = \begin{pmatrix} \pi_{oil,t} \\ \Delta m_{2,t} \end{pmatrix} \quad (Eq\ 6)$$

25. **To keep the regression economically meaningful, this paper sets the lag length to 12 and then applies the general-to-specific approach to drop insignificant regressors**. Consequently, all lags beyond three periods are insignificant and dropped. Also, the following tests are applied to the regression results: (i) the Lagrange-multiplier test suggests no autocorrelation in residuals; (ii) all the eigenvalues lie inside the unit circle and thus the ADL model is stable; (iii) Lagrange-multiplier test shows no autocorrelation in the residuals; (iv) and the residuals satisfies the normality condition.

Table 6. Regression Results for Headline Inflation

Variable	Coefficient	Statistics
Food inflation (-1)	0.45	3.14**
Food inflation (-3)	0.21	2.39*
Dummy for regime	2.26	3.74**
Dummy for regime X Food inflation (-1)	-0.66	-2.41*
Dummy for regime X Food inflation (-3)	-0.385	-2.44**
Dummy for regime X NEER (-1)	-0.059	-3.00**
Dummy for regime X NEER (-2)	-0.02	-1.84**
Dummy for regime X NEER (-3)	-0.067	-3.23**
Constant	0.28	1.96
Note: Coefficients for other control variables are not reported.		

The regression results (Table 6) show that: with control for broad money and oil prices,
(i) No pass-through of NEER to headline inflation before the economic reform in 2012;
(ii) The pass-through of NEER to headline inflation is 11 percent after the regime switch.

26. **Meanwhile, a nonlinear model is also constructed to double-check the time-varying property of the exchange rate pass-through**.[12] Given that inflation and the exchange rate vary dramatically from 2002 to 2015, a unified framework which incorporates the idea proposed by Taylor (2000) that the pass-through is dependent on the level of inflation is employed. Then, the nonlinear regression results are compared with the ADL outcome to reinforce robustness of the findings.

27. **Researchers have employed the nonlinear framework to study the behavior of exchange rates**, such as Michael, Nobay and Peel (1997) and Kilian and Taylor (2003). Inspired by Shintani, Terada-Hagiwara, and Yabu (2013), this paper uses the Logistic transition function, $\Phi(x_t, D)$, to capture the time-varying feature and also allows it to change after the regime switch (Eq 7).

$$\pi_t = a_0 + \sum_{i=1}^{q} a_i \times \pi_{t-i} + \Phi(x_t, D) * \left(\sum_{i=1}^{q} b_i \times \Delta NEER_{t-i} \right) + \sum_{i}^{q} B_i X_{t-i} + u_t \qquad (Eq\ 7)$$

where, $\Phi(x_t, D) = \frac{1}{1+e^{-D*x_t}}$, $(Eq\ 8)$

$$D = \begin{cases} D_1\,, & \text{before the regime switch} \\ D_2\,, & \text{after the regime switch} \end{cases}$$

$$x_t = \frac{(\sum_{i=0}^{2} \pi_{t-i})}{3}$$

28. **For the optimal lag length of the nonlinear model, AIC suggests 9 while BIC indicates 2**. In this context, the paper takes the 3–period lags to compare the results with the ADL model and also compute the 9–period lag results. The estimated time-varying pass-through[13] is displayed in the following chart (Figure 5); (i) before April 2012, the long-term pass-through is close to zero; (ii) after the regime switch in 2012, the pass-through jumps from zero to around 12 percent, which is close to the estimated value of the ADL model above. Both empirical frameworks point to the same finding that the pass through increased after the switch to a floating exchange rate regime in 2012.

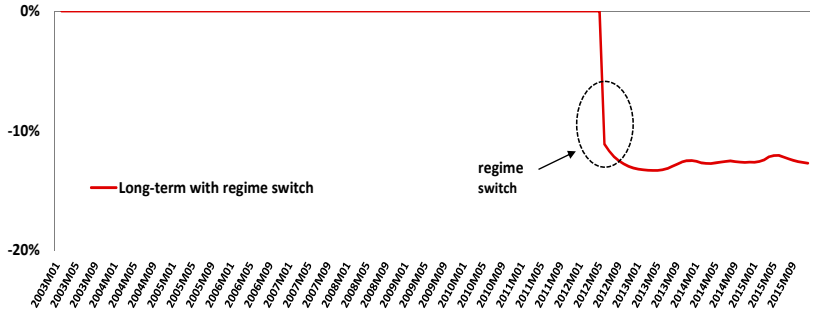
29. **Razafimahefa (2012) finds that the average pass-through for SSA countries is estimated at around 40 percent** while the average pass-through for SSA countries with the floating regime around 30 percent. The difference between Razafimahefa (2012) and this paper could arise for the following reasons: (i) this paper uses monthly data while Razafimahefa (2012) used quarterly data. When monthly data is seasonally adjusted, some

[12] The regression equation is set up based on the paper of Shintani, Terada-Hagiwara and Yabu (2013).

