Conference Paper

Inflation Targeting Under Attack:
Evidence from Emerging Market Economies

Seedwell Hove
University of Cape Town
Albert Tounamama
University of Cape Town
Fulbert Tchanatchana
Ministere des Finances du Quebec

27 - 29 October 2010
Indaba Hotel and Conference Centre
Johannesburg
South Africa

Hosted by

DPRU Development Policy Research Unit

TIPS

Inflation targeting under attack: evidence from emerging market economies

Seedwell Hove* Albert Touna Mama† Fulbert Tchana Tchana‡

10 September 2010

Abstract

Over the years, emerging market economies have experienced different waves of external shocks due to commodity price fluctuations causing macroeconomic instabilities. Sometimes the swings were too wide, long lived and too uncertain, making it difficult to stabilise economies. The challenges confronting policy makers in maintaining price stability in the face of these shocks in emerging countries should not be underestimated. The adoption of inflation targeting by many emerging market economies was considered as a positive step towards macroeconomic stabilisation. The question now is on whether inflation targeting regime responded better to these shocks than other regimes. This paper tests the robustness and resilience of inflation targeting compared to other monetary policy regimes when it is under attack from commodity terms of trade shocks. We specified a panel VAR model and analyze in a comparative framework, aggregated impulse response functions of key economic variables (inflation, output gap, monetary variables and exchange rates) to terms of trade shocks to evaluate if inflation targeting responded better than other regimes to commodity terms of trade shocks. We found in general that inflation targeting countries responded better to terms of trade shocks especially with respect to inflation. Monetary targeters also responded better to than exchange rate targeters. However output gap was found to be more volatile under inflation targeting in the shortrun than in the longrun.We also find evidence that economic variables experienced much variability before inflation targeting than after inflation targeting, implying that inflation targeting is better placed to deal with terms of trade shocks. The results suggest that countries which are prone to external shocks can stabilise their economies especially in the longrun by adopting inflation targeting.

Key words: Inflation targeting, terms of trade shocks, emerging markets, panel VAR

JEL Classification: E52, G28

*University of Cape Town, Email: seedwell.hove@uct.ac.za

†University of Cape Town, Email: albert.tounamama@uct.ac.za

‡Department of Research and Modelling, Ministere des Finances du Quebec , Email: fulbert.tchanatchana@finances.gouv.qc.ca

1 Introduction

Over the years, emerging market economies have continued to experience large different waves of commodity terms of trade shocks, posing serious challenges for their macroeconomic stability. The resulting macroeconomic instability has prompted renewed interest in the understanding of policy options to respond to commodity terms of trade shocks. These shocks have been found to be larger and more persistent and have been pointed out as the overriding cause of macroeconomic volatility in developing countries (Mendoza, 1995). As noted by Spatafora and Warner (1995), many emerging countries have export bases that are characterized by a high concentration in a relatively small number of commodities whose world prices are very volatile.This makes them to be more vulnerable to terms of trade shocks. The global economic upswing since 2003 has spurred a sharp increase in world prices for resource commodities. Oil inflation rose by almost 160% between 2003 and 2008, being double that of the 1970s. Food prices also rose by over 900% during the same period (Batini and Tereanu, 2009). Sometimes the swings are too wide, long lived and too uncertain and the degree of persistence in commodity prices limits the scope for stabilisation policy so that the price movements typically require rapid fundamental adjustment (Deaton and Miller, 1995).

The recurrent terms of trade shocks and the need to stabilise economies have called into question several fundamental assumptions and beliefs about suitable monetary policy responses and raised the need to identify a suitable monetary policy regime. The adoption of inflation targeting (IT) by many emerging market economies is one such potential line of defense against external shocks. The challenge is that these economies are complex, with dynamic systems in which the transmission of shocks can change over time. Also most external shocks to these countries are not foreseen and the likely magnitude, duration and effects on the economy are often unclear, hence the daunting task confronting them in maintaining macroeconomic stability in the face of these shocks should not be underestimated (Cashin et al., 2004). The efficacy of inflation targeting in macroeconomic stabilisation in the face of external shocks is thus an empirical question.

Previous empirical studies on monetary responses to external shocks have focused primarily on oil price shocks and exchange rates shocks (see for example Mishkin and Schmidt-Hebbel, 2007; Blanchard and Gali, 2007). Although the focus on oil price was relevant during that time, its narrow coverage left many questions unanswered. The other studies on the terms of trade shocks focused on the implications for the choice of exchange rates (see for example Broda, 2004; Edwards and Yeyati, 2005). Some open economy inflation targeting studies such as Ball (1998) and Svensson (2000) did not look at monetary policy response to exogenous shocks or the implication of their responses on macroeconomic variables. This literature therefore has paid less attention to the analysis of implications of business cycles induced by terms of trade shocks for modern monetary policy like inflation targeting. The fact that emerging market economies have been subjected to similar trade shocks, yet experienced different business cycles raises important issues about the response to these shocks. The right response to global relative price shocks is not straight forward, yet recent advances of monetary policy setting has made prominence the adoption of inflation targeting as a good monetary policy in emerging market economies. Its promise is based on its transparency, flexibility and operating flexible exchange rate which facilitate necessary adjustments to deal with terms of trade

shocks. And yet there continue to be unresolved issues about the role of inflation targeting in reducing the impact of external shocks and speeding up the economy's adjustment to them.

