Terms of Trade Shocks and Inflation Targeting in Emerging Market Economies

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Terms of Trade Shocks and Inflation Targeting in Emerging Market Economies.

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Abstract

Emerging market economies (EMEs) have persistently experienced different waves of commodity terms of trade disturbances, generating macroeconomic instabilities. The adoption of inflation targeting (IT) by many emerging market economies has raised the questions about its relative suitability in dealing with these shocks compared with other regimes. This paper tests the robustness of inflation targeting compared to monetary targeting and exchange rate targeting regimes in coping with commodity terms of trade shocks. It uses a panel VAR technique to analyse in a comparative framework, aggregate impulse response functions and variance decompositions of variables to commodity terms of trade shocks. The results show that in general, IT countries respond better to commodity terms of trade shocks especially with respect to inflation and output gap. However, exchange rates are more volatile in IT countries than in exchange rate targeting countries. The results suggest that EMEs countries can reduce the adverse effects of commodity terms of trade fluctuations when they adopt inflation targeting, but they also need to pay attention to exchange rate movements.

Keywords: Inflation targeting, commodity terms of trade shocks, emerging markets, panel VAR.

JEL classification: E52, G28

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1 Introduction

Over the years, emerging market economies (EMEs) have continued to experience different waves of commodity terms of trade shocks which were periodically large and persistent. For example the sharp increases in commodity prices between 2003 and 2008, where oil and food prices rose by almost 160% and 900% respectively, have generated large terms of trade fluctuations (Batini and Tereanu, 2009). In many EMEs, such swings in commodity terms of trade have become a recurring source of macroeconomic volatility (Mendoza, 1995; Ahmed, 2003). These experiences have called into question the role of inflation targeting as a monetary policy framework compared with other monetary policy frameworks in dealing with these exogenous shocks. Bernanke et al. (1997) emphasised that the right response to external shocks is important because wrong policy responses may aggravate macroeconomic volatility.

Previous empirical studies on exogenous shocks and macroeconomic dynamics have focused on the role of the exchange rate regimes in dealing with these shocks (see e.g. Broda, 2004; Edwards and Yeyati, 2005). They have overlooked the role of alternative monetary policy regimes. The few studies that have analysed the monetary policy responses to external shocks have focused primarily on oil price shocks (see e.g. Mishkin and Schmidt-Hebbel, 2007; Blanchard and Gali, 2007). The focus on oil price shocks limits the scope and coverage of these studies, leaving many questions about policy responses to relative price shocks unanswered. For example, the mechanisms through which commodity price movements affect macroeconomic variables under different monetary policy regimes is still unclear. Thus, there is little guidance on the choice of monetary policy regimes to cope with commodity terms of trade shocks.

This study fills this gap by examining how different monetary policy frameworks can account for differences in macroeconomic volatility generated by commodity terms of trade shocks. Specifically, the study tests the resilience of inflation targeting (IT) relative to monetary targeting (MT) and exchange rate targeting (ET) in dealing with commodity terms of trade shocks in EMEs.1 The study also compares the responses of IT countries before and after the adoption of inflation targeting to see if IT really makes a difference when the economy is hit by external shocks. The study employs the panel vector autoregression (VAR) framework and estimates impulse responses and variance decompositions of inflation, output gap, exchange rates and interest rates to commodity terms of trade shocks under alternative monetary policy regimes.

The study contributes to literature in several ways. Firstly, it contributes to the debate on the optimal policy responses to external shocks by empirically validating alternative monetary

1 Resilience is the capacity to absorb shocks and recover quickly following such shocks.
policy responses to commodity terms of trade shocks in a unified framework. Since the failure of central banks to deal with the shocks of the 1970s, little consensus has emerged on the best monetary policy framework to deal with terms of trade shocks. However, recent advances in monetary policy making have made prominence the adoption of inflation targeting as a way of stabilising economies. The proponents of this regime argue that the monetary policy framework that can effectively deal with external shocks is the one based on the trinity of flexible exchange rate, inflation target and monetary policy rule (see e.g. Taylor, 2000). They claim that IT can deliver the expected, while dealing with the unexpected. On the contrary, the opponents of IT argue that it is more vulnerable to external shocks, hence other monetary policy regimes can stabilise economies better (see e.g. Kumhof, 2001; Stiglitz, 2008).

Secondly, in contrast to previous studies which use standard terms of trade indices, this study uses country-specific commodity terms of trade indices. This is motivated by many factors. For instance, commodity terms of trade indices capture the fluctuations of exchange rates that are more exogenous to the business cycle than standard terms of trade indices (Aghion et al., 2004). In addition, Raddatz (2007) argues that the use of commodity terms of trade indices give a better chance to exogenous shocks to actually play a role because they have larger explanatory power for output and price fluctuations than standard terms of trade indices. More importantly, Chen and Rogoff (2003) argues that the exchange rate is very sensitive to the movements in commodity terms trade, especially in commodity exporting countries because commodities are the most volatile components of traded goods. As such, the use of commodity terms of trade indices may help resolve some empirical puzzles which have been found in modeling real exchange rates and macroeconomic dynamics. Finally, commodity terms of trade indices capture both the country’s exposure to global commodity cycles and a larger set of fundamental relative price movements that are not indicated by movement in price of one commodity such as oil (Tytell and Spatafora, 2009). This makes them to be more relevant for macroeconomic analysis.

Thirdly, the study focuses specifically on EMEs. These economies have a number of features that are important within the framework of monetary policy design in the presence of commodity terms of trade shocks. For instance, they are generally small in sizes, open and rely on trade in commodities. This makes them to be more vulnerable to commodity terms of trade shocks than advanced countries (Spatafora and Warner, 1995). Several studies have estimated that terms of trade volatility in EMEs is more than three times higher than in advanced countries (see e.g. Loayza et al., 2007; Jacks et al., 2011). Hence their effects are quite significant in EMEs. In addition, many EMEs are unable to adopt optimal counter cyclical stabilisation policies because of low financial sector development, sudden stops of capital
flows, weak institutional frameworks (Calvo and Mishkin, 2003) and weak shock absorbers (Hoffmaister and Roldos, 2001). Also, their heterogeneous monetary policy frameworks provide a spectrum of experiences which allow clear comparison of different monetary policy responses to commodity terms of trade shocks. Therefore, the focus on these countries helps to deepen our understanding of appropriate monetary policy responses to commodity terms of trade shocks, taking into account their structural and institutional realities.

The results show that there are differences in the responses to commodity terms of trade shocks, with inflation targeting having relatively better outcomes. More precisely, the results provide robust evidence of lower responses of output gap, inflation and interest rates in inflation targeters than in monetary targeters and exchange rate targeters. Also, when the responses of variables for inflation targeters before and after IT adoption are compared, the results show that output gap, inflation, exchange rates and interest rates are substantially higher for the period before IT adoption than after IT adoption. However, the responses of exchange rates to commodity terms of trade shocks are higher in IT countries than in ET countries. Through variance decompositions, the study also provides evidence that commodity terms of trade shocks account for larger variability of output gap and inflation in non-IT countries than in IT countries. Overall, IT countries seem to exhibit smaller responses followed by exchange rate targeters and lastly monetary targeters. The results suggest that the adoption of inflation targeting can reduce the impact of commodity terms of trade shocks on the economy. However, policy makers also need to pay attention to exchange rate fluctuations induced by commodity terms of trade shocks.

The rest of the paper is organised as follows: section 2 outlines the review of literature, section 3 presents the theoretical framework. Section 4 outlines the estimation method and identification framework while section 5 describes the data and variables. Section 6 presents the analysis of estimation results and section 7 presents robustness tests. Finally, section 8 concludes and provides some policy recommendations.

2 Review of Literature

There are two strands of literature related to exogenous shocks, macroeconomic instability and policy responses. The first strand focuses on the role of exchange rates in dealing with terms of trade shocks, and the second relates to the design of optimal monetary policy in small open economies.

The strand of literature that links terms of trade shocks to exchange rates has its roots in the arguments of Friedman (1953) and Meade (1955). This literature claims that flexible
exchange rates act as "shock absorbers" in small open economies. According to this view, flexible exchange rates allow smooth adjustment in relative prices and enable the economy to cope with exogenous shocks. However, in the case of fixed exchange rates, the adjustment of the real exchange rate to equilibrium takes place through changes in domestic nominal prices and wages. If prices and wages are rigid, this adjustment can be costly. This theory predicts that countries with flexible exchange rates can potentially insulate the economy from external shocks, and avoid costly and protracted adjustment processes. Indeed, since the flexible exchange rate is a component of inflation targeting, its combination with monetary independence can enhance effective countercyclical monetary policy.

Subsequent empirical literature has tested the insulation hypothesis of exchange rates. For example Broda (2004) tests whether the macroeconomic effects of terms of trade shocks differ across exchange rate regimes in 75 developing countries from 1973 to 1996. He finds that the short-run real GDP response to terms of trade shocks is smaller in countries with flexible exchange rates than those with fixed exchange rates. Also the depreciation of the real exchange rate is immediate after negative terms of trade shocks under flexible exchange rate than under fixed exchange rate. He concludes that flexible exchange rates allow countries to buffer negative terms of trade shocks through smooth changes in the exchange rate. However, his study uses standard terms of trade indices. The problem is that in the presence of nominal price rigidities and incomplete exchange rate pass-throughs, standard terms of trade indices may pose challenges for proper model identification. Rigidities may prevent these indices from adequately capturing contemporaneous movements that induce immediate exchange rate responses (Chen and Rogoff, 2003).