[13] The results are the model with 3-period lags.

useful information could be filtered out; (ii) the after-regime-switch time series is less than 4 years, relatively short; (iii) this paper uses proxy variables to control for other effects when running regression while Razafimahefa (2012) does not; (iv) the paper uses the equilibrium state to compute the long term pass-through while Razafimahefa (2012) uses the 4th quarter response as the long term pass-through.

Figure 5. The Long-run Pass-Through of the NEER to Headline Inflation



Sources: NSO of Malawi, RBM and staff estimates.

VII. Sources of Headline Inflation

30. **This section conducts an analysis on the driving forces of headline inflation in Malawi.** The regression equations are specified using the new Open-Economy Keynesian framework with optimizing agents and nominal rigidities (Clarida et al. (2002), Adolfson et. al (2011)). A growing body of literature extends the basic New-Keynesian Model to the open-Economy context. We draw on the model used in Walsh (2010):

$$\pi_t = \beta E_t \pi_{t+1} + \tilde{\beta} MC_t - \beta\gamma\left(E_t(\ln FX_{t+1} + lnP^f_{t+1} - lnP^h_{t+1}) - (lnFX_t + lnP^f_t - lnP^h_t)\right) + \gamma\left((lnFX_t + lnP^f_t - lnP^h_t) - (lnFX_{t-1} + lnP^f_{t-1} - lnP^h_{t-1})\right) \quad (Eq\ 9)$$

where, MC_t is the marginal cost of production unit, FX_t is the exchange rate, P^h_t and P^f_t are prices of goods produced within and outside the economy respectively, ln is the natural log and E_t is the expectation operator (Eq 9). From 2002 to 2015, because the global inflation remains low and stable, the regression equation drops the variable of external inflation to avoid multicollinearity with the constant. Instead, the regression uses the changes in oil prices as a control variable.

31. **In addition, this paper assumes that the marginal cost is influenced by the real growth rate.** Also, firms need to borrow to expand their production, so the interest rate is one variable that has impacts on the marginal cost. In this context, the paper modifies the marginal cost function to be:

$$MC_t = F(\Delta GDP, r) \quad (Eq\ 10)$$

where, ΔGDP is real growth rate and r is the benchmark rate for borrowing. The monetary authorities use the T-bill rate and broad money as intermediate policy tools to manage inflation and exchange rate expectations, which implies three more behavior equations.

Furthermore, it is natural to assume that production is subject to all the economic factors mentioned above. Lastly, as a small open economy, Malawi is subject to external shocks not only through exchange rate, but also through external demand or price fluctuations.

$$C_0 Y_t = CC_0 + \sum_{i}^{q} C_i Y_{t-i} + \sum_{i}^{q} F_i X_{t-i} + \varepsilon_t \qquad (Eq\ 11)$$

where Y_t includes real growth, headline inflation, T-bill rate and change rates of NEER and broad money.

$$Y_t = \begin{pmatrix} \Delta GDP_t \\ \pi_t \\ \Delta NEER_t \\ \Delta m_{2,t} \\ r_{Tbill,t} \end{pmatrix} \qquad (Eq\ 12)$$

$X_t = (\pi_{oil,t})$, CC_0 is the constant item.

32. **The paper adopts the approach of Gregory and Hansen (1996) to test if there is cointegration among the variables after taking into account a structural break**. The null hypothesis (H0) for the Gregory and Hansen test is: no co-integration against the presence cointegration in the present of an unknown regime shift. Three statistics are calculated for the test, namely, ADF-type, Z_α-type and Z_t-type statistics. This test not only offers three criteria to determine the optimal lag length, but also estimates the most possible timing of the regime shift. All statistics cannot reject the null hypothesis at the 10–percent significance level except for the ADF-type statistic with AIC. Therefore, there is no co-integration for the sample period taking into account regime switch (Table 7).[14]

Table 7. Results of Test for Co-integration with Regime Shifts

Based on Gregory and Hansen (1996)
H0: no co-integration with the presence of a unknown regime shift

Information criterion	Statistics (at 10–percent significance level)		
	ADF-type	Z_t-type	Z_α-type
AIC	Reject H0	Cannot reject H0	Cannot reject H0
BIC	Cannot reject H0	Cannot reject H0	Cannot reject H0
Downward T-value	Cannot reject H0	Cannot reject H0	Cannot reject H0

Note: The ADF-type statistic under AIC cannot reject H0 at the 5 percent level.

[14] Table 7 presents the major statistics for the test. Meanwhile, the detailed test results for inflation, real growth, NEER, broad money and T-bill rate are presented in Appendix II.