The purpose of the present study is to analyze empirically the robustness and resilience of inflation targeting, compared to other regimes in the face of commodity terms of trade shocks[1] and explore any role of inflation targeting in accounting for the macroeconomic dynamics. This is done by analysing and comparing the adjustment process of inflation, output gap, exchange rates, money supply growth and interest rates to terms of trade disturbances under different monetary policy regimes. The study used panel vector autoregressive (VAR) model. We use this technique for three reasons; Firstly, panel VAR is able to estimate the effects of commodity terms of trade shocks on macroeconomic aggregates. Secondly, it enable us to identify different monetary policy responses to these shocks with weak and uncontroversial assumptions (Loayza and Raddatz, 2007). Thirdly the panel VAR is able to consider the complex dynamic relationship between terms of trade shocks and economic variables while allowing for country specific unobserved heterogeneity (Love and Zicchino, 2006). We evaluate the differences between impulse responses of variables in inflation targeting countries and non inflation targeting countries (counterfactuals) as well as before and after inflation targeting[2]. Since the exchange rate is likely to be the main transmission mechanism of external shocks[3], we also evaluate the responses to exchange rate shocks, paying more attention to the dynamics of the devaluation-inflation pass through effects in different monetary policy regimes[4]. This paper therefore provides an empirical foundation of the policy responses to different episodes of terms of trade shocks in the boom bust cycles.

A distinctive feature of our work from existing literature is its introduction of terms of trade shocks into the inflation-targeting framework. We analyse the transmission of commodity terms of trade shocks under alternative monetary policy regimes, benchmaking on inflation targeting, thus bringing together the two strands of literature. This adds structure and understanding to the debate on the sources and dynamics of macroeconomic fluctuations due to external shocks and how policy can be crafted to deal with such shocks. This is important because macroeconomic dynamics in emerging market economies are heavily influenced by the external sector (Ahmed, 2003). Bernanke et al. (1997) pointed out that the macroeconomic effects of external shocks can be aggravated by wrong policy responses, yet most of the work on the impact of terms of trade shocks have ignored the role of alternative monetary policy regimes. The other interesting part of this study is the fact that stabilising aggregate price level in the face of relative price shocks could introduce increased variability in output that could possibly outweigh the benefits associated with reduced price level uncertainty. This study therefore contributes to literature by providing empirical validation of the theory of how relative price shocks affect the macroeconomic performance under comparative monetary policy regimes.

While most of the previous studies used the standard terms of trade indices, our study departs from those approaches and instead use country specific commodity terms of trade indices. These country specific indices are better than broad terms of trade indices because the latter captures the fluctuations of exchange rates that are less exogenous

[1] Resilience in this case is defined as the capacity to absorb shocks and recover quickly following a shock.

[2] Non inflation targeting countries are comprised of Monetary targeters and exchange rate targeters.

[3] The exchange rate is where the effects of the external shock is likely to be reflected.

[4] The exchange rate passthrough is there to guage the degree of inflationary pressures coming from external sources.

to the business cycle than fluctuation in commodity prices (Aghion et al., 2004). Also as pointed out by Raddatz (2007), the use commodity terms of trade indices gives a better chance to exogenous shocks to actually play a role because they have larger explanatory power for output and price fluctuations than the broad terms of trade indices. Since the commodity terms of trade indices consider both the export and import dimensions of the external shock they are able to capture a larger set of fundamental relative price movements that are not indicated by movement in price of only one commodity like oil. This enables us to measure exogenous stochastic shifts in relative prices of commodity exports and imports. Tytell and Spatafora (2009) pointed out that commodity terms of trade indices are more relevant for macroeconomic analysis since they capture the country specific dimension of the global commodity cycles. Dehn (2000) noted that they are likely to behave differently from broad aggregate indices and the exchange rate is likely to be sensitive to them, especially in countries which specialise in a narrow range of commodities. To the best of our knowledge, commodity based terms of trade analysis in the framework of different monetary policy regimes distinguishes our paper from most others in literature.

Another value addition of this paper is its focus on emerging market economies. These economies mostly specialise in primary commodities whose prices fluctuate greatly in the world markets (Collier and Goderis, 2007). Most emerging market economies are mired by their inability to adopt optimal counter cyclical stabilisation policies because of low financial sector development (Caballero, 2002), sudden stops of capital flows (Calvo and Reinhart, 2000), and weak institutional frameworks (Calvo and Mishkin, 2003). Emerging market economies are also of symmetric importance among developing countries because their business cycle stabilisation efforts are sometimes hampered by weak shock absorbers (Hoffmaister and Roldos, 2001). Existing literature offers little guidance on the implications of terms of trade disturbances for optimal monetary policy setting in emerging market economies.

The results shows that there are noticeable differences in the response of inflation, with inflation targeting countries having relatively better outcomes. However output gap was found to be more volatile under inflation targeting in the shortrun than in the longrun. We also find evidence that economic variables experienced more variability before inflation targeting than after inflation targeting, implying that inflation targeting is better placed to deal with terms of trade shocks In terms of response of other variables, although inflation targeting is better off, the difference is small. Inflation targeters also experienced low exchange rate pass through effects than other regimes.

The results suggest that inflation stabilisation by inflation targeting comes at a cost of increased output gap variability in the shortrun. In terms of other variables, the differences are very small. The results also suggest that monetary policy regimes in place explains differential response of the economy to terms of trade shocks. In the longrun, stronger commitment to maintaining low and stable inflation can lead to improved policy trade-off that make it possible to have a smaller impact of a given terms of trade shock.

The rest of the paper is organised as follows; section 2 outlines the review of literature, section 3 provides the methodology used and data analysis, while section 4 provides the estimation results. Section 5 concludes and provides policy recommendations.

2 Review of Literature

This study is related to two strands of literature.The first one is on the effects of terms of trade on the macroeconomy and the second one relates to the debate on the role of inflation targeting in shaping the macroeconomic dynamics in emerging market economies. In this framework, inflation targeting comes in as policy responses to terms of trade shocks.

2.1 Terms of trade and macroeconomic dynamics

Macroeconomists have known for a long time that terms of trade shocks explain much of the macroeconomic dynamics in developing countries. Some theoretical insights in this direction relates to Corden (1984) who analysed a version of the "Dutch Disease model". This theory posits that terms of trade shocks have an effect on the relative price of exportables to importables. This may affect permanent income thus lead to a spending effect and a resource movement effect through consumption and investment decisions as a result of change in their relative wealth. This pattern feeds into fluctuations of macroeconomic variables. However the effects depends on whether the shock is transitory or permanent and anticipated or unanticipated. Cashin and McDermott (2002) argued that an unfavourable terms of trade shock has a consumption smoothing effect due to reduction in national income relative to future income and consumption tilting effect resulting from the current increase in current import prices relative to future import prices. There is also a real exchange rate effect resulting from the increase in the price of imported goods relative to exportables.