Edwards and Yeyati (2005) also empirically examine the shock absorption power of flexible exchange rates under terms of trade shocks using a sample of 183 countries for the period 1974–2000. They find that flexible exchange rates perform better than fixed exchange rates. They also conclude that the effectiveness of exchange rate regimes in economic stabilisation depends on the type of the shock hitting the economy. For instance fixed exchange rates are suitable for dealing with nominal shocks, while flexible exchange rates are suitable for dealing with real shocks. Nevertheless, their study does not consider the potential role of alternative monetary policy regimes in coping with terms of trade shocks.

The strand of literature on the design of monetary policy in small open economies argues that exchange rates can be incorporated in monetary policy rules to account for disturbances in the external sector. For example, Ball (1998) extends the theoretical model of inflation targeting to open-economy settings by including the exchange rate in the Taylor rule. He argues that an appreciation of the exchange rate perhaps due to favourable terms of trade can
lead to cuts in the interest rate, followed in the next period by an offsetting increase in the interest rate. Therefore, the economy which is subject to external shocks can make frequent adjustments of the interest rates. The model suggests that small open economies should target the long run inflation rate in order to reduce volatility in economic activity induced by external shocks. Nevertheless, his model does not focus on peculiar features of emerging market economies like trade in commodities as a source or propagation mechanism of external shocks. In the context of EMEs, the consideration of such key features may be crucial in explaining the macroeconomic dynamics and adjustment processes following external shocks.

Svensson (2000) develops a forward-looking open economy inflation targeting model with a cost push shock and an open economy Taylor rule. He notes that a cost push shock affects the real exchange rate which in turn affects both domestic and foreign demand. The key insight of his model is that flexible inflation targeting framed with respect to forecast inflation can cope with unfavourable supply shocks because of anchored inflation expectations, transparency and flexibility. The model predicts that inflation targeting can reduce short run effects of disturbances on real variables while anchoring medium term inflation expectations.

In a calibrated model, Kumhof (2001) looks at the relative performance of IT compared to other regimes in the face of many shocks. Under the negative tradable endowment shock and the real interest rate shock (exogenous shocks), IT performs worse than exchange rate targeting in terms of deviation of tradable consumption from its steady state value. In terms of welfare, monetary targeting seems to be superior to exchange rate targeting and IT. He also finds that inflation targeting imposes a very tight limit on exchange rate flexibility. Nevertheless, the study does not explicitly consider the optimal monetary policy responses to commodity terms of trade shocks. Also the model is calibrated and not estimated, hence it would be more tractable to consider an empirical approach in the evaluation of different monetary policy regimes.

Using a panel VAR technique, Mishkin and Schmidt-Hebbel (2007) test for differences in dynamic responses of macroeconomic variables to oil price shocks and exchange rate shocks between inflation targeters and non-inflation targeters. They find that inflation targeting countries have smaller inflation responses to oil price shocks and exchange rate shocks. Although their study brings to attention the role of alternative monetary policy regimes in the face of exogenous shocks, it only uses oil prices which do not capture a larger set of fundamental relative price movements. Their study also uses developed countries as a control group for a sample of IT EMEs, yet developed countries are different from EMEs.
3 Theoretical framework

To motivate the empirical estimation in the next section, a simple theoretical framework which captures the interactions of key macroeconomic variables is postulated. In this case, a modified version of the small open economy model developed by Ball (1998) and Cavoli et al. (2006) is considered. The core structure of the small open economy model includes an IS equation, a Phillips Curve, an uncovered interest parity (UIP) condition, monetary policy rule and the terms of trade equation.

Each emerging market economy is assumed to be small with respect to the rest of the world, such that the later is considered as exogenous. The model also assumes that each emerging market economy has exports, imports and non-traded goods. Primary commodities are assumed to constitute a significant portion of exports such that the economy is a net exporter of mainly commodities.

The terms of trade is defined as the ratio of the price of exports to the price of imports. In growth terms, the terms of trade is described by:

\[ \Delta f_{it} = \pi_{Xit} - \pi_{Mit} \]  

where \( \Delta f_{it} \) is the growth of terms of trade, \( \pi_{Xit} \) is the change in domestic price of exported goods and \( \pi_{Mit} \) the change in domestic price of imported goods of country \( i \) at time \( t \). The law of one price is assumed to hold on both exports and imports. Taking this into account, and after some computations, the terms of trade can be written as:

\[ f_{it} = f_{it-1} + \pi_{Xt}^* - \pi_t^*. \]  

Relaxing some assumptions and for empirical estimation purposes, the following broad specification of the terms of trade equation is considered instead:

\[ f_{it} = \alpha_{it0} + \alpha_1 f_{it-1} + \pi_{Xt}^* - \pi_t^* + \varepsilon_{fit}. \]  

Equation (3) shows that the change in terms of trade is a result of the change in the price of exported goods and change in world price. Since primary commodities account for a significant portion of exports, the terms of trade index can be considered as the commodity

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2 This is true for almost any emerging market economy. However for a few big countries such as China, Russia and India, this is becoming an exception. But for the major part of the sample period it is also true for these countries.

3 See Appendix A for derivation.
The equation which links real exchange rate, nominal exchange rate and commodity terms of trade is given by:

$$\Delta q_{it} = \Delta e_{it} + \pi_{it} - \pi_{Xt}^* + \Delta f_{it},$$  \hspace{1cm} (4)

where $\Delta q_{it}$ is the growth rate of real exchange rate of country $i$ at time $t$, $\Delta e_{it}$ is the change in the nominal exchange rate of country $i$ at time $t$, $\pi_{it}$ is the inflation of country $i$ at time $t$ and $\pi_{Xt}^*$ is the world inflation of exported goods at time $t$. In the rest of the paper the following approximation is made:

$$q_{it-1} = \theta e_{it-1},$$  \hspace{1cm} (5)

where $\theta$ is a positive parameter. It follows that,

$$q_{it} = e_{it} + (\theta - 1)e_{it-1} + \pi_{it} - \pi_{Xt}^* + \Delta f_{it}$$  \hspace{1cm} (6)

The equation shows that the real exchange rate is affected by the change in nominal exchange rate, domestic inflation, change in prices of exports and change in commodity terms of trade.

The model also describes the evolution of the nominal exchange rate according to the uncovered interest parity (UIP) relation as follows:

$$e_{it} = e_{it-1} + \beta_2 (r_{it} - r_t^*) + \varepsilon_{eit}$$  \hspace{1cm} (7)

where $\beta_2$ is a parameter, $r_{it}$ is the real interest rate of country $i$ at time $t$, $r_t^*$ is the rest of the world interest rate at time $t$ and $\varepsilon_{eit}$ is the disturbance term that captures other influences on the exchange rate and the noise in the foreign exchange and asset markets. In most cases, the UIP condition is stated as an identity which relates the change in the exchange rate to the interest rate differential between the domestic economy and the rest of the world. The UIP is included in the model to capture the behavior of the asset markets. More specifically, it captures the idea that a rise in interest rates makes domestic financial assets to be more attractive leading to the appreciation of the exchange rate.

The evolution of inflation is described by a Phillips curve as:

$$\pi_{it} = \gamma_1 \pi_{it-1} + \gamma_2 y_{it} + \gamma_3 q_{it} + \gamma_4 y_{it-1} + \varepsilon_{\pi it}$$  \hspace{1cm} (8)

where $\gamma_1$, $\gamma_2$, $\gamma_3$ and $\gamma_4$ are parameters, $\varepsilon_{\pi it}$ is the disturbance term components. In this

\footnotetext[4]{Going foward, the terms of trade is described as the commodity terms of trade.}
\footnotetext[5]{The derivation of this equation is in Appendix A.}
specification, the lagged inflation term captures the inflation inertia, while the current and lagged output gap capture the contemporaneous as well as lags in the transmission of output shocks to inflation. The real exchange rate affects inflation through import prices. Substituting equation (6) in (8), the above Phillips curve can be written as:

\[
\pi_{it} = \lambda_1 \pi_{it-1} + \lambda_2 y_{it} + \lambda_3 e_{it-1} - \lambda_3 \pi^*_X t + \lambda_3 (f_{it} - f_{it-1}) + \lambda_5 y_{it-1} + \varepsilon_{\pi it} \quad \text{(9)}
\]

where \(\lambda_1, \lambda_2, \lambda_3, \lambda_4\) and \(\lambda_5\) are the new parameters.

The output gap is described by the modified IS curve of the Mundell-type open economy model. It is close to the IS curve by Cavoli et al. (2006) with the difference that some interrelations are with current variables instead of lags. The equation is:

\[
y_{it} = \delta_{i0} + \delta_1 y_{it-1} + \delta_2 (r_{it} - \pi_{it}) + \delta_3 q_{it} + \delta_4 y^{*}_{it} + \varepsilon_{yt} \quad \text{(10)}
\]

where \(\delta_{i0}, \delta_1, \delta_2, \delta_3\) and \(\delta_4\) are parameters, \(y_{it}\) is the output of country \(i\) at time \(t\), \(y^{*}_{it}\) is the foreign output at time \(t\). \(\varepsilon_{yt}\) is an IS shock which captures other influences on output gap. The lagged output gap term is there to capture persistence effects on output gap which may arise due to costly adjustment processes. Also, the rise in interest rates reduces output gap, indicating that monetary policy affects the economy. As is common in most specifications of the output gap, this IS equation shows that output is affected by the real exchange rate and foreign output.