33. **Identification of shocks in the short-run SVAR framework is predicated on the ordering of variables.** The paper assumes that economic activities respond to policy shocks with a lag because it takes time for the economy to absorb them. Meanwhile, price variables respond to shocks more quickly than quantity variables, implying that price and exchange rate immediately absorb shocks while real production does with a lag.

$$\begin{bmatrix} 1 & 0 & 0 & 0 & 0 \\ . & 1 & 0 & 0 & 0 \\ \cdot & \cdot & 1 & 0 & 0 \\ \cdot & \cdot & . & 1 & 0 \\ . & . & . & . & 1 \end{bmatrix} \begin{bmatrix} \varepsilon_{\Delta gdp} \\ \varepsilon_{\pi} \\ \varepsilon_{NEER} \\ \varepsilon_{m2} \\ \varepsilon_{Tbill} \end{bmatrix} = \begin{bmatrix} . & 0 & 0 & 0 & 0 \\ 0 & . & 0 & 0 & 0 \\ 0 & 0 & \cdot & 0 & 0 \\ 0 & 0 & 0 & . & 0 \\ 0 & 0 & 0 & 0 & . \end{bmatrix} \begin{bmatrix} \mu_{\Delta gdp} \\ \mu_{\pi} \\ \mu_{NEER} \\ \mu_{m2} \\ \mu_{Tbill} \end{bmatrix} \qquad (Eq\ 13)$$

34. **The optimal strategy for regression is to divide the whole sample into two sub-periods**: before and after the regime shift. This section compares the periods before and after the regime shift and discusses the difference between their response functions.

35. **The impulse response functions of headline inflation show that it has become more responsive and resilient after the 2012 regime shift**, in the face of shocks to real GDP growth, NEER, broad money and T-bill rate (Figure 6).

- Compared to the response before the regime reform, the response of headline inflation to a one-unit shock to real growth is significantly higher, and converges to the equilibrium level after period ten. This result is consistent with economic intuition that without price controls, economic variables move freely to absorb the shocks and enable the economy to return to equilibrium more quickly, reflecting stronger economic resilience.

- In response to the shock to the NEER, the reaction of headline inflation after the regime shift shows greater fluctuation, which takes about 5 periods to subside. This can be explained by capital flow management and price control before 2012. With these policy interventions, inflationary expectation could become anchored.

- In response to the shock to broad money, the floating exchange rate regime allows headline inflation to absorb newly-injected liquidity, causing it to increase. In contrast, the fixed regime, combined with price controls distort the price response to the monetary signal.

- Headline inflation's response to an interest rate hike repeats the same dynamic pattern as in the case of a shock to the NEER. Compared to the period with the fixed exchange rate regime, an interest rate shock has a larger negative impact on headline inflation, but it absorbs the shock, rebounds and moves towards the equilibrium after 14 months.

36. **The variance decomposition of the forecast errors shows that shocks to headline inflation itself remains the most significant source of inflation fluctuation** although all other shocks turn out to explains a larger part of its variance after 2012 (Figure 7). In particular:

- Shocks to the NEER explain more than 20 percent of inflation variance after one month. This is largely due to the adoption of floating exchange regime. In contrast, during the fixed regime, shocks to the NEER could only account for less than 5.5 percent on average.