Barro and Sala-I-Martin (2004) developed a model which emphasised the effects of terms of trade shocks on output growth through relative prices and external demand for domestically produced goods and services. They argued that the effects of terms of trade shocks on output depend on the effects of relative price changes on productivity improvements. Through this channel, changes in competitiveness due to terms of trade shocks are likely to produce faster impulses in the case of negative shocks than positive shocks especially if there is rigid exchange rates and downward sticky prices.

Mendoza (1995) developed a three-sector intertemporal general equilibrium model to examine the relationship between terms of trade disturbances and business cycles. The model identifies three key transmission mechanisms of terms of trade shocks to the domestic economy, that is international capital markets, cost of imported inputs (through exchange rates) and the overall purchasing power of exports. The model predicts that terms of trade shocks could account for nearly half of actual GDP and real exchange rate variability especially in developing countries.

On the empirical perspective, Kose (2002) examined the role of world prices in inducing and propagating business cycle fluctuations in developing countries using calibrations of a multi-sector small open economy model. He found that terms of trade shocks can explain almost all variance in output in an open developing country. These results concur with Andrews et al. (2009) who analysed the effects of terms of trade shocks on macroeconomic volatility

using a sample of 71 countries. They found that terms of trade are important source of output and inflation volatility.

Deaton and Miller (1995) and Collier and Gunning (1999) among others have largely documented the importance of commodity price shocks in driving economic fluctuations in developing countries. Deaton and Miller (1995) found that a 10% increase in commodity prices results in a 6% increase in output. They observed that high commodity prices are transmitted to the economy through booms and busts and can be detrimental to the economy. Deaton and Miller (1995) computed a country specific commodity based terms of trade index and used it in their analysis. For emerging countries this is important because they import and export commodities whose prices fluctuations bring commodity terms of trade shocks.

Edwards and Yeyati (2005) analysed the effectiveness of alternative exchange rate regimes under external shocks using cross country data of 183 countries over the period 1974–2000. He found that countries with flexible exchange rates grow faster than those with fixed exchange rates and that output have larger responses to negative terms of trade shocks than positive. The implication of their result is that the effectiveness of exchange rate regimes in economic stabilisation depends on the type of the shock hitting the economy, with fixed exchange rates being suitable where there are nominal shocks, while flexible exchange rates are more suitable for real shocks. Also adverse terms of trade shocks caused larger decline in real GDP in countries with fixed than flexible exchange rates. A similar study involving 75 developing countries by Broda (2004) examined the effect of terms of trade shocks on real GDP, consumer prices and real exchange rates across different exchange rate regimes. He found that shortrun real GDP response to terms of trade changes to be smaller in countries with flexible exchange rates than those with fixed exchange rates. Also the depreciation of real exchange rate is immediate after negative terms of trade shock under flexible exchange rate than under fixed exchange rate. Flexible exchange rates allows countries to buffer negative terms of trade shocks through smooth changes in the exchange rate, hence flexible exchange rates appreciates to offset inflationary impact of terms of trade shocks. This generally follows from Mundell (1961) arguments that flexible exchange rates acts as "shock absorbers" in small economies. Although these studies have given a consistent picture of the effects of terms of trade shocks and provide the basis for the choice of exchange rates, they lack a policy flavour to deal with the effects of terms of trade shocks.

2.2 Inflation targeting and external shocks.

One of the most intriguing aspects of inflation targeting regime is its impact on the real economy. In this direction, there is a large body of literature which tries to explain why inflation targeting should plausibly make a difference in the face of external shocks. Credibility based theoretical contributions on the role of inflation targeting have asserted that well established policy credibility is essential in coping with unfavourable supply shocks (Svensson, 1997). The argument is argued that if inflation targeting is framed with respect to forecast inflation, rather than actual realised inflation, then it can deal with supply side shocks. The forward looking dimension of inflation targeting helps in anchoring inflation expectations. This literature advocates that if inflation expectations are managed efficiently,

central banks can improve stabilisatlion of both inflation and output. In the advent of the shock that pushes inflation away from the target, the central bank adjusts policy interest rates to affect both the level of spending in the economy and inflation expectations, thereby pulling inflation back to target. This happens through the enhanced credibility of the central bank which tends to limit the risk of higher inflation becoming entrenched in inflation expectations. This allows central bank to smooth cyclical shocks without inducing countervailing shifts in the long term interest rates. The framework embodies feedbacks from all information and uses communication to enhance transparency inorder to limit the damage to credibility associated with overshooting of inflation targets. The literature predicts that if properly implemented inflation targeting can reduce short run effects of disturbances on real variables while retaining firmly anchored medium term inflation expectations and hence reducing the degree of inflation variability that is required to achieve a given degree of stability of real variables.

The inflation-output gap volatility trade-off as originally emphasised by Taylor (1979) was acknowledged, but if inflation expectations are firmly anchored, the inflation-output gap variability tradeoff will be lower and temporal (Bernanke et al., 1999). Indeed as argued by Debelle (1999), greater credibility can improve the output inflation variability tradeoff by ensuring that inflation expectations do not adjust rapidly to shocks. This provides an anchor of prices and wages especially if inflation targeting is flexible. The adjustment of the policy horizon can also allow output stabilisation. These early contributions provides a structure necessary for the study of the effects of terms of trade shocks on inflation and output variability under different monetary policy regimes.