Substituting equation (6) into the above equation and rearranging yields:

\[
y_{it} = \varphi_{i0} + \varphi_2 r_{it} - \varphi_3 \pi_{it} + \varphi_4 e_{it} + \varphi_4 f_{it} + \varphi_1 y_{it-1} + \varphi_5 e_{it-1} - \varphi_4 f_{it-1} - \varphi_4 \pi^*_X t + \varphi_6 y^*_t + \varepsilon_{yt} \quad \text{(11)}
\]

This new specification is close to Lubik and Schorfheide (2007) and Spatafora and Warner (1995), in which the IS equation of Cavoli et al. (2006) has been modified to include the commodity terms of trade instead of real exchange rate. This helps to capture the direct effects of commodity terms of trade on output. According to Spatafora and Warner (1995), terms of trade shocks affect output through the spending effect and the resource movement effect. In terms of the spending effect, terms of trade shocks increase aggregate wealth which raise demand for non-tradable goods relative to importable goods. This results in increase in the price and output in the non-traded sector. In the case of a resource movement effect, positive terms of trade shocks raise the marginal product of factors of production in the export sector, resulting in the movement of mobile factors of production from the non-traded sector.
into the export sector. This acts to decrease output. The overall effect on the non-traded output is to increase or decrease it depending on which effect dominates. Mendoza (1995) notes that terms of trade shocks may be transmitted to the economy through international capital mobility, cost of imported inputs and the real exchange rate.

The model is closed by describing the monetary policy rule. The central bank uses a Taylor rule where it adjusts its interest rates in response to movements in output gap, inflation and exchange rates. The Taylor rule is specified as follows:

\[ r_{it} = \omega_1 r_{it-1} + \omega_2 y_{it} + \omega_3 \pi_{it} + \omega_4 \Delta e_{it} + \varepsilon_{rit} \]  

(12)

where \( \omega_1, \omega_2, \omega_3 \) and \( \omega_4 \) are parameters, \( \varepsilon_{rit} \) is the disturbance term. In this specification, the central bank responds to inflation, output gap and exchange rate while at the same time it maintains some degree of interest rate smoothing.

The structural model for the panel of small open emerging market economies described above can be regrouped in the following system of equations.

\[
\begin{align*}
    f_{it} &= \alpha_i + \alpha_1 f_{it-1} + \pi^*_X t - \pi^*_t + \varepsilon_{fit} \\
    \varepsilon_{it} &= \varepsilon_{it-1} + \beta_2 (r_{it} - r^*_t) + \varepsilon_{eit} \\
    \pi_{it} &= \lambda_1 \pi_{it-1} + \lambda_2 y_{it} + \lambda_3 e_{it} + \lambda_4 e_{it-1} \\
    y_{it} &= \varphi_i f_{it-1} + \varphi_4 \pi_{it} + \varphi_3 \pi_{it} + \varphi_2 y_{it-1} \\
    r_{it} &= \omega_1 r_{it-1} + \omega_2 y_{it} + \omega_3 \pi_{it} + \omega_4 \Delta e_{it} + \varepsilon_{rit}
\end{align*}
\]

Rearranging the model equations by sending all the endogenous variables to the left and distinguishing between the lagged variables, the country specific characteristics and rest of the world variables, the following matrix equation is obtained:

\[ AY_{it} = X_i + BY_{it-1} + CX^*_t + \varepsilon_{it} \]  

(13)

where,

\[
A = \begin{pmatrix}
1 & 0 & 0 & 0 & 0 \\
0 & 1 & 0 & 0 & -\beta_2 \\
-\lambda_3 & -\lambda_3 & 1 & -\lambda_2 & 0 \\
-\varphi_4 & -\varphi_4 & \varphi_3 & 1 & -\varphi_2 \\
0 & -\omega_4 & -\omega_3 & -\varphi_4 & 1
\end{pmatrix},
\]
\[ B = \begin{pmatrix}
\alpha_1 & 0 & 0 & 0 & 0 \\
0 & 1 & 0 & 0 & 0 \\
-\lambda_3 & \lambda_4 & \lambda_1 & \lambda_5 & 0 \\
-\varphi_4 & \varphi_5 & 0 & \varphi_1 & 0 \\
0 & \omega_4 & 0 & 0 & \omega_1
\end{pmatrix}, \quad C = \begin{pmatrix}
0 & 1 & -1 & 0 \\
-\beta_2 & 0 & 0 & 0 \\
0 & \lambda_3 & 0 & 0 \\
0 & -\lambda_4 & 0 & \varphi_6 \\
0 & 0 & 0 & 0
\end{pmatrix}, \]

\[ Y_{it} = \begin{pmatrix}
f_{it} \\
e_{it} \\
\pi_{it} \\
y_{it} \\
r_{it}
\end{pmatrix}, \quad Y_{it-1} = \begin{pmatrix}
f_{it-1} \\
e_{it-1} \\
\pi_{it-1} \\
y_{it-1} \\
r_{it-1}
\end{pmatrix}, \quad X_i = \begin{pmatrix}
\alpha_{i0} \\
0 \\
0 \\
\varphi_{i0} \\
0
\end{pmatrix}, \]

\[ X_t^* = \begin{pmatrix}
r_t^* \\
\pi_{Xt}^* \\
y_t^*
\end{pmatrix} \quad \text{and} \quad \varepsilon_{it} = \begin{pmatrix}
\varepsilon_{fit} \\
\varepsilon_{eit} \\
\varepsilon_{\pi it} \\
\varepsilon_{rit} \\
\varepsilon_{yit}
\end{pmatrix} \]

\[ Y_{it} = F_i + \Gamma Y_{it-1} + T_t + u_{it} \]  \hspace{1cm} (14)

\( Y_{it} \) is the vector of endogenous variables, \( A \) the matrix of structural coefficients and contemporaneous interactions, \( B \) is the matrix of lagged interactions, \( C \) is the matrix of external time interactions, \( X_i \) is the vector of constants for each country, \( X_t^* \) is the vector of exogenous variables from the rest of the world at time \( t \) and \( \varepsilon_{it} \) is the vector of structural disturbances which are assumed to be normally distributed with mean zero, constant variance, serially uncorrelated and orthogonal to each other.\(^6\)

The structural equation (13) cannot be estimated directly because of the correlation between the variables and the error terms. Therefore, there is a need to transform the structural equations into reduced form equations which can actually be estimated. In order to achieve this, equation (13) is pre-multiplied by \( A^{-1} \) to obtain the following reduced form equation:

\[ Y_{it} = F_i + \Gamma Y_{it-1} + T_t + u_{it} \]  \hspace{1cm} (14)

where \( F_i = A^{-1}X_i \), \( \Gamma = A^{-1}B \), \( T_t = A^{-1}CX_t^* \) and \( u_t = A^{-1}\varepsilon_{it} \). \( u_t \) is the reduced form residual vector which is assumed to be white noise.

The dynamic responses of variables are analysed under different monetary policy regimes. Under inflation targeting, the central bank adjusts interest rates to keep inflation rate on target. Under monetary targeting, the central bank adjust interest rates to keep money growth rate constant while under exchange rate targeting, the monetary authority target the nominal exchange rate.

\(^6\)However, this paper will not consider the rest of the world variables explicitly, it will approximate them by time variables.
4 Estimation Method and Identification

4.1 Empirical Model

This study seeks to examine if commodity terms of trade shocks affect differently, EMEs with different monetary policy regimes. To test this hypothesis, the study applies the reduced form panel VAR framework as in equation (14). However, in order to improve the econometric properties of the model in the estimation, the study follows Love and Zicchino (2006) and considers the following broad specification instead: 7

\[ Y_{it} = \Gamma_0 + \Gamma(L)Y_{it} + F_i + T_t + u_{it} \]  

(15)

where: \( Y_{it} = (CTOT_{it}, YGAP_{it}, INFL_{it}, ER_{it}, RTS_{it}) \) is a vector of all variables. \( CTOT_{it} \) is the commodity terms of trade, \( YGAP_{it} \) is the output gap, \( INFL_{it} \) is the inflation rate, \( ER_{it} \) is the exchange rate variable and \( RTS_{it} \) is the interest rate. \( \Gamma_0 \) is a matrix of constants, \( F_i \) is the vector of country specific fixed effects and \( T_t \) is a vector of time fixed effects which accommodates aggregate shocks to \( Y_{it} \) that are common across countries. \( u_{it} \) is the reduced form residual vector. \( \Gamma(L) \) is the matrix of polynomial lags that captures the relationships between variables and their lags. \( i \) and \( t \) are country and time indices respectively. As Love and Zichino (2006) notes, the application of VARs in panel data requires the assumption that the underlying structure is the same for each cross-sectional unit. 8

The advantages of the panel VAR method are threefold. Firstly, it provides a flexible framework which combines the traditional VAR approach with panel data, thus increasing the efficiency and the power of analysis while capturing both temporal and contemporaneous relationships among variables (Mishkin and Schmidt-Hebbel, 2007). Secondly, the technique can take into account complex relationships and identifies dynamic responses of variables following exogenous shocks using both impulse response functions and variance decompositions. In that way, it provides a systematic way to capture rich dynamic structures and comovements between different variables over time. This allows clear examination of the economy’s responses to commodity terms of trade shocks under different monetary policy regimes. Thirdly, it addresses the endogeneity problem by allowing for endogenous interactions and feedback effects between variables in the system. Also, the introduction of fixed effects permits the model to account for country specific unobserved heterogeneity.

\footnote{7The stata codes developed by Love and Zichino (2006) are used to run the Panel VAR model}

\footnote{8Love and Zichino (2006) argues that since this requirement is likely to be violated in practice, one way of overcoming the restriction on the parameters is to allow for individual heterogeneity in the levels of the variables by introducing fixed effects \( F_i \). This means that there are no restrictions on the unconditional means and variances of \( Y_{it} \) which help to capture the cross-sectional heterogeneity between countries.}
4.2 Identification

The challenge in estimating model (15) is the presence of country-specific unobserved characteristics. Therefore, fixed effects are introduced to take into account individual country heterogeneity. However, fixed effects are correlated with regressors because of the lags of the dependent variables in the system. The mean-differencing procedure commonly used to eliminate fixed effects tend to create biased coefficients. Following Arellano and Bover (1995) and Love and Zicchino (2006), the forward mean differencing (Helmert procedure) is used to remove all future values for each country-year. This procedure involves removing fixed effects of all variables by transforming them into deviations from the average future observations. The transformation ensures that the variance is standardized by weighting each observation and errors that are not correlated. The procedure preserves the orthogonality between the transformed variables and the lagged regressors. Thus the coefficients are estimated by GMM where lagged regressors are used as instruments. This transformation preserves homoskedasticity while reducing serial correlation (Arellano and Bover, 1995).