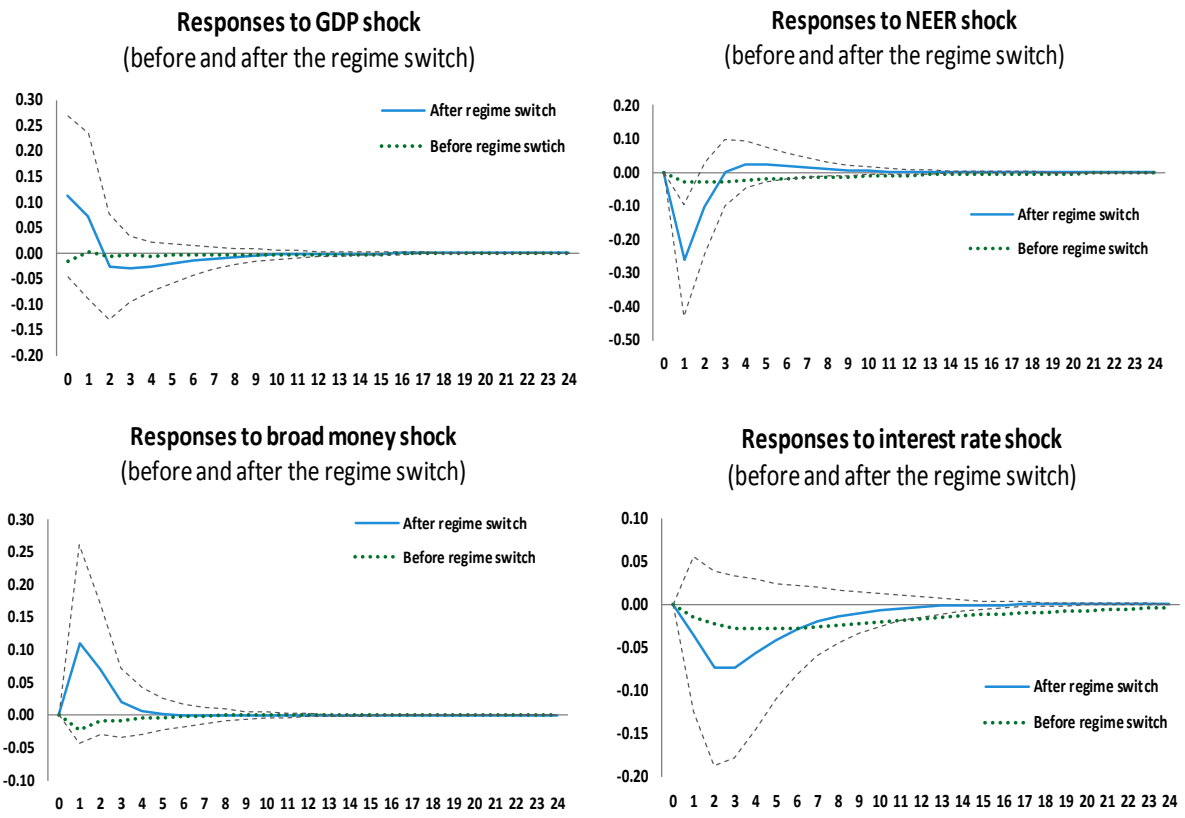
- Shocks to T-bill rates have become noticeable after the regime shift, accounting for about 4 percent of inflation variation. Before the regime shift, shocks to the interest rate only explain less than 1 percent of the variance of inflation. This might reflect improvement in the monetary transmission mechanism although more efforts are needed to strengthen liquidity management and align the policy rate and money market rates.

- After the exchange rate regime shift, the shocks to broad money contribute to less than 5 percent of headline inflation variation while its contribution reaches 8 percent under the fixed regime. Considering that headline inflation has become more responsive to broad money shocks, it is the smaller variance of broad money that helps to reduce the percentage contribution to the variance of inflation. [15]

The 24–month average contribution of real growth shocks to inflation fluctuations increases from less than 1 percent before the regime switch to almost 5 percent after the regime switch. Intuitively, the market-based production has been more fluctuated than before. Nevertheless, it also builds up economic resilience.

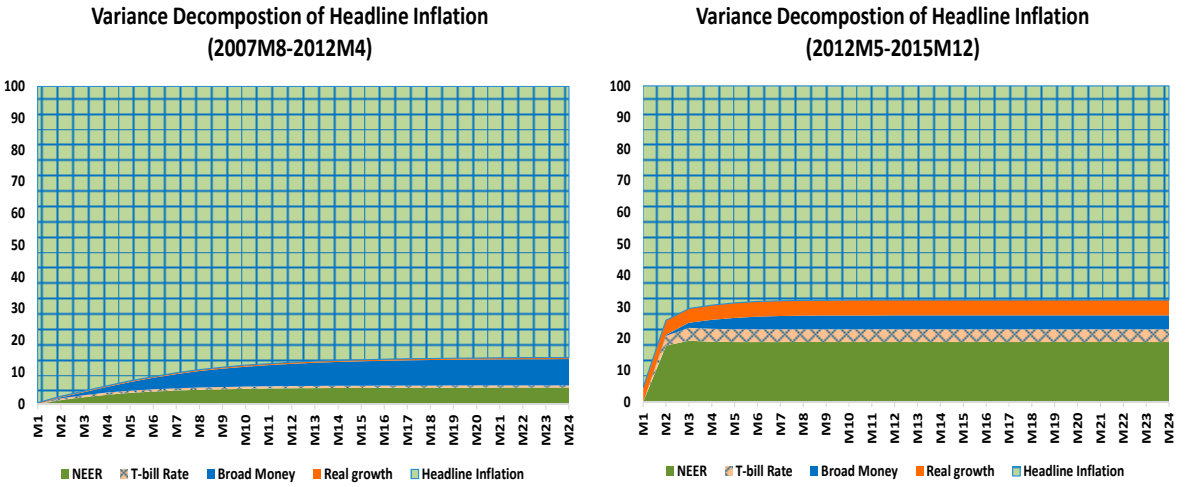
[15] Please see Loungani and Swagel (2001). Shocks to highly-powered money is not only representatives of the RBM's judgment about the current status and near-term trend in inflation, but also reflective of the current fiscal situation.

Figure 6. Impulse Responses of Headline Inflation



Source: IMF staff calculations.

Figure 7. Variance Decomposition of the Forecast Errors



Source: IMF staff calculations.