Ball (1998) extended the theoretical models of inflation targeting to open-economy settings, emphasising the role of the exchange rate and the economy's exposure to external shocks. These studies involved the modification of Taylor rules to include the exchange rate. The implications of inflation targeting in a small open economy are not as clear as in the case of a closed economy. Ball (1998) considered both the direct and indirect effects of the exchange rates. Thus movements in the exchange rate have strong implications for the setting of interest rates. He noted that an appreciation of the exchange rate perhaps due to a favourable terms of trade leads to a cut in the interest rate, followed in the next period by an offsetting increase in the interest rate. The cut in the interest rate is called for because the appreciation is contractionary. He shows that an economy subject to exchange rate fluctuations will be forced to make frequent adjustments to the interest rate in order to achieve a strict inflation target which may generate volatility in output. To avoid excessive variability in the economy, a refined measure of inflation (long run inflation rate) should be targeted. He noted that the only problem in open economy settings is that it may create large fluctuations in exchange rates and output.

In a theoretical model,Svensson (2000) analysed an open economy inflation targeting model in which a cost push shock was introduced in the inflation equation. The model was also characterised by open economy Taylor rule. He noted that real exchange rate affect the relative price between domestic and foreign goods which in turn affects both domestic and foreign demand. The direct effect of exchange rate via import prices through intermediate inputs and final goods is the fastest transmitter of impulses. If flexible inflation targeting is adopted with some weight on output gap, inflation would be stabilised over a longer horizon, thus also stabilising the real exchange rates and output gap after a shock. The central bank also has the option of widening the target band and lengthen the target

horizon which may allow it to deal with uncertainty associated with the supply shock without breaching its target. This helps to smooth the transition of inflation back to target following a shock, since policy acommodates the first round effects of the supply shock (Batini and Haldane, 1998).

Through a DSGE framework, Clarida et al. (1999) argued that monetary policy especially inflation targeting should neutralise second round effects of relative price shocks. Second round effects of relative price shocks include their eventual impact on inflation expectations, wages, and, price setting in the economy and may propagate through direct and indirect channels. According to this view,the best response would be for policy makers to accomodate first-round effects which may involve relative price adjustments, but to respond to more generalized inflation pressures arising from the shock, such as rising inflation expectations, taking into account the pressures on food price inflation and other imported commodities[5]. As complemented by Aoki (2001) if terms of trade shocks are persistent, they can change inflation expectations and thus affect aggregate inflation for a long time. This idea was supported by Woodford (2004) who argued that even if the economy is subject to exogenous real disturbances, it is still possible for optimal monetary policy to be one that maintains completely stable prices. This model implies that the shortrun response to shocks should systematically differ depending on the existing monetary policy regime.

Despite the theoretical advances on the role of inflation targeting in the face of shocks, empirically oriented studies show rather fragmented and inconclusive results especially for emerging and developing countries. Kumhof (2001) used the tradable endowment and interest rate shock in a calibrated model and showed that inflation targeting was not superior to other regimes like exchange rate targets (ET) or monetary targets (MT) since it is vulnerable to external shocks as the other regimes. On the adjustment to exogenous shocks, the differences between inflation targeting and exchange rate targeting was found to be small. Monetary targets were found to be superior to exchange rate targets under negative tradables endowment shock and the real interest rate shock, with inflation targeting imposing a very tight limit on exchange rate flexibility. However, vulnerability to speculative attacks was found to be smaller under inflation targeting than other regimes. This model is limited in that it is calibrated and not estimated. Also as argued by Lane (2003), this analysis fails recognise the presence of commodity prices movements and their shock transmission capacity especially in developing countries. These may force the economy to adjust to terms of trade shocks through changes in output and employment at speed determined by price stickiness which may further aggravate swings in economic activity.

The role of the exchange rate as a component of inflation targeting which can stabilise the economy was analysed by Edwards (2006). He found that flexible exchange rates allow smoother adjustment in relative prices and a decline in passthorugh effects, thus showing shock absorption. Frankel (2007) strengthened the case by noting that floating exchange rates allows monetary independence and automatic adjustment to trade shocks. Flexibility of the regime is also a necessary response to uncertainty about future behavior of shocks and gives central banks the option to respond aggressively to external shocks. This is important for inflation targeting countries because of operating flexible exchange rate regimes. However this analysis does not provide a clear policy pattern to deal with exogeneous shocks.

[5]First round effects- are direct effects on the general price index

Studies by IMF (2005) and Goncalves and Salles (2008) on the experience of emerging market economies found that inflation targeting improved economic performance, lowers inflation, inflation expectations and its variability. In a similar study, Aizenman et al. (2008) found strong response of inflation targeting to exchange rate shocks in commodity exporting countries. These studies did not consider the explicit discussion of economic variables responses to external shocks, which infact may be a test of the resilience of inflation targeting when it is under attack.

Cuche-Curti et al. (2008) in a study of the welfare implications of different monetary policy regimes following different shocks found that inflation targeting was suitable when external shocks are the prevalent source of volatility in a small open economy. They also noted that flexible inflation targeting that partially smoothens exchange rate volatility has superior performance when the main source of nominal rigidity is in the goods market and when shocks originate from abroad. In an economy characterized by nominal rigidities in the labour market, a perfectly passive policy, namely monetary targeting, fares the best. They also noted that in the economy without nominal frictions, the response of inflation to a supply shock tends to be small. This study did not give due attention to the policy responses to relative price shocks especially those emanating from commodity prices.

A more closer study is the one by Mishkin and Schmidt-Hebbel (2007) who tested for the systematic differences between macroeconomic variables of inflation targeters and non-targeters using a panel VAR methodology. They found that inflation targeting helps countries achieve lower inflation in the long run, experience smaller inflation response to oil price shocks and exchange rate shocks, strengthen monetary policy independence and efficiency. The problem with this study is that they only used fluctuations in oil prices, thereby making a more generalisation on the effects of external shocks under different regimes. They also used developed countries as a control group, yet they may have totally different resilient features with emerging markets.