The impulse response functions of variables to commodity terms of trade shocks are then estimated. The key identifying assumption is the exogeneity of commodity terms of trade shocks. This assumption rests on the small open economy structure, where countries are price takers in the world markets for commodities (Ahmed, 2003; Edwards and Yeyati, 2005). In the estimations, reduced-form errors may be correlated, making impulse response functions to be unreliable. Following Sims (1980), the standard Choleski decomposition of the variance-covariance matrix of residuals is used to identify the innovations in the system. The Choleski decomposition induces a recursive orthogonal structure on the shocks. In this case, the variance-covariance matrix of the residuals is assumed to be diagonal and lower triangular (which implies the orthogonality of shocks). This procedure relies on recursive causal ordering of variables for identification of shocks. The variables listed earlier in the VAR impact the other variables contemporaneously, while disturbances in the variables listed later have lagged effects on the preceding ones. Thus the variables are ordered according to the degree of exogeneity, with earlier variables considered to be more exogenous than later variables (Mishkin and Schmidt-Hebbel, 2007).

Variables in the panel VAR are ordered as follows: commodity terms of trade, output gap, inflation, exchange rates and interest rates. Terms of trade is ordered first, implying that it does not react to contemporaneous changes in other variables. It is believed that this is the most exogenous variable because of the small open economy argument. Output

\textsuperscript{9}This identification scheme has been frequently used in monetary policy transmission studies (see Christiano et al., (1999)).
gap is ordered second consistent with the assumption that commodity terms of trade shocks affect output gap contemporaneously and with a lag while there is likely to be no feedback effects. Inflation and exchange rates are ordered after output gap, because economic theory suggests that contemporaneous causation goes from output gap dynamics to movements in domestic prices and exchange rates. The exchange rates are ordered after inflation because of the argument that the effect of inflation on exchange rates is likely to be contemporaneous and if there is any feedback effect, it is likely to happen with a lag. However as noticed by Ahmed (2003), the reverse can be true since changes in the exchange rate can be a source of instability for domestically driven shocks. Finally, interest rates are ordered last. This is based on the consideration that being a policy variable, it react contemporaneously to the dynamics of the earlier macroeconomic variables, although the feedback effects are expected to operate with a lag. This is in line with several studies in monetary transmission processes (see e.g. Bernanke and Mihov, 1998; Christiano et al., 1999). Our study adopts an ordering almost similar to Mishkin and Schmidt-Hebbel (2007).

The differences in dynamic responses of variables to terms of trade shocks are evaluated by comparing aggregate impulse response functions and variance decompositions (innovation accounting) across both periods and monetary policy regimes. The impulse response functions trace out the time path of variable responses to shocks in the error terms for several periods in the future and inform us on the sign and time trajectory of the impact. The confidence intervals on the impulse response functions are generated by Monte Carlo simulations. Variance decomposition explains the percentage of the variation in output gap, inflation, exchange rates and interest rates explained by the commodity terms of trade shocks. If inflation targeting improves the country’s resilience to external disturbances, then commodity terms of trade shocks are expected to account for less volatility of the variables in IT than in other regimes.

5 Data and Variables

5.1 Data

This study uses quarterly panel data for 35 emerging market economies from 1980-2008. The countries are listed in Table 1. The sample is divided into 15 inflation targeters and 20 non-inflation targeters (control group). The sample of inflation targeters is further divided with respect to time, that is before inflation targeting and after inflation targeting. This constitutes unbalanced panels because of the differences in the adoption dates of inflation targeting. Non-inflation targeters are divided into monetary targeters and exchange rate targeters to allow for heterogeneity in the setting of monetary policies. There are 11 monetary targeters and 9
exchange rate targeters in the sample of non-inflation targeters. Non-inflation targeters are further divided in terms of time, where 1995 is the dividing year. This allows for dynamic comparison between two time horizons, that is, before and after 1995. This period is chosen because it is consistent with the inflation targeters’ average adoption dates in the 1990s.

[Table 1 here]

The main variable in this study is the commodity terms of trade index. The commodity terms of trade index was originally developed by Deaton and Miller (1996). The index used in this study was modified and updated by Tytell and Spatafora (2009). The commodity terms of trade index is a weighted average of the main commodity export prices divided by the weighted average of the main commodity import prices.\(^\text{10}\) This index is related to the standard terms of trade index but conceptually different because it focuses on commodities and reflect their importance in the overall economy.

The commodity terms of trade is calculated as follows:

\[
CTOT_{it} = \frac{\prod_j (P_{jt}/MUV_t)^{X_{ji}}}{\prod_j (P_{jt}/MUV_t)^{M_{ji}}}
\]

where \(P_{jt}\) is the individual commodity prices, \(MUV_t\) is the manufacturing unit value index defined as the trade-weighted index of the five major developed countries’ exports of manufactured commodities to developing countries.\(^\text{11}\) As is common in most studies, MUV is used as a deflator in order to get real commodity export and import prices (see e.g. Cashin and McDermott, 2002). \(X_{ji}\) is the share of exports of commodity \(j\) in country \(i\)’s GDP and \(M_{ji}\) is the share of imports of commodity \(j\) in country \(i\)’s GDP. In order to allow the effect of commodity export or import prices to be larger for countries with higher commodity exports or imports and for cross country differences to be taken into account, the deflated index is weighted by the share of commodity exports or imports in a country’s GDP (Tytell and Spatafora, 2009). The weights for both imports and exports are fixed and averaged over time and applied to world prices of the same commodity to form a country specific geometrically weighted index of prices. This allows supply responses to price changes to be excluded so

\(^{10}\) The index constructed by Tytell and Spatafora (2009) is based on the prices of six commodity categories (food, fuels, agricultural raw materials, metals, gold, and beverages). Overall, there are 32 commodities involved namely; beef, lamb, wheat, rice, corn (maize), bananas, sugar, coffee, cocoa, tea, soybean meal, fish, hides, soybeans, natural rubber, har log, cotton, wool, iron, copper, nickel, aluminum, lead, zinc, tin, soya oil, sun oil, palm oil, coconut oil, gold, shrimp and crude oil

\(^{11}\) The developed countries considered here are France, Germany, Japan, United Kingdom and United States of America
that terms of trade variation is determined by the price volatility of particular commodities. This makes the commodity terms of trade index to be exogenous to the behavior of individual countries. Since the nature and composition of each country’s exports and imports are different, the commodity terms of trade indices move differently for each country even though the underlying world prices are the same. In the estimations, the growth of commodity terms of trade is used. Higher commodity terms of trade are expected to appreciate the real exchange rate.

Output gap is measured by the deviation of real GDP from its trend. It is computed using the Hodrick Prescott filter with a smoothing parameter of 1600. In most literature on monetary policy in small open economies, output gap represents the IS equation (see e.g. Ball, 1998; Svensson, 2000; Cavoli et al., 2006). It enters the panel VAR as a measure of economic activity which captures business cycle fluctuations.

Inflation is measured by the annualised change in composite consumer price indices. Quarterly measures of inflation are used. In small open economy models, inflation is represented by the Phillips curve equation. As common in monetary policy literature, inflation enters the model as a policy goal variable being an indicator of price changes (see e.g. Bernanke and Mihov, 1998).

For the exchange rate variable, the percentage change in the bilateral nominal exchange rate for each country is used. This reflects the depreciation or appreciation of the bilateral nominal exchange rates. Although some studies use the real exchange rate, this study uses the bilateral nominal exchange rate because it allows the evaluation of the direct effects of commodity terms of trade shocks on the exchange rate. Several studies in literature use bilateral nominal exchange rates in the panel VAR to capture the transmission of external shocks to EMEs (see e.g Mishkin and Schmidt-Hebbel, 2007).

The interest rate variable used is the policy interest rates of central banks. Whenever the policy interest rate is not available, the three months treasury bill rates are used. Policy rates are interest rates at which the central bank provides short term loans to banks. Several studies on the monetary transmission mechanism based on VARs use this variable as an indicator of the stance of monetary policy (see e.g. Christiano et al., 1999; Bernanke and Blinder, 1992).12 It is the operating target of the central bank. As shown in the theoretical framework, the short term policy interest rate is depicted by the Taylor rule. The choice of this variable is

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12 This study did not include money supply growth, although it is an intermediate variable for monetary targeters. It is believed that the inclusion of interest rate effectively reduce the effectiveness and predictive power of money supply since short term interest rates are better measures of monetary policy stance than money supply (Sims 1980). Also in a standard ISLM model, money supply require an increase in the interest rates to restore money market equilibrium. The omission of this variable is in line with most literature on monetary policy.
motivated by the observation that most central banks follow a monetary policy rule in their responses to economic disturbances. The variables description and data sources are presented in Table 2 in the Appendix.

[Table 2 here]

5.2 Descriptive Analysis

The paper proceeds by providing some descriptive statistics to uncover some key stylised facts of the data. Figure 1 shows the profile of commodity terms of trade indices which have been detrended by the Hodrick Prescott filter for different monetary policy regimes. Commodity terms of trade have fluctuated significantly over the years. The profile of booms and busts in commodity terms of trade shocks seems to follow major global economic disturbances such as the debt crises in 1982, the Mexican crises in 1998, Asian crises in 1997, oil shocks in the 1990s and the global financial crises from 2007. The rise in commodity prices from 2003 which peaked in 2008 is also reflected by the high volatility in commodity terms of trade around 2007. The busts seem to be larger, sharp and relatively shorter and are intercepted by booms. The general picture is that different regimes were exposed to similar patterns of commodity terms of trade shocks.