IX. Policy Implications and Conclusion

37. **This paper provides a first estimate of the inflation dynamics after Malawi adopted the floating exchange rate regime in 2012**. There is strong evidence that inflation in Malawi underwent a structural break and the behavior properties of macroeconomic variables have changed subsequently. The paper applies the VAR approach to this period taking into account the interaction among macro variables.

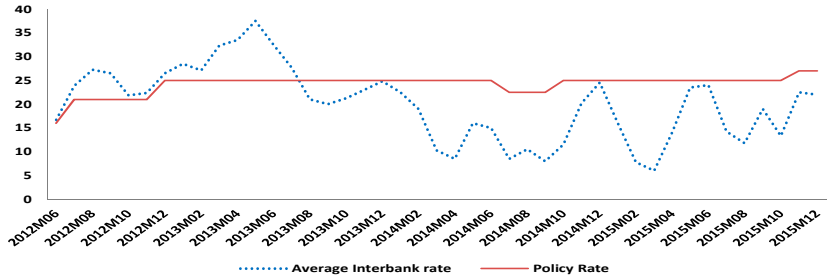
38. **The main conclusion and policy suggestions are**:

- After the regime shift, nonfood inflation has become more autonomous[16] while there is a strong pass-through to food inflation. This helps explain why headline inflation remains so elevated after the adoption of the floating regime although adverse weather-related shocks also play important roles in driving up inflation. Given the significant influence of nonfood prices in the new regime, it is necessary to pay special attention to domestic nonfood market and monitor any new direction of price movements.

- Since May 2012, the pass-through of exchange rate to inflation has increased to around 11 percent when other effects are controlled for, which is also reflected in the increased share of headline variance explained by NEER shocks. As a means to shelter the economy from adverse supply shock, the exchange rate contributes to the building up of economic resilience. Nevertheless, excessive movement in the exchange rate could damage investor's confidence and hamper growth. In this context, foreign exchange intervention should be limited to smoothing volatility of the exchange rate.

- The contribution of interest rate shocks increases after 2012 means the improvement of monetary policy transmission compared with that in the past. However, it also indicates that the variance of interest rate shocks is on the rise. In this context, it is necessary to strengthen communication with the public and make policy design more transparent, and thus credible. In this way, variances of the shock to T-bill rate would decline, helping to further reduce the variance of inflation (Figure 8).

Figure 8. Policy Rate and Interbank Rate in Malawi



Source: The Reserve Bank of Malawi.

[16] Based on the econometric results of Section IV, the second-round impact of food prices is negligible on non-food prices when other macro effects are controlled.

The impulse response functions show clearly that broad money shocks have a strong impact on headline inflation. Among all the factors, high-powered reserve money is one primary source for board money shocks. Two major channels for reserve money growth are credit to the government and credit to the private sector. Due to recent two-digit inflation, the banking sector has shown strong risk-averse tendency and therefore credit to private sector stalls. However, lack of fiscal discipline and capability leads to massive fiscal slippage and accumulated arrears. If fiscal deficit is monetized this would undermine public confidence in the credibility of policies to reduce inflation. Without remedial measures, the economy could end up with high inflation and zero growth. In this context, strengthening budget control and improving public financial management are indispensable to anchoring inflation expectations.

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Appendix I. Economic Model for the Pass-Through of Exchange Rate to Domestic Prices

In the domestic good market, there is a representative final-good producer and a continuum of monopolistically competitive importing firms. Each of the importing firms imports a differentiated intermediate good from abroad and sell it to the final-good producer.

For each importing firm, its demand function is

$$D_{it} = \left(\frac{P_{it}}{P_{final,t}}\right)^{-\theta} D_t \tag{A.1}$$

where P_{it} is the contracted price of imported good i with the final good producer, D_t is the composite demand for the final good, and $P_{final,t}$ is the final good price

The profit maximization objective function of each importing firm is:

$$P_{it}D_{it} - FX_{t-1}P_{t-1}^{f}D_{it}$$

where FX_{t-1} is the exchange rate and $P_{t-1}^{f}$is the foreign input price, which is determined fully by the foreign company. The profit maximization price for importing firm i is:

$$P_{it}^{*} = \frac{\theta}{\theta-1} FX_{t-1}P_{t-1}^{f} \tag{A.2}$$

The final-good producer signs a price contract with each importing firm for two periods. After the first period, the importing firm has a possibility of $(1-\phi(E_t\pi_t))$ to opt out of the contract and reprice its intermediate good because importing firms face fixed cost for price adjustment; if the importing firm chooses to stay with the previous contract, the price movement takes into account current inflation level. This implies that, for the firms with prices set at the previous period, $(1-\phi(E_t\pi_t))$ reprice their goods at P_{it}^{*} and $\phi(E_t\pi_t)$ have the price of their goods to be automatically adjusted to $P_{it-1}^{*} * (1+E_t\pi_t)$