These theoretical and empirical arguments lead us to the following testable hypothesis:

Hypothesis 1. *Inflation targeting countries should have lower responses of macroeconomic variables to commodity terms of trade shocks than countries with other monetary policy regimes.*

Hypothesis 2. *The operating flexible exchange rate in inflation targeting countries should help in reducing the adverse effects of terms of trade shocks, making the exchange rate pass-through effects to be less for inflation targeters than non inflation targeters.*

3 Methodology and Data

3.1 Empirical model

Our interest is to evaluate if terms of trade shocks affect differently countries with different monetary policy regimes. To evaluate these policy responses we apply the Panel Vector Autoregressive (PVAR) methodology following Broda

(2004) and Raddatz (2007). We specify the structural model as follows:

$$A_0 Yit = C_i + A(L)Y_{it} + B(L)X_{it} + \varepsilon_{it} \tag{1}$$

Where; $Yit = (YGAPPERC_{it}, INFL_{it}, MSGRO_{it}, RATES_{it}, ER\_CHANGE_{it})$ *that is vector of endogeneous variables*

$YGAPPERC_{it}$ = *output gap*, $INFL_{it}$ = *inflation rate*, $MSGRO_{it}$ = *Money supply growth*, $RATES_{it}$ = *Interest rate*, ER_CHANGE_{it} = *Exchange rate changes*

X_{it} = *vector of exogeneous variables that is commodity terms of trade* $(CTOT)$

A_0 = *matrix of structural coefficients and contemporaneous interactions*

C_i = *vector of constants representing country specific intercept terms.*

ε_{it} = *vector of iid structural disturbances with distribution* $\varepsilon_{it} \sim N(0, \Omega)$

$A(L)$ *and* $B(L)$ = *matrices of polynomial lags that captures the relationships between edogeneous variables and their lags*

Pre-multiplying (1) by A_0^{-1} we get the following reduced form model which we can estimate:

$$Y_{it} = \alpha_i + D(L)Y_{it} + E(L)X_{it} + u_{it} \tag{2}$$

Where: $\alpha_i = A_0^{-1}C_i$, $D(L) = A_0^{-1}A(L)$, $E(L) = A_0^{-1}B(L)$ *and* $u_{it} = A_0^{-1}\varepsilon_{it}$ being the reduced form residual vector.

This approach provides a flexible framework which combines the traditional VAR approach pioneered by Sims (1980) with panel data to study the dynamic interaction of variables when there is no clear theory regarding the causal link and feedback effects between endogenous and exogenous variables (Love and Zicchino, 2006). Since it can also fit the high frequency data, it can take into account the persistence of the terms of trade shocks. Our macroeconomic variables are highly interlinked, and therefore might be endogenous. Panel VAR addresses the problem of endogeneity by building a system of equations in which each variable is explained by its own lagged values plus past values of other variables. This technique also allows us to capture the stochastic and dynamic patterns of the data thereby helping to distinguish between inflation targeters and non-targeters' response to shocks. The application of panel VARs is not new. They have been typically used to identify dynamic responses of economies to particular shocks (see for example Binder et al., 2005; Ahmed, 2003; Broda, 2004; Raddatz, 2007).

3.2 Identification

The model assumes that terms of trade shocks are exogenous of terms of trade. This is intuitively valid since we are dealing with small open economies who are price takers in the world markets of commodity prices (Broda, 2004). This means that terms of trade movements do not react contemporaneously or with lags to changes in a country's structural characteristics. This assumption lead to a VAR specification where terms of trade shocks are block exogenous. The validity of the assumption of terms of trade exogeneity has been supported by a number of studies (see for example Kose, 2002; Ahmed, 2003; Broda, 2004; Raddatz, 2007).

Even though the vector of disturbances are assumed to be *iid*, they do not fully identify our structural model (Ahmed, 2003). The innovations may still be contemporaneously correlated that is the covariance matrix Ω may not be a diagonal matrix, making shocks to affect multiple variables in the current period (Lutkepohl, 2005). The common practice in literature, is to impose some structure of the VAR system based on economic theory. Sims (1980) suggested the orthogonalisation of the covariance matrix using the standard Choleski factorisation which involves a recursive causal ordering of variables according to the degree of exogeneity. This introduces some restrictions on the contemporaneous correlations between the variables. This restriction implies that a variable coming earlier in the ordering affects the next ones both contemporaneously and with a lag, while a variable coming later has merely lagged effects on the preceding ones (Love and Zicchino, 2006). This restriction is used to recover A_0 and Ω from the reduced form panel VAR equations. Therefore A_0^{-1} should be identified so as to identify the structural innovations ε_{it} and the dynamic responses of Y_{it} (Hoffmaister and Roldos, 2001). This restriction is equivalent to imposing a lower triangular block on A_0 matrix as follows[6]:

$$A_0 = \begin{pmatrix} A_{11}^0 & A_{12}^0 \\ A_{21}^0 & A_{22}^0 \end{pmatrix} = \begin{pmatrix} 1 & 0 & 0 & 0 & 0 & 0 \\ a_{21} & 1 & 0 & 0 & 0 & 0 \\ a_{31} & a_{32} & 1 & 0 & 0 & 0 \\ a_{41} & a_{42} & a_{43} & 1 & 0 & 0 \\ a_{51} & a_{52} & a_{53} & a_{54} & 1 & 0 \\ a_{61} & a_{62} & a_{63} & a_{64} & a_{65} & 1 \end{pmatrix} \tag{3}$$

The lower triangular matrix is the choleski decomposition of the estimated covariance matrix and the system resulting from a causal ordering is a recursive model.

The appropriate specification of a VAR model and ordering of variables has been subject of debate in the literature (Mishkin and Schmidt-Hebbel, 2007). Even though there is a general consensus of ordering variables according to their degree of exogeneity, the ordering may still be too arbitrary. To overcome the problem of arbitray ordering, we may also consider alternative orderings and also use generalised impulse response functions as suggested by Pesaran and Shin (1998). Following these arguments, we order our variables in the PVAR as follows: terms of trade, output

[6] This implies that $a_{12} = a_{13} = a_{14} = a_{15} = a_{16} = 0$. Identification requires a further assumption that $a_{23} = a_{24} = a_{25} = a_{26} = a_{34} = a_{35} = a_{36} = a_{45} = a_{46} = a_{56} = 0$

gap, inflation, exchange rates, money supply growth and interest rates. The way variables influence each other depends on their position in the ordering. Terms of trade is therefore ordered first, allowing for no contemporaneous feedback effects from other variables. Inflation and exchange rates are ordered after output gap, because economic theory assumes that contemporaneous causation goes from output gap dynamics to domestic price movements and exchange rate movements. However as noted by Ahmed (2003), the reverse can be true especially for the exchange rate where its changes can be a source of instability for domestically driven shocks. The ordering of interest rates and money supply growth at the far end permits them to react contemporaneously to the dynamics of the earlier macroeconomic variables, although the feedback effects from these policy variables to macrooeconomic variables is expected to operate with a lag. This is common in US monetary policy studies applying VARs (see for example Stock and Watson, 2001; Bernanke and Mihov, 1998). Our study adopts an almost similar ordering to Mishkin and Schmidt-Hebbel (2007). We also change ordering of variables as a robustness test.