[Figure 1 here]

In Table 1, countries are grouped according to their monetary policy regimes. The table shows that for inflation targeters, Mexico, Thailand and Chile have large volatility of commodity terms of trade, while Hungary and Poland have relatively lower volatility. This is intuitive because these countries rely on few commodity exports whose prices are very volatile in world markets. For example, Chile relies on copper which accounts for over 40% of its total exports. Thailand and Mexico depend on rice and oil respectively. However, the levels and volatilities of other macroeconomic variables seem to be high in Brazil and Peru, possibly reflecting their historical experiences with hyper-inflation and exchange rate volatility in the 1980s. For monetary targeters, terms of trade volatility is considerably high in Nigeria, Algeria and Argentina. This also corresponds to the large volatility of exchange rates and output gap which may indicate that much of these fluctuations originate externally. There is a strong correlation between inflation and exchange rates especially in Argentina and Croatia which may possibly reflect previous high exchange rate pass-throughs and less credibility of

\(^{13}\)The commodity terms of trade indices in the figure are HP filtered so that they are interpreted as deviations from a trend which represent shocks.
monetary policies. Among exchange rate targeters, Table 1 shows that Ukraine, El Salvador, Venezuela and Malaysia exhibit considerably higher volatility in commodity terms of trade of 9.23%, 8.76%, 7.85% and 7.82% respectively. Ukraine and Venezuela are oil exporters, thus the volatility of their exchange rates may be coming from oil price movements. The table also shows that Malaysia and El Salvador have high volatility of commodity terms of trade and output gap. This comovement can be explained by fluctuations in international prices of rubber and coffee, which are their key exports respectively.

Table 3 compares summary statistics of inflation targeters before and after the adoption of inflation targeting. It shows that commodity terms of trade variability is higher before IT adoption than after IT adoption. It is apparent from the table that the average levels of most variables are relatively high before inflation targeting than after inflation targeting possibly indicating past sharp business cycle fluctuations and hyper-inflations in the 1980s especially in Latin American countries. Moreover, the volatility of output gap, inflation and interest rates is quite high before inflation targeting than after inflation targeting possibly reflecting the process of disinflation (Batini et al., 2006).

[Table 3 and 4 here]

In Table 4, summary statistics for inflation targeters, monetary targeters and exchange rate targeters after 1995 are compared. On average, exchange rate targeters have higher commodity terms of trade variability than inflation targeters and monetary targeters. Inflation targeters have average inflation rate of 5.44 while monetary targeters and exchange rate targeters have 10.65 and 12.40 respectively. Inflation volatility is considerably lower in IT countries, while it is six times higher in monetary targeters and four times higher in exchange rate targeters. This may be explained by the credibility of monetary policy and the anchoring of inflation expectations. As predicted by theory, output gap exhibits more volatility in exchange rate targeters than in other regimes. The other key stylised fact in Table 4 is that the exchange rate is more stable in inflation targeters than exchange rate targeters which is generally unexpected considering the sluggishness in the adjustment of the exchange rates in the latter. Overall, the descriptive statistics show that inflation targeters exhibit lower volatility than other regimes and the observed standard deviations are substantially higher before IT adoption than after IT adoption.14

14Although all these countries are classified as emerging market economies, there are some variations between countries in terms of real GDP per capita and population sizes. This variation is taken into account later in the robustness tests when some large countries are excluded from the analysis.
5.3 Panel data tests

To estimate the empirical model correctly, the variables should be stationary and the model should be estimated with correct lag length. Stationarity tests are done using the Fisher Type of test as suggested by Maddala and Wu (1999). This test combines the p-values from individual unit root tests. Asymptotically, this test follows a chi-square distribution with 2N degrees of freedom. This test can handle unbalanced panels and the lag lengths of the individual augmented Dickey-Fuller tests can be determined separately. The null hypothesis is that the variables are not stationary. Table 5 shows the results. Based on this test, the null hypothesis is rejected showing that the variables are stationary. Therefore the panel VAR is estimated in levels. The estimation of panel VARs in levels is also common in recent studies of developing countries (see e.g. Raddatz, 2007; Loayza and Raddatz, 2007).

![Table 5 here]

VARs are generally sensitive to lag length. Kireyev (2000) points out that the correct number of lags is important for VARs because too few lags fail to capture the proper dynamics of the system and lead to omitted variable bias while too many lags lead to loss of too much information. In our estimation, the selection of the optimum lag length is guided by the Akaike information criteria, Bayesian information criteria and the Hannan-Quinn Criteria. Based on these criteria, the optimal lag length is four, which is also consistent with most estimations using quarterly data.

6 Estimation Results

This section compares and discusses the results, focusing on the impulse response functions and variance decompositions of output gap, inflation, exchange rates and interest rates explained by commodity terms of trade shocks under different monetary policy regimes.

6.1 Responses to commodity terms of trade shocks

The impulse responses to one positive standard deviation shock in commodity terms of trade for inflation targeters before and after IT adoption are discussed first. Figure 2 shows the results. The central solid lines show the point estimates of the impulse response functions and the outer dashed lines show confidence intervals of the impulse response functions.

![Figure 2 here]
The results show that a commodity terms of trade shock leads to an appreciation of the exchange rate. The booming commodity sector together with an appreciating exchange rate generate a wealth effect. This will result in an increase in demand for non-traded goods by either the government or the private sector, creating overheating of the economy. The prices of non-traded goods will rise, thereby inducing inflationary pressures in the economy. The central bank responds by raising interest rates.

On impact, the shock results in an initial drop in output gap for the period before IT adoption. The output gap increases over time peaking at about 0.8% in the third quarter in which the effect becomes significant. On the other hand, for the period after IT adoption, the shock leads to an initial positive effect on output gap which drops subsequently, but it is not significant. The response of the output gap is relatively stronger, sustained and more cyclical before IT adoption than after IT adoption. The weaker responses of the output gap for the period after IT adoption may reflect the fact that IT regime takes into account output fluctuations in the policy rule. This concurs with other findings in literature (see e.g. Mishkin and Schmidt-Hebbel, 2007) which reports low volatility of the output gap to oil price shocks after IT adoption than before IT adoption.

The responses of inflation are shown in the second row of Figure 2. The results show that commodity terms of trade shocks induce significantly positive and larger effects on inflation before inflation targeting than after inflation targeting. Specifically, for the period before IT adoption, inflation rises, peaking at about 2.5% in the third quarter. For the period after IT adoption, the rise in inflation peaks at about 0.3% in the fourth quarter. The inflation response for the period after IT adoption is relatively low possibly reflecting the stabilising role of IT. This is in line with other studies which show that there has been a decline in inflation volatility after the adoption of inflation targeting (see e.g. Goncalves and Salles, 2008).

Figure 2, third row shows that the nominal exchange rates appreciate by 0.5% on impact and further to 2% in the first quarter before depreciating gradually. For the period after IT adoption, the nominal exchange rate also appreciates up to the second quarter before the adjustment. The effect is significant. The responses of the exchange rate to commodity terms of trade shocks seem to be more volatile before IT adoption than after IT adoption. Although the opposite is expected due to flexible exchange rates under inflation targeting, as Sgherri (2008) notes, this result may reflect that IT central banks respond to exchange rates in order to smooth out its high volatility. This result however is not uncommon in literature, for example Edwards (2006) finds no evidence that the adoption of IT increases exchange rate volatility.
The fourth row in Figure 2 depicts the policy interest rates responses. For the period before IT adoption, interest rates rise by about 3% on impact and 4% in the first quarter followed by a protracted decrease. However, for the period after IT adoption, commodity terms of trade shocks induce a contemporaneous interest rate decrease of 0.1% which becomes positive after three quarters. This may imply that IT central banks lower interest rates in order to dampen the real output fluctuations after a commodity terms of trade shock. The positive response in the medium term is in response to rising inflation because of rising commodity prices. In general, the interest rate responses are stronger and more volatile before IT adoption than after IT adoption. This suggests that before IT adoption, central banks reacted to shocks more aggressively than after IT adoption. After IT adoption, the response to shocks has been gradual as central banks smooth their interest rates over several periods to reduce their volatility and improve the predictability of monetary policy (Svensson, 2000). Also, the impulse responses of the interest rate after IT adoption are less hump shaped than what is observed in most theoretical DSGE models, thus further supporting the interest rate smoothing phenomenon (see e.g. Batini and Tereanu, 2010).

Next, the paper compares the impulse responses of IT countries and non-IT countries. However, since the group of non-inflation targeters is heterogeneous in terms of monetary policy frameworks, aggregating them may lead to loss of interesting details. Therefore, as highlighted in the previous section, the group is subdivided into monetary targeters and exchange rate targeters as well as for the period before 1995 and after 1995 and compared with a benchmark case of inflation targeters. Figure 3 shows the impulse responses between inflation targeters after IT adoption and non-inflation targeters (monetary targeters and exchange rate targeters) after 1995.

[Figure 3 here]

In the first row of Figure 3, the results show that there is less variability and slower adjustment process of output gap in IT countries than monetary targeters and exchange rate targeters following a commodity terms of trade shock. However, the response in IT is not significant. The output gap response in monetary targeters is positive and significant up to the second quarter. The exchange rate targeters exhibit significantly largest output gap volatility and the responses are relatively more persistent compared to the first two regimes. The impact becomes significant after the fourth quarter. This response dynamics mirrors the greater cyclicality of the output gap that is also observed in the descriptive analysis in Table 4. This finding suggests that exchange rate targeters are more vulnerable to commodity terms of trade shocks while IT countries allow the flexible exchange rates to partially offset the output
gap fluctuations. The result accords with the findings of Edwards and Yeyati (2005) who observe that terms of trade shocks are amplified in countries that have more rigid exchange rates, while countries with flexible exchange rates buffer shocks and protracted adjustment of output. They emphasise that flexible exchange rates act as shock absorbers which reduce volatility in output.