The price composite of the economy is defined as:

$$P_t = \prod_i \left(\widetilde{P_{it}}\right)^i$$

where $1 = \int i\, di$

Therefore, $\ln P_t = \frac{1}{2} ln\widetilde{P_{it}} + \frac{1}{2} ln\widetilde{P_{it-1}}$

$$\begin{aligned}
&= \frac{1}{2}\left(lnP_{it}^{*} + \left(1-\phi(E_t\pi_t)\right)lnP_{it}^{*} + \phi(E_t\pi_t) * (lnP_{it-1}^{*} + E_t\pi_t)\right) \\
&= \frac{1}{2}(2 * lnP_{it}^{*} - \phi(E_t\pi_t)(lnP_{it}^{*} - lnP_{it-1}^{*}) + \phi(E_t\pi_t) * E_t\pi_t) \\
&= lnP_{it}^{*} - \frac{1}{2} * \phi(E_t\pi_t) * (lnP_{it}^{*} - lnP_{it-1}^{*}) + \frac{1}{2} * \phi(E_t\pi_t) * E_t\pi_t
\end{aligned}$$

$$\begin{aligned}
\Delta lnP_t = \Delta lnP_{it}^{*} - \frac{1}{2} * \phi(E_t\pi_t) * \Delta lnP_{it}^{*} + \frac{1}{2} * \phi(E_t\pi_t) * \Delta lnP_{it-1}^{*} + \frac{1}{2} * \phi(E_t\pi_t) * E_t\pi_t \\
- \frac{1}{2} * \phi(E_{t-1}\pi_{t-1}) * E_{t-1}\pi_{t-1}
\end{aligned} \tag{A.3}$$

Plug (A.2) into (A.3),

$$\pi_t = \frac{\theta}{\theta-1}(\Delta lnFX_{t-1} + \pi^f_{t-1}) - \frac{1}{2} * \frac{\theta}{\theta-1} * \phi(E_t\pi_t) * (\Delta lnFX_{t-1} + \pi^f_{t-1}) + \frac{1}{2} * \frac{\theta}{\theta-1} * \phi(E_t\pi_t) * (\Delta lnFX_{t-2} + \pi^f_{t-2}) + \frac{1}{2} * \phi(E_t\pi_t) * E_t\pi_t - \frac{1}{2} * \phi(E_{t-1}\pi_{t-1}) * E_{t-1}\pi_{t-1} \quad \text{(A.4)}$$

where $\Delta lnFX_{t-1}$ is the change rate of exchange rate.

In (A.4), domestic price change, π, is a function of the change rate of foreign exchange $\Delta lnFX$, expected domestic price change $E\pi$, foreign price changes π^f_{t-1}, and their lags.

Appendix II: Test on Co-integration with a Structural Break

For the test of Gregory and Hansen (1996),
H0: no co-integration with the presence of an unknown regime shift.
H1: co-integration in the presence of an unknown regime shift.

When the test chooses the number of lags that minimize the Akaike information criterion, the test results show:

(i) ADF-type statistic indicates that the null hypothesis can be rejected at a 10–percent significance level;

(ii) Z_t-type and Z_α-type statistics cannot reject the null hypothesis at the 10–percent significance level.

Gregory-Hansen Test for Cointegration with Regime Shifts
Model: Change in Regime — Number of obs = 101
Lags = 3 chosen by Akaike criterion — Maximum Lags = 12

	Test Statistic	Breakpoint	Date	Asymptotic Critical Values 1%	5%	10%
ADF	-6.38	78	2014m1	-6.92	-6.41	-6.17
Zt	-6.10	75	2013m10	-6.92	-6.41	-6.17
Za	-53.08	75	2013m10	-90.35	-78.52	-75.56

When the test chooses the number of lags that minimize the Bayesian information criterion, the test results show: all three statistics cannot reject the null hypothesis at the 10-percent significance level.

Gregory-Hansen Test for Cointegration with Regime Shifts
Model: Change in Regime — Number of obs = 101
Lags = 0 chosen by Bayesian criterion — Maximum Lags = 12