We also impose the restriction of similar underlying structure for each cross-sectional unit, since the use of a PVAR approach requires the underlying structure to be the same. This is standard in literature on external shocks and economic performance (see for example Ahmed, 2003; Broda, 2004). This is intuitive since we are dealing with emerging market economies which are relatively homogeneous, hence the heterogeneity of parameters is likely to be small and the exogenous dynamic process of commodity terms of trade shocks are likely to be relatively similar. The advantage of this assumption is that it increases the number of degrees of freedom and if the differences in slope coefficients are uncorrelated with exogenous variables, parameters would be consistent (Raddatz, 2008). However as pointed out by Pesaran and Shin (1998), the disadvantage is that if the slope parameters are heterogeneous across cross sectional units or if the exogenous shocks differ, the model may be incorrectly specified.

The analysis of the macroeconomic variables responses to terms of trade shocks is done through impulse responses and variance decompositions (innovation accounting). The impulse response function traces out the time path of variable responses to shocks in the error terms for several periods in the future. They inform us on the sign and time trajectory of the impact of a one standard deviation shock to one variable in the system on another thus helping us to analyse the "causes and effect" phenomenon (Cochrane, 2005). Generally, we can write the impulse response function of economic variables to commodity terms of trade shocks as:

$$y_{it} = \Psi(L) e_{it}^{ctot} \tag{4}$$

where yit represents economic variables, $\Psi(L)$ *is a lag polynomial and* e_{it}^{ctot} *is the commodity terms of trade shock.* The coefficients of $\Psi(L)$ shows how a terms of trade shock affects macroeconomic variables over time. The comparison of impulse response functions of the effects of terms of trade shocks under different monetary policy regimes is done by noting their differences. The size of the differences in impulse responses is an indicator of the amount of information in a variable of interest and suggest greater strength of one monetary policy regime over the other. If inflation targeters respond better to external disturbances, then we would expect lower responses of variables to these shocks in IT countries than in other regimes. Variance decompositions helps in evaluating how important

terms of trade shocks are in explaining inflation, output gap, exchange rate, money supply growth and interest rate variability under different monetary policy regimes.

3.3 Data and Variables

We use quarterly panel data for 35 emerging market economies from 1980-2008. We divide the sample into 15 inflation targeters and 20 non inflation targeters (control group). We further divide the sample of inflation targeters into two that is before inflation targeting and after inflation targeting. This constitutes an unbalanced panel because of the differences in adoption dates of inflation targeting. Non inflation targeters are divided into monetary targeters and exchange rate targeters. There are 11 monetary targeters and 9 exchange rate targeters as shown in table 1. For non inflation targeters, we take 1995 as the dividing year to allow for dynamic comparison between two time horizons that is before and after 1995. The figure also shows geographical distribution of these countries as Latin America, Asia, Europe and Africa.

Our main variable used in this study is the commodity terms of trade index. This follows from Deaton and Miller (1995) and its use is a better alternative to the common approach of using the standard terms of trade index. Although these indices are somehow related they differ in that the commodity terms of trade are more focused on commodities and reflect their importance in the overall economy.

This index is a weighted average of the main commodity export prices divided by the weighted average of the main commodity import prices as follows:

$$CTOT_{it} = \frac{\prod_{j}(P_{jt}/MUV_t)^{X_{ji}}}{\prod_{j}(P_{jt}/MUV_t)^{M^{ji}}} \tag{5}$$

where P_{jt}=individual commodity prices, MUV_t=manufacturing unit value index is a trade-weighted index of the five major developed countries' exports of manufactured commodities to developing countries. It is used as a deflator so that we get real commodity export and import prices. The use of the MUV index as a deflator is common to most studies in the commodity price literature (Cashin and McDermott, 2002). X_{ji}=share of exports of commodity j in country i's GDP. M_{ji}= share of imports of commodity j in country i's GDP. 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. Keeping the weights constant over time, allows supply responses of price changes to be excluded from the analysis so that the index is exogeneous. Inorder to allow the effect of commodity export prices to be larger for countries with higher commodity exports, the deflated index is weighted by the share of commodity exports or imports in a country's GDP. Defining the weights in terms of GDP allows the composition of exports and imports as well as cross country differences to be taken into account (Tytell and Spatafora, 2009). 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