With respect to inflation response, (second row, Figure 4) monetary targeters seem to experience higher volatility compared to inflation targeters with modest responses and exchange rate targeters with negative responses. More specifically, a one standard deviation shock in terms of trade results in an initial jump in inflation by 0.15% for inflation targeters and 0.5% jump for monetary targeters. The effects are significant. There is a decrease in inflation by about 0.1% for exchange rate targeters maybe due to exchange rate appreciation. Consistent with other findings, the lower response of inflation in IT countries compared to monetary targeters may reflect the anchoring of inflation expectations. In fact, Batini and Tereanu (2010) find that IT forward looking rules exhibit lower responses than other rules following oil price shocks. They suggest that this could be a result of the forward looking and transparent nature of IT which reduces the propagation power of inflation. Similarly, Mishkin and Schmidt-Hebbel (2007) find that inflation responses are significantly smaller for inflation targeters than non-inflation targeters following oil price shocks.

As expected, positive innovations in commodity terms of trade induce some appreciation of the nominal exchange rate during the period contemporaneous to the shock in IT countries. This is followed by the adjustment of the exchange rate in the medium term towards the equilibrium. Quantitatively, a commodity terms of trade shock induces a significant 0.7% appreciation of the exchange rate for inflation targeters in the first quarter. In contrast, for monetary and exchange rate targeters, there is an initial depreciation on impact, followed by a rather faster convergence towards the equilibrium in the medium term. In terms of volatility, monetary targeters exhibit highest volatility in the exchange rate followed by inflation targeters, while exchange rate targeters exhibit lowest volatility of the exchange rate. This finding is in line with theoretical expectations and the findings of Gerlach and Gerlach-Kristen (2006) which point to the presence of sluggish adjustments of the exchange rate in countries which target the exchange rate, implying no direct responses to terms of trade shocks.

Interest rate responses to commodity terms of trade shocks are shown in the fourth row of Figure 4. IT countries significantly respond by lowering interest rates on impact, followed by an offsetting increase in the interest rates in the second quarter. In contrast, the initial response for monetary targeters is positive, while it is negative for exchange rate targeters. The differences in the responses can be explained by the fact that interest rates are adjusted in line
with inflation developments. In which case, the response of inflation is negative for exchange rate targeters. Interest rate responses are considerably higher for monetary targeters than for inflation targeters and exchange rate targeters, which as suggested by Calvo and Reinhart (2002) indicates lack of credibility in non-IT regimes. For inflation targeters, the result may imply that there is interest rate smoothing which is implemented to avoid volatility in real activity (see e.g. Sack and Wieland, 2000). Since inflation and output gap are also relatively stable under IT, this shows that central banks adjust interest rates to stabilise inflation by ensuring a more gradual and smoother return of output to its trend.

It is also important to analyse whether there are any systematic differences of dynamic responses for non inflation targeters before and after 1995. This helps to see if there might be a time effect on the response to shocks in different periods. Figure 4 and 5 show the impulse responses for monetary targeters and exchange rate targeters. In both cases, output gap responds less to commodity terms of trade shocks before 1995 than after 1995.\[15\] The responses are significant in the first quarter for monetary targeters while in exchange rate targeters the responses are significant in the 5th and 6th quarters. The reaction of inflation is larger before 1995 than after 1995 in exchange rate targeters but the opposite reaction is observed for monetary targeters. Mishkin and Schmidt-Hebbel (2007) found that inflation is more volatile to oil price shocks after 1997 than before 1997 in non-inflation targeting countries.

[Figure 4 and 5 here]

The exchange rate responses in both monetary and exchange rate targeters are relatively small before 1995 than after 1995. However, in the case of interest rates, higher volatility and persistence are observed after 1995 than before 1995 for monetary targeters in contrast to the responses in exchange rate targeters. Overall, there seems to be no consistent picture in impulse responses among non-IT countries before and after 1995 suggesting that time is not necessarily a factor in the way variables respond to external shocks. This may imply that the observed differences in the responses of variables to commodity terms of trade shocks are attributed to differences in monetary policy regimes.

6.2 Variance decompositions

The analysis of variance decompositions focuses on the variance of variables accounted for by commodity terms of trade shocks. Table 6 presents the results.\[16\]

\[\text{\cite{footnote15}}\]See first rows of Figure 4 and Figure 5
\[\text{\cite{footnote16}}\]Although variance decompositions to shocks in other variables are computed, they are not reported because they are not relevant for the postulated hypothesis. This paper is interested in the variation of the variables
The results show that about 1.51% of variability in output gap in the short-run is explained by commodity terms of trade shocks before IT adoption. However, for the period after IT adoption, commodity terms of trade shocks account for about 1.13% of the output gap variability in the short-run and about 1.103% in the long-run. A similar pattern is also observed in the case of inflation, where commodity terms of trade shocks account for larger variations before IT adoption than after IT adoption. This may reflect the fact that inflation expectations have become anchored after IT adoption such that the effects of external shocks are not completely passed through to prices. However, in the case of exchange rate variations, commodity terms of trade shocks account for larger variations after IT adoption than before IT adoption.

When variance decomposition of variables for monetary targeters and exchange rate targeters for different time periods are compared, mixed results are observed. For example commodity terms of trade account for larger variance of inflation in monetary targeters before 1995, while for exchange rate targeters, it accounts for larger variance after 1995. Table 6 also shows that output gap variations explained by commodity terms of trade shocks are generally higher for monetary targeters and exchange rate targeters than inflation targeters. Probably, this indicates greater vulnerability of non-IT countries to business cycle fluctuations generated by commodity terms of trade shocks. However, these contributions are relatively smaller than calibration estimates by Mendoza (1995) who finds that terms of trade shocks account for about 50% of output fluctuations in fixed exchange rate regimes. This difference can be rationalised by differences in the estimation methods since Mendoza (1995) calibrates his model while the present study empirically estimates the model.

Commodity terms of trade shocks account for 2.47% of inflation at the 10th quarter and 2.49% at the 20th quarter in monetary targeters while it contributes about 2.08% and 1.96% in exchange rate targeters. The fluctuations of inflation accounted for by commodity terms of trade shocks in IT countries are 1.58% and 1.73% in 10 and 20 quarters respectively. This is far less than in non-inflation targeters. This evidence reinforces earlier impulse responses in this study which shows more muted responses of inflation to commodity terms of trade shocks in IT countries.

The variance decomposition of the exchange rate indicates that commodity terms of trade shocks explain about 3.09% and 1.86% in monetary targeters and exchange rate targeters respectively, compared to 7.53% in inflation targeters in the short-run. This shows higher volatility of exchange rates in IT countries which can be explained by the presence of flexible exchange rate. However, these contributions are relatively smaller than calibration estimates by Mendoza (1995) who finds that terms of trade shocks account for about 50% of output fluctuations in fixed exchange rate regimes. This difference can be rationalised by differences in the estimation methods since Mendoza (1995) calibrates his model while the present study empirically estimates the model.

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exchange rates. Other papers have reached a similar conclusion that terms of trade shocks account for larger variation of exchange rates in flexible exchange rate regimes than in pegs (see e.g. Bleaney and Fielding, 2002; Broda, 2004). Furthermore, commodity terms of trade shocks account for about 2.31% of the interest rate variation in the 20th quarter for inflation targeters. This is relatively lower than in monetary targeters and exchange rate targeters with the variances of 2.93 and 3.48 respectively. This may suggest that when monetary policy is credible and predictable as presumed in IT countries, it can avoid costly responses to external shocks.

7 Robustness checks

This section provides robustness checks. First, the results are tested to evaluate their sensitivity to the ordering of variables in the panel VAR. The reason for this test is that the Choleski decomposition is sensitive to the way variables are ordered in the panel VAR. This also helps to overcome the criticism of arbitrary ordering of variables normally leveled on Choleski decomposition (Pesaran and Shin, 1998). Therefore the model is reestimated with alternative ordering of variables where exchange rates are now ordered before inflation. The results are shown in Figure 6 and Figure 7. Generally, the shapes of impulse response functions of the output gap before and after IT adoption are similar to the baseline case. As in the benchmark case, inflation responds strongly before inflation targeting while it responds with a delay after IT adoption. Similar impulse response patterns are also noticed in the response of exchange rates and interest rates. Comparing different monetary policy regimes in Figure 7, it is observed that the profiles and shapes of impulse response functions are broadly similar to the baseline identification scheme.\textsuperscript{17} Thus the results are not sensitive to the way variables are ordered in the panel VAR.

\[\text{Figure 6 and 7 here}\]

Second, the panel VAR model is reestimated in first differences. This is motivated by the recent controversies about the need to difference data that has a time series component (see e.g. Enders, 2004). Also, there are several studies which have estimated panel VARs in first differences, which makes this alternative specification to be comparable with existing results (see e.g. Broda, 2004; Loayza and Raddatz, 2007). Figure 8 reports the results before and after IT adoption and Figure 9 displays results under alternative monetary policy regimes. In terms

\textsuperscript{17}We also tried several alternative ordering arrangements for example inflation was ordered before output gap and exchange rate was ordered before output gap but the results did not significantly change.
of volatility, the responses of output gap, exchange rates and interest rates are broadly similar to the baseline case, but the profile of inflation responses is different. However, the significance of the impulse response functions deteriorated. Also the impulse response functions from first differenced variables exhibit more cyclicality and unsmooth pattern than in the benchmark case. The possible explanation is that the data should be in levels and not in differences. As Francis and Ramey (2009) argues, overdifferencing can lead to imprecise and biased estimates in VARs.