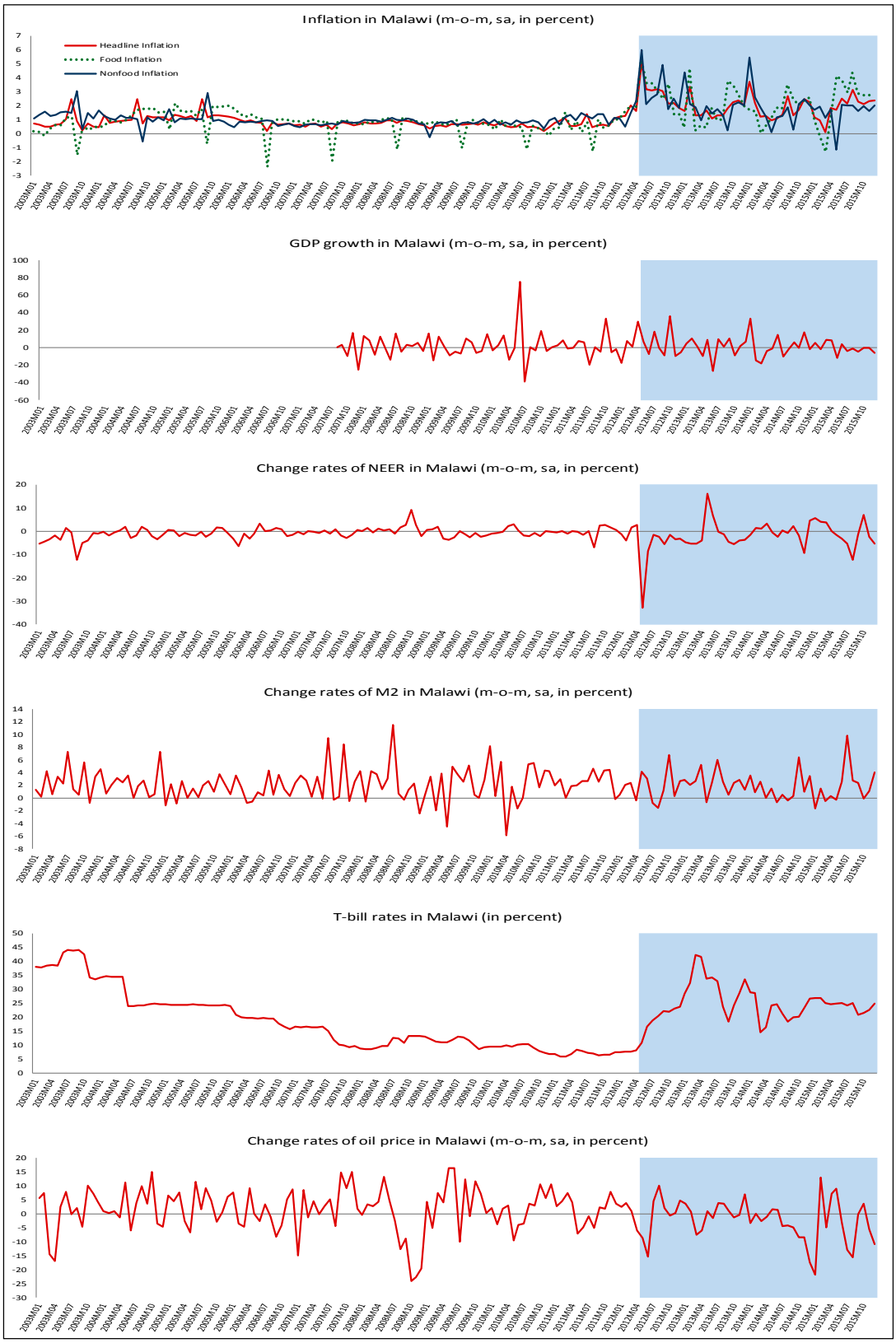
	Test Statistic	Breakpoint	Date	Asymptotic Critical Values 1%	5%	10%
ADF	-5.93	76	2013m11	-6.92	-6.41	-6.17
Zt	-6.10	75	2013m10	-6.92	-6.41	-6.17
Za	-53.08	75	2013m10	-90.35	-78.52	-75.56

When the test chooses the number of lags such that the last lag is significant according to its t-statistic starting from a maximum number of lags, the test results show: all three statistics cannot reject the null hypothesis at the 10–percent significance level.

Gregory-Hansen Test for Cointegration with Regime Shifts
Model: Change in Regime — Number of obs = 101
Lags = 5 chosen by downward t-statistics — Maximum Lags = 12

	Test Statistic	Breakpoint	Date	Asymptotic Critical Values 1%	5%	10%
ADF	-4.89	75	2013m10	-6.92	-6.41	-6.17
Zt	-6.10	75	2013m10	-6.92	-6.41	-6.17
Za	-53.08	75	2013m10	-90.35	-78.52	-75.56

Appendix III. Plots of Time Series used in the Paper



Appendix IV. Regression Results in Tabular Form

Regression Results for Food Inflation		
Variable	Coefficient	Statistics
Food inflation (-1)	0.25	3.43**
Food inflation (-2)	0.20	2.40*
Nonfood inflation (-1)	0.18	2.27*
Nonfood inflation (-5)	0.19	2.65**
Nonfood inflation (-10)	0.19	2.89**
Nonfood inflation (-12)	0.50	5.60**
Dummy for regime	0.37	1.71
Dummy for regime X Food inflation (-2)	-0.43	-2.75**
Dummy for regime X Food inflation (-7)	0.34	3.05**
Dummy for regime X Food inflation (-8)	-0.33	-2.47*
Dummy for regime X Nonfood inflation (-12)	-0.75	-6.84**
Constant	-0.76	-3.35**
Note: Coefficients for other control variables are not reported.		