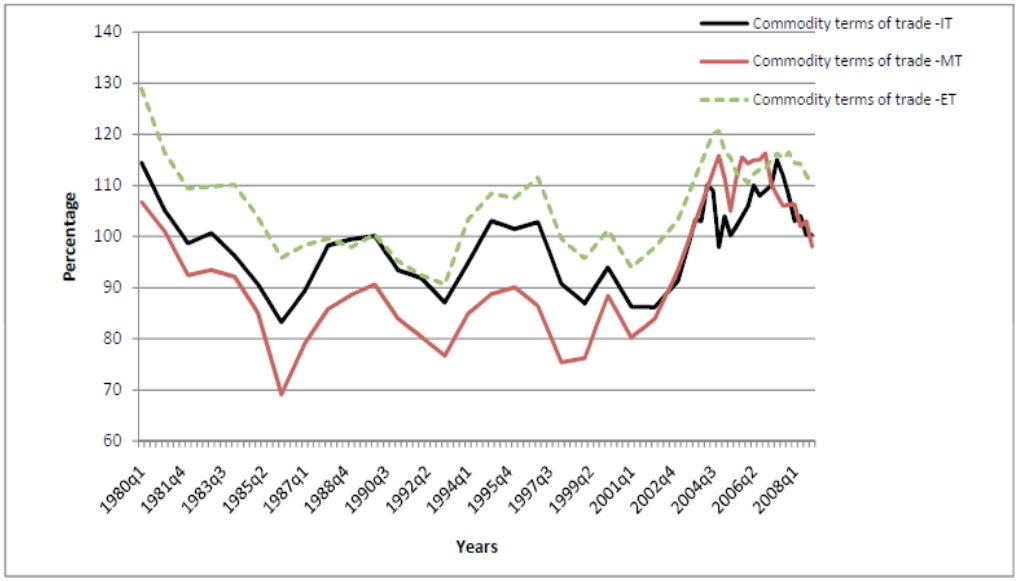
same. In this case the movements in commodity terms of trade reflects only changes in commodity prices rather than changes in the volumes of exports and imports due to price fluctuations. The updated data for the Deaton and Miller (1995) index was obtained from Raddatz (2008) and Tytell and Spatafora (2009). We also consider the standard terms of trade index which is computed as the ratio of export prices to import prices in the robustness checks.

Output Gap is there to capture the business cycles and is measured by the deviation of output from its trend. Output is measured by the real Gross Domestic Product and the trend output is obtained from the Hodrick Prescott Filter (with a smoothing parameter of 1600). This is standard in literature (see for example Mishkin and Schmidt-Hebbel, 2007). Inflation is measured by the composite consumer price indices as calculated in different countries. This variable enters the model as a policy goal variable being an indicator of prices as is common in literature (see for example Bernanke and Mihov, 1998). Exchange rates are calculated as the percentage change in the exchange rate for each country which measure the devaluation or appreciation of the nominal exchange rates (Mishkin and Schmidt-Hebbel, 2007). For interest rates we use discount rates of the central bank or policy rates as used in different countries following Bernanke and Blinder (1992). This is the rate at which the central bank provides short term loans to banks. The variable features in the panel VAR as an instrument of monetary policy and is an indicator of monetary policy stance. Money supply growth (change in the level of M2 monetary aggregates) was included as a monetary indicator variable and is an important intermediate target of monetary policy for monetary targeters. The components of M2 are the currency in circulation, demand deposits and time deposits. These variables and data sources are listed in table 2 in the appendix.

We further take a look at the data and analyse some descriptive statistics. In figure 1 we analyse commodity terms of trade dynamics with respect to different monetary policy regimes. In general, there are noticeable busts in the late 1980s and minor booms in the 1990s. This was followed by major terms of trade boom which reached its peak around 2007. The booms seems to be larger but relatively shorter than busts with the latest boom being longer than other previous booms. This primarily reflects the increase in commodity prices. We notice that emerging market economies with different monetary policy regimes experienced generally similar patterns of booms and busts of terms of trade shocks. This similar pattern helps us in our task of comparing the behavior of macroeconomic variables and policy responses of different monetary policy regimes to these shocks. Figure 5 shows the evolution of commodity terms of trade across different regions. It is apparent that commodity terms of trade are more volatile in African and Latin American countries. Asian countries experienced mild shocks while European countries had smoother commodity terms of trade profile. To a greater extent this distributional pattern reflects differences in the composition of exports and imports as well as their price volatilities. Tytell and Spatafora (2009) noted that the pattern for Latin America reflects its dependence on both fuels and non fuel commodities while most Sub Saharan countries depends more on non fuel commodities.

We also show summary statistics for our variables. Table 3 which compares inflation targeters before and after the adoption of inflation targeting shows that commodity terms of trade variability was marginally higher after inflation targeting adoption than before IT adoption. However there is a significant decrease in inflation, output

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



gap and interest rate variability after the adoption of inflation targeting. Possibly this may be a reflection of the role of inflation targeting in reducing the standard deviations of these variables. Table 4 shows summary statistics of inflation targeters after IT adoption and non inflation targeters after 1995. It is apparent from the table that commodity terms of trade variability was higher among non inflation targeters than inflation targeters. The average inflation level for inflation targeters during the inflation targeting period was lower than for non inflation targeters during the 1995-2008 period. Also inflation variability was higher in non inflation targeting countries than inflation targeting countries. A similar pattern is also reflected in output gap variability, exchange rate volatility as well as money supply growth and interest rate variabilities where inflation targeters are better than non targeters. Table 5 shows comparative summary statistics for inflation targeters, monetary targeters and exchange rate targeters. We observe that on average monetary targeters had higher commodity terms of trade variability than inflation targeters and exchange rate targeters. In terms of inflation outcomes, on average inflation targeters had average inflation rate of 5.44 while monetary targeters and exchange rate targeters had 10.65 and 12.43 respectively. The variability of inflation was lowest in inflation targeting countries, while it was four times higher for monetary targeters and seven times higher for exchange rate targeters. While output gap variability is highest in exchange rate targeting countries, compared to other regimes, the volatility of money supply growth and interest rates are lowest in inflation targeters than non inflation targeters.

The systematic differences in the behavior of macroeconomic variables between inflation targeters and non inflation targeters as well as before and after inflation targeting give us ground to believe that inflation targeting can make a difference. The purpose of this paper is to test this conjenture and rationalise it in a panel VAR model framework.

3.4 Panel data tests

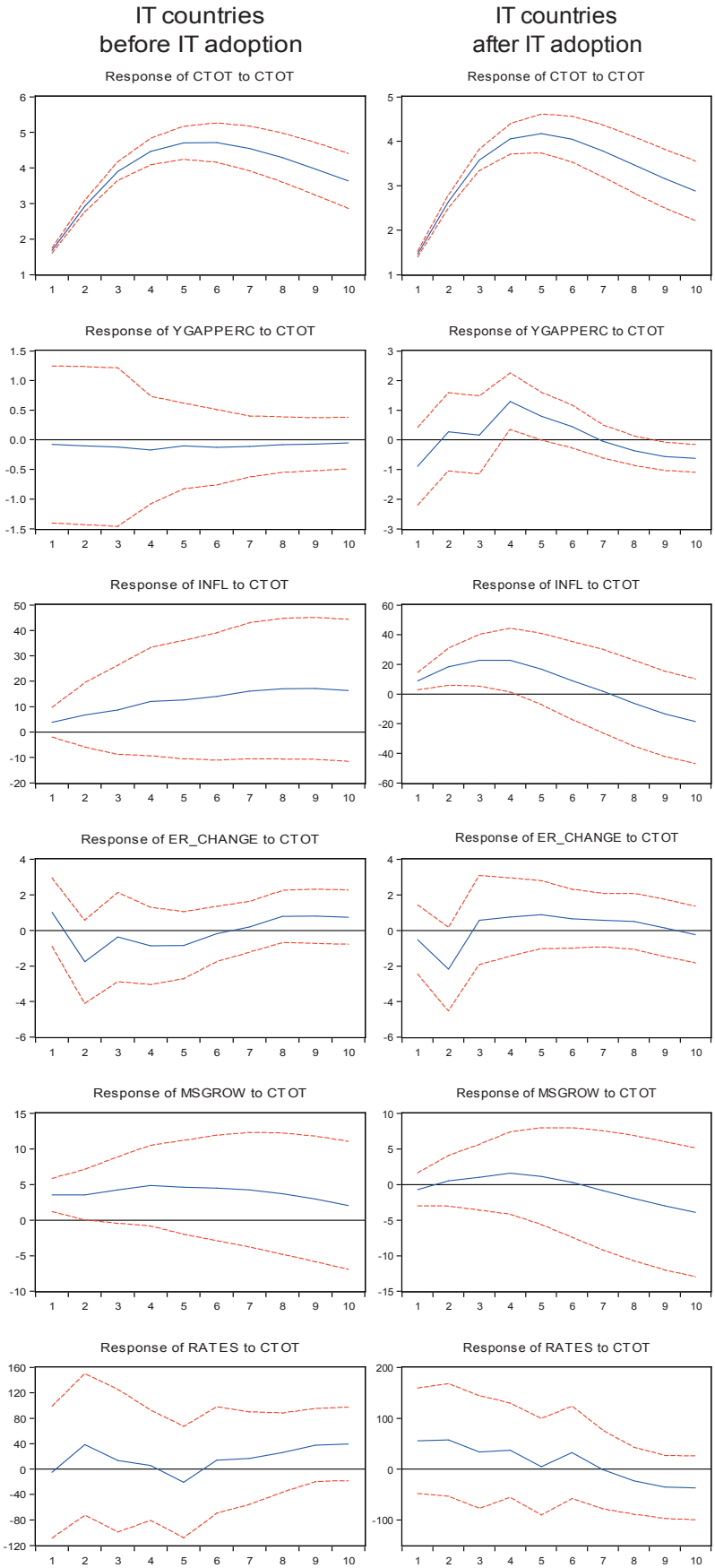
Although stationarity tests have been standard in macroeconomics, there has been debates on whether macroeconomic variables should be represented by trend stationary or by first differences stationary variables (see for example Bernanke and Mihov, 1998; Stock and Watson, 2001). Sims et al. (1990) argued that the common practice of transforming the models to stationarity by differencing or integration if the data appears to be integrated is not really necessary because statistics of interest often have limiting distributions that are not affected by non stationarity. This suggests that the hypothesis can be tested without first transforming to stationary regressors. They argued that what matters is not whether the variables are integrated, but whether the statistics of interest have a limiting distribution. Enders (2004) argued that differencing throws away a lot of useful information concerning comovements in the data. The use of VARs in levels can also be justified on the need to avoid imposing incorrect restrictions which may lead to wrong inferences (Kim and Roubini, 2000). We therefore test for stationarity of the variables using the Fisher Type of Test as suggested by Maddala and Wu (1999). This test combines the p-values from individual unit root tests. Table 6 shows the results. Basing on this test, we fail to reject the null hypothesis of no unit roots. We therefore proceed to estimate the panel VAR in levels since the variables are stationary. The estimation of panel VARs in levels is also common in recent studies (see for example Raddatz, 2007; Loayza and Raddatz, 2007). The selection of the optimum lag length is guided by the Akaike information criteria (AIC) and the Bayesian information criteria (BIC), thus we include 4 lags as shown on table 7.

4 Estimation Results

The discussion of the results focuses on impulse response functions and variance decompositions of dynamic responses of macroeconomic variables induced by terms of trade shocks based on the counterfactual experiments with different monetary policy regimes in which inflation targeting is the benchmark. We first compare impulse responses of inflation, output gap, exchange rates, money supply growth and interest rates to a terms of trade shock for inflation targeters before and after IT adoption in figure 3. The central solid lines shows the point estimates of the impulse response functions and the outer lines show confidence intervals of the response functions.

For output gap, a one standard deviation shock to commodity terms of trade leads to a 0.2% drop in output gap on impact before inflation targeting, but the effect is not significant. After the adoption of inflation targeting, we notice that the shock leads to an initial drop before a rise in output gap at the second quarter. It peaks to 1.1% at the 4th quarter before a protracted decrease which becomes more stationary in the longrun. Perhaps this implies that the issue of output stabilisation is a longrun phenomenon under inflation targeting. Impulse response profiles for inflation are shown in the third row of figure 3. Positive terms of trade shock lead to a larger increase in inflation before inflation targeting than after inflation targeting. Specifically after IT adoption, inflation initially rises, peaking at about 20% before decreasing to 0% at the 7th quarter. The inflation response for inflation targeters is significant up to the third quarter. This low response of inflation to terms of trade shocks for inflation targeters

Figure 2: Impulse responses of variables to commodity terms of trade shocks: Inflation targeters before and after inflation targeting