Third, the key identifying assumption in this study is the exogeneity of terms of trade shocks. However, in the entire sample there are some relatively large economies which may control the market for particular commodities. Thus the study investigates the sensitivity of the results to the exclusion of these large economies in the estimations. Following Edwards and Yeyati (2005), large economies are defined as countries with aggregate real GDP in USD in the top quintile of the global real GDP distribution. The IMF’s World Economic Outlook, 2008 is used to make this classification. Using this classification, the countries excluded from the estimations are Brazil, Russia, India and China (BRIC). Figure 10 and Figure 11 reports the results for the periods before and after IT adoption and across regimes respectively. In both cases the magnitudes and dynamics of the responses are generally similar to those in the original specification. In fact, for the responses across regimes, the output gap exhibit lower volatility in IT countries than monetary targeters and exchange rate targeters. This is in line with Bleaney and Fielding (2002) who find higher output fluctuations in pegged exchange rate regimes than in flexible exchange rate regimes. Inflation exhibits less inertial effects in IT countries than in monetary targeting countries but for exchange rate targeters, the initial response is negative. Also, as the original results show, exchange rate response is lower in exchange rate targeters than in inflation targeters and monetary targeters. This is not a surprise considering the sluggish adjustment of the nominal exchange rate in exchange rate targeting countries (Broda, 2004). Therefore the exclusion of big economies does not qualitatively change the results.

To ascertain the exogeneity of commodity terms of trade, the study conducts Granger causality and block exogeneity test. The test investigates the statistical significance of the variables of the system based on the Wald test. The results are shown on Table 7. Based on the overall p-value of the Chi-square, the null hypothesis of no Granger causality or no endogeneity of the dependent variable is accepted. This shows that the commodity terms of
trade is exogenous. Therefore this affirms the ordering of commodity terms of trade first in the panel VAR specification.

Forth, some studies claim that oil exporting countries may respond differently to shocks (see e.g Spatafora and Warner, 1995). To determine if the inclusion of oil exporters drive the results, the panel VAR model is reestimated with a sample that excludes major oil exporters. Table 8 presents a list of major oil exporter countries which were excluded. Figure 12 reports the impulse responses before and after IT adoption while Figure 13 reports the impulses for different monetary policy regimes. The results for the comparison of dynamic responses before and after IT adoption demonstrate some similarities with those in the benchmark specification. This is intuitive considering that the original sample of inflation targeters included only three oil exporters (Mexico, Indonesia and Colombia). Also for different regimes, it is observed that inflation responses tend to follow the dynamic pattern of output gap. However, interest rate responses are relatively less persistent when oil exporters are excluded than in the benchmark case. A possible explanation is that oil exporting central banks do not respond aggressively to terms of trade shocks compared to oil importers. Overall, the exclusion of oil exporters does not have a significant effect on the results.

Fifth, in the baseline specification, 1995 was considered as the cut-off period for non-inflation targeters based on the average period for the adoption of inflation targeting in the 1990s. However, in terms of distribution, with the exception of Chile and Israel which adopted inflation targeting much earlier in the 1990s, most of the countries adopted inflation targeting in the late 1990s and early 2000s. Hence, it is important to evaluate if the results are sensitive to the average starting period of inflation targeting. To this effect, year 2000 is alternatively considered as the average starting period for inflation targeting and thus the dividing year for non-inflation targeters when the early IT adopters are not considered. The results are displayed in Figure 14. The results show that most of the variables display similar response patterns as in the baseline case. The only exception is the response of inflation under exchange rate targeters which rises on impact and fall over time. However, when the responses are compared across monetary policy regimes in terms of volatility, conclusions similar to the baseline case are reached.
8 Conclusion

This study empirically evaluates the responses of different monetary policy regimes to commodity terms of trade shocks in emerging market economies. The analysis helps to determine if inflation targeting is better than other regimes during turbulent times. Country specific commodity terms of trade indices are used rather than standard terms of trade mainly because the former capture exchange rate fluctuations which are more exogenous to the business cycles. The panel VAR model is specified in order to analyse and compare aggregate impulse response functions and variance decompositions of economic variables following commodity terms of trade shocks.

The empirical results show that in general, countries which have adopted inflation targeting respond better to commodity terms of trade shocks than countries which have not adopted. However, commodity terms of trade shocks seem to propagate higher exchange rate volatility in inflation targeting countries than exchange rate targeting countries. Also, when the responses of variables to commodity terms of trade shocks before and after IT adoption are compared, the results show that the responses of output gap, inflation, nominal exchange rates and interest rates are substantially higher before, than after IT adoption. This may suggest that inflation targeting is making the difference. There is also evidence of interest rate smoothing in IT countries implying less aggressive responses to commodity terms of trade shocks. These results are generally robust to most sensitivity tests and consistent with other studies.

The study also finds considerable evidence that commodity terms of trade disturbances account for relatively higher variation of most variables in non-inflation targeting countries than in inflation targeting. They also explain larger variation of most variables before IT adoption than after IT adoption, both in the short-run and the long-run. However, the variance decomposition of the exchange rates indicate that commodity terms of trade shocks explain relatively larger variation in IT than non-IT countries.

The findings suggest that the adoption of IT makes some differences in the way macroeconomic variables respond to commodity terms of trade shocks. The lower responses of output gap and inflation in IT countries than non IT countries suggest that increasing the flexibility of exchange rates may provide a further insulation against shocks since they act as shock absorbers. However, the increased flexibility of exchange rates in IT countries comes at a cost of increased volatility in exchange rates when the economy is hit by commodity terms of trade shocks. This suggests that IT emerging market economies need to pay attention to the effects of exchange rate movements generated by commodity terms of trade shocks. Although commodity terms of trade shocks may have undesirable effects on macroeconomic variables, this analysis shows that the adoption of inflation targeting can make the effects manageable.
References


APPENDIX

A: Terms of trade and real exchange rate

Terms of trade is given by:

\[ f_{it} = p_{X_{it}} - p_{M_{it}} \]  \hspace{1cm} (A.1)

where \( p_{X_{it}} \) is the price of exports and \( p_{M_{it}} \) is the price of imports

\[ \Delta f_{it} = \pi_{X_{it}} - \pi_{M_{it}} \]  \hspace{1cm} (A.2)

Given the law of one price on imports and exports, it follows that:

\[ \pi_{X_{it}} = \pi_{X_{t}} - \Delta e_{it} \]  \hspace{1cm} (A.3)

\[ \pi_{M_{it}} = \pi_{M_{t}} - \Delta e_{it} \]  \hspace{1cm} (A.4)

where \( \pi_{X_{it}} \) is exported inflation (change in price of exports), \( \pi_{X_{t}} \) is the change in the world price of exports which is assumed to be exogenous. \( \Delta e_{it} \) is the change in the nominal exchange rate, \( \pi_{M_{it}} \) is imported inflation (change in domestic price of imports) and \( \pi_{M_{t}} \) is the change in the world prices of imports. Substituting equation (A.3) and equation (A.4) into equation (A.2) yields:

\[ \Delta f_{it} = \pi_{X_{t}} - \Delta e_{it} - (\pi_{M_{t}} - \Delta e_{it}) \]  \hspace{1cm} (A.5)

\[ \Delta f_{it} = \pi_{X_{t}} - \pi_{M_{t}} \]  \hspace{1cm} (A.6)

The world price of imports is assumed to be equal to the general world price index such that the world price of imports grows at the rate of world inflation:

\[ \pi_{M_{t}} = \pi_{t} \]  \hspace{1cm} (A.7)

where \( \pi_{M_{t}} \) is imported inflation and \( \pi_{t} \) is the world inflation. Using this assumption, equation (A.6) becomes:

\[ \Delta f_{it} = \pi_{X_{t}} - \pi_{t} \]  \hspace{1cm} (A.8)

which implies that:

\[ \pi_{t} = \pi_{X_{t}} - \Delta f_{it} \]  \hspace{1cm} (A.9)

Let us recall that the real exchange rate \( (q_{it}) \) is define by:
\[ q_{it} = e_{it} + p_{it} - p_t^* \]  \hspace{1cm} (A.10)

Expressed in terms of change, real exchange rate is:

\[ \Delta q_{it} = \Delta e_{it} + \pi_{it} - \pi_t^* \]  \hspace{1cm} (A.11)

Substituting equation (A.9) into equation (A.11) results in:

\[ \Delta q_{it} = \Delta e_{it} + \pi_{it} - \pi_t^* \chi_t + \Delta f_{it} \]  \hspace{1cm} (A.12)
Table 1: Summary statistics for the sample of inflation targeters, monetary targeters and exchange rate targeters

<table>
<thead>
<tr>
<th></th>
<th>CTOT</th>
<th>Output gap</th>
<th>Inflation</th>
<th>Exchange Rates</th>
<th>Interest rates</th>
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<td>Mean</td>
<td>S.dev</td>
<td>Mean</td>
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<td></td>
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</table>

The various columns report summary statistics of the variables for each country. CTOT is the commodity terms of trade growth, S.dev is the standard deviation. For each variable, the two columns display the mean and standard deviation.

Inflation targeters are countries which set numerical targets of inflation and makes an institutional commitment to achieve these targets. Inflation forecast acts as the intermediate target of monetary policy.

Monetary targeters uses instruments to achieve a target growth rate of a monetary aggregate, such as reserve money, M1, or M2 where the targeted aggregate becomes the nominal anchor or intermediate target of monetary policy.

Exchange rate targeters have monetary authorities who are ready to buy or sell foreign exchange to maintain the predetermined exchange rate at its announced level or range for example, currency board, regimes with no separate legal tender, fixed pegs, crawling pegs with and without bands.

Sources: Authors’ computations based on the sources in Table 2.
Table 2: Variables description and data sources

<table>
<thead>
<tr>
<th>Variable</th>
<th>Description</th>
<th>Sources</th>
</tr>
</thead>
<tbody>
<tr>
<td>Commodity terms of trade</td>
<td>Commodity terms of trade is measured as the weighted average of commodity export prices divided by the weighted average of commodity import prices. The weight used is the manufacturing unit value index.</td>
<td>Based on Deaton and Miller (1996), modified and updated data obtained from Tytell and Spatafora (2009)</td>
</tr>
<tr>
<td>Output Gap</td>
<td>Output gap is the difference between the log of actual and trend GDP. Hodrick Prescott filter with a smoothing parameter of $\lambda = 1600$ is used.</td>
<td>IFS and World Development Indicators</td>
</tr>
<tr>
<td>Inflation</td>
<td>Inflation is measured by the change in consumer price indices. It is an indicator of price changes in a small open economy.</td>
<td>Datastream, IFS and World Development Indicators</td>
</tr>
<tr>
<td>Exchange rates</td>
<td>The exchange rate variable used is the percentage change in the bilateral nominal exchange rate. In this case the bilateral nominal exchange rate is the price of the currency of each country in terms of the USD.</td>
<td>IFS and World Development Indicators</td>
</tr>
<tr>
<td>Interest rates</td>
<td>The interest rate is the central bank’s policy rate. If the policy interest rate is not used, the three month treasury bill rate is used instead.</td>
<td>IFS and Central Bank websites</td>
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</table>

Table 3: Summary statistics of inflation targeters before and after inflation targeting adoption

<table>
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<tr>
<th>Variables</th>
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<th>Inflation Targeters after inflation targeting adoption</th>
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</thead>
<tbody>
<tr>
<td></td>
<td>Obs Ave S.dev Min Max</td>
<td>Obs Ave S.dev Min Max</td>
</tr>
<tr>
<td>CTOT</td>
<td>1136 0.92 17.47 -44.86 31.83</td>
<td>604 0.13 4.26 -43.15 15.31</td>
</tr>
<tr>
<td>INFL</td>
<td>1136 109.1 528.93 -0.59 7481.64</td>
<td>604 5.44 3.85 -3.2 23.85</td>
</tr>
<tr>
<td>YGAP</td>
<td>1136 0.16 13.70 -9.874 9.3</td>
<td>604 0.04 1.21 -6.8 4.49</td>
</tr>
<tr>
<td>ER</td>
<td>1136 10.54 48.37 -100 1181.21</td>
<td>604 0.351 5.13 -1.18 40.37</td>
</tr>
<tr>
<td>RTS</td>
<td>1136 168.4 140.2 2.4 6184</td>
<td>604 8.5 5.3 1.25 41.95</td>
</tr>
</tbody>
</table>

CTOT = commodity terms of trade, INFL = inflation, YGAP = output gap, ER = exchange rates, RTS = Interest rates, Obs = number of observations, Ave = average, S.dev = standard deviation, Min = minimum, Max = maximum

Sources: Authors’ computations based on the sources in table 2
Table 4: Summary statistics of inflation targeters, monetary targeters and exchange rate targeters after 1995

<table>
<thead>
<tr>
<th>Variables</th>
<th>Inflation targeters after inflation targeting adoption</th>
<th>Monetary targeters after 1995</th>
<th>Exchange rate targeters after 1995</th>
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</thead>
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<td>Ave S.dev Min Max</td>
<td>Ave S.dev Min Max</td>
<td>Ave S.dev Min Max</td>
</tr>
<tr>
<td>CTOT</td>
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<tr>
<td>INFL</td>
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</tr>
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<td>8.5 5.3 1.25 41.95</td>
<td>14.83 16.25 1.07 118.4</td>
<td>33.17 16.3 2.17 135</td>
</tr>
</tbody>
</table>

CTOT = commodity terms of trade, INFL = inflation, YGAP = output gap, ER= exchange rates, RTS= Interest rates, Ave= average, S.dev = standard deviation, Min = minimum, Max = maximum
Observations under IT=604, observations under MT=616 and observations under ET=540
Sources: Authors’ computations based on the sources in table 2

Table 5: Panel unit root tests based on the Fisher Type Test

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</table>

H₀: Panel series are not stationary
### Table 6: Variance decompositions

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<th>Inflation 10</th>
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<td>1.73</td>
<td>7.53</td>
<td>7.68</td>
<td>2.03</td>
<td>2.31</td>
</tr>
<tr>
<td>MT after 1995</td>
<td>2.25</td>
<td>1.25</td>
<td>2.47</td>
<td>2.49</td>
<td>3.09</td>
<td>3.09</td>
<td>2.02</td>
<td>2.93</td>
</tr>
<tr>
<td>ET after 1995</td>
<td>5.66</td>
<td>4.81</td>
<td>2.08</td>
<td>1.96</td>
<td>1.86</td>
<td>1.87</td>
<td>3.65</td>
<td>3.48</td>
</tr>
</tbody>
</table>

This table reports the variance of each variable which is explained by commodity terms of trade shocks at the 10th and 20th quarters.

IT= inflation targeters, MT= Monetary targeters, ET = Exchange rate targeters

### Table 7: VAR Granger causality and Block exogeneity Wald Test

<table>
<thead>
<tr>
<th>Variables</th>
<th>Chi -square ($\chi^2$)</th>
<th>P-values</th>
</tr>
</thead>
<tbody>
<tr>
<td>Output gap</td>
<td>0.409</td>
<td>0.981</td>
</tr>
<tr>
<td>Inflation</td>
<td>2.491</td>
<td>0.646</td>
</tr>
<tr>
<td>Exchange rate</td>
<td>1.082</td>
<td>0.897</td>
</tr>
<tr>
<td>Interest Rates</td>
<td>0.290</td>
<td>0.991</td>
</tr>
<tr>
<td>All</td>
<td>4.75</td>
<td>0.997</td>
</tr>
</tbody>
</table>

$H_0$: No Granger causality or no endogeneity.

All captures the p-values based on the block exogeneity test.
Table 8: List of oil exporting countries in each monetary policy regime

<table>
<thead>
<tr>
<th>Inflation targeters</th>
<th>Monetary targeters</th>
<th>Exchange Rate Targeters</th>
</tr>
</thead>
<tbody>
<tr>
<td>Colombia</td>
<td>Algeria</td>
<td>Ecuador</td>
</tr>
<tr>
<td>Indonesia</td>
<td>Nigeria</td>
<td>Ukraine</td>
</tr>
<tr>
<td>Mexico</td>
<td>Russia</td>
<td>Venezuela</td>
</tr>
</tbody>
</table>

Figure 1: Commodity terms of trade shocks under different monetary policy regimes

Source: Tytell and Spatafora, 2009
Figure 2: Impulse responses of variables to commodity terms of trade shocks: Inflation targeters before and after Inflation targeting

Inflation targeters before IT adoption

Response of YGAP to CTOT shock

Inflation targeters after IT adoption

Response of YGAP to CTOT shock

Response of INFL to CTOT shock

Response of ER to CTOT shock

Response of RTS to CTOT shock

Errors are 5% on each side generated by Monte-Carlo simulations with 500 repetitions
Figure 3: Impulse responses of variables to commodity terms of trade shocks: inflation targeters, monetary targeters and exchange rate targeters

Errors are 5% on each side generated by Monte-Carlo simulations with 500 repetitions
Figure 4: Impulses to CTOT shock: Monetary targeters before and after 1995

Errors are 5% on each side generated by Monte-Carlo simulations with 500 repetitions
Figure 5: Impulses to CTOT shock: Exchange rate targeters before and after 1995

Errors are 5% on each side generated by Monte-Carlo simulations with 500 repetitions.
Figure 6: Impulses to CTOT shock with alternative ordering of variables: Inflation targeters before and after IT adoption

Errors are 5% on each side generated by Monte-Carlo simulations with 500 repetitions
Figure 7: Impulses to CTOT shock with alternative ordering of variables: Inflation targeters, Monetary targeters and Exchange rate targeters

Errors are 5% on each side generated by Monte-Carlo simulations with 500 repetitions
Figure 8: Impulses to CTOT shock in first differences: Inflation targeters before and after IT adoption.

Errors are 5% on each side generated by Monte-Carlo simulations with 500 repetitions.
Figure 9: Impulses to CTOT shock in first differences: Inflation targeters, monetary targeters and exchange rate targeters.

Errors are 5% on each side generated by Monte-Carlo simulations with 500 repetitions.
Figure 10: Impulses to CTOT shock excluding big economies: Inflation targeters before and after IT adoption.

Errors are 5% on each side generated by Monte-Carlo simulations with 500 repetitions.
Figure 11: Impulses to CTOT shock excluding big economies: Inflation targeters, monetary targeters and exchange rate targeters.

Errors are 5% on each side generated by Monte-Carlo simulations with 500 repetitions.
Figure 12: Impulses to CTOT shock excluding oil exporters: Inflation targeters before and after IT adoption

Errors are 5% on each side generated by Monte-Carlo simulations with 500 repetitions
Figure 13: Impulses to CTOT shock excluding oil exporters: Inflation targeters, monetary targeters and exchange rate targeters.

Errors are 5% on each side generated by Monte-Carlo simulations with 500 repetitions.
Figure 14: Impulses to CTOT shock: Inflation targeters, monetary targeters and exchange rate targeters after 2000.

Errors are 5% on each side generated by Monte-Carlo simulations with 500 repetitions