Regression Results for Non Food Inflation		
Variable	Coefficient	Statistics
Food inflation (-1)	0.18	3.21**
Food inflation (-10)	0.19	3.76**
Nonfood inflation (-1)	0.27	2.95**
Nonfood inflation (-6)	0.13	1.74
Nonfood inflation (-11)	0.20	2.94**
Nonfood inflation (-12)	-0.29	-4.32**
Dummy for regime	3.37	13.24**
Dummy for regime X Food inflation (-2)	-0.55	-5.17**
Dummy for regime X Food inflation (-4)	0.42	4.53**
Dummy for regime X Food inflation (-5)	-0.70	-6.67**
Dummy for regime X Food inflation (-8)	-0.52	-4.48**
Dummy for regime X Food inflation (-11)	0.45	4.78**
Dummy for regime X Food inflation (-12)	0.53	5.50**
Dummy for regime X Nonfood inflation (-1)	-0.75	-6.90**
Dummy for regime X Nonfood inflation (-6)	-0.18	-1.96
Dummy for regime X Nonfood inflation (-9)	-0.33	-4.71**
Dummy for regime X Nonfood inflation (-11)	-0.41	-4.91**
Dummy for regime X Nonfood inflation (-12)	-0.75	-6.84**
Constant	-0.30	-1.55
Note: Coefficients for other control variables are not reported.		

Regression Results for Headline Inflation		
Variable	Coefficient	Statistics
Food inflation (-1)	0.45	3.14**
Food inflation (-3)	0.21	2.39*
Dummy for regime	2.26	3.74**
Dummy for regime X Food inflation (-1)	-0.66	-2.41*
Dummy for regime X Food inflation (-3)	-0.385	-2.44**
Dummy for regime X NEER (-1)	-0.059	-3.00**
Dummy for regime X NEER (-2)	-0.02	-1.84**
Dummy for regime X NEER (-3)	-0.067	-3.23**
Constant	0.28	1.96
Note: Coefficients for other control variables are not reported		

Results for autocorrelation test:

It cannot be rejected that there is no autocorrelation up to 4 lags.

Lagrange-multiplier test

lag	chi2	df	Prob > chi2
1	2.4227	4	0.65852
2	3.3564	4	0.50005
3	1.9961	4	0.73648
4	4.1851	4	0.38153

H0: no autocorrelation at lag order

Results for normality test:

It cannot be rejected that the disturbances of the VAR are normally distributed.

Jarque-Bera test

Equation	chi2	df	Prob > chi2
inf_f_sa_dsa	0.136	2	0.93430
inf_nf_mom_sa	3.548	2	0.16962
ALL	3.684	4	0.45040

Skewness test

Equation	Skewness	chi2	df	Prob > chi2
inf_f_sa_dsa	-.0525	0.071	1	0.78957
inf_nf_mom_sa	.04154	0.045	1	0.83279
ALL		0.116	2	0.94375

Kurtosis test

Equation	Kurtosis	chi2	df	Prob > chi2
inf_f_sa_dsa	3.1001	0.065	1	0.79921
inf_nf_mom_sa	3.7366	3.504	1	0.06123
ALL		3.569	2	0.16792

Results for VAR stability:

There is one eigenvalue which is 1.00267, so it is not stable.

Results for autocorrelation test:

It cannot be rejected that there is no autocorrelation up to 4 lags.

Cumby-Huizinga test for autocorrelation (Breusch-Godfrey)
H0: variable is MA process up to order q
HA: serial correlation present at specified lags >q

H0: q=0 (serially uncorrelated) HA: s.c. present at range specified				H0: q=specified lag-1 HA: s.c. present at lag specified			
lags	chi2	df	p-val	lag	chi2	df	p-val
1 - 1	0.057	1	0.8118	1	0.057	1	0.8118
1 - 2	0.658	2	0.7198	2	0.466	1	0.4948
1 - 3	1.596	3	0.6602	3	0.588	1	0.4431
1 - 4	1.634	4	0.8027	4	0.011	1	0.9154

Test allows predetermined regressors/instruments
Test requires conditional homoskedasticity

Results for heteroskedasticity test:

It cannot be rejected that there is no heteroscedasticity.

Cameron & Trivedi's decomposition of IM-test

Source	chi2	df	p
Heteroskedasticity	89.57	88	0.4333
Skewness	17.58	14	0.2264
Kurtosis	7.91	1	0.0049
Total	115.07	103	0.1959

Results for normality test:

It is rejected at the one-percent significance level that the disturbances are normally distributed. In this context, central limit theorem is utilized to derive its asymtotic distribution and other statistic properties.

Shapiro-Wilk W test for normal data

Variable	Obs	W	V	z	Prob>z
r	164	0.93112	8.653	4.915	0.00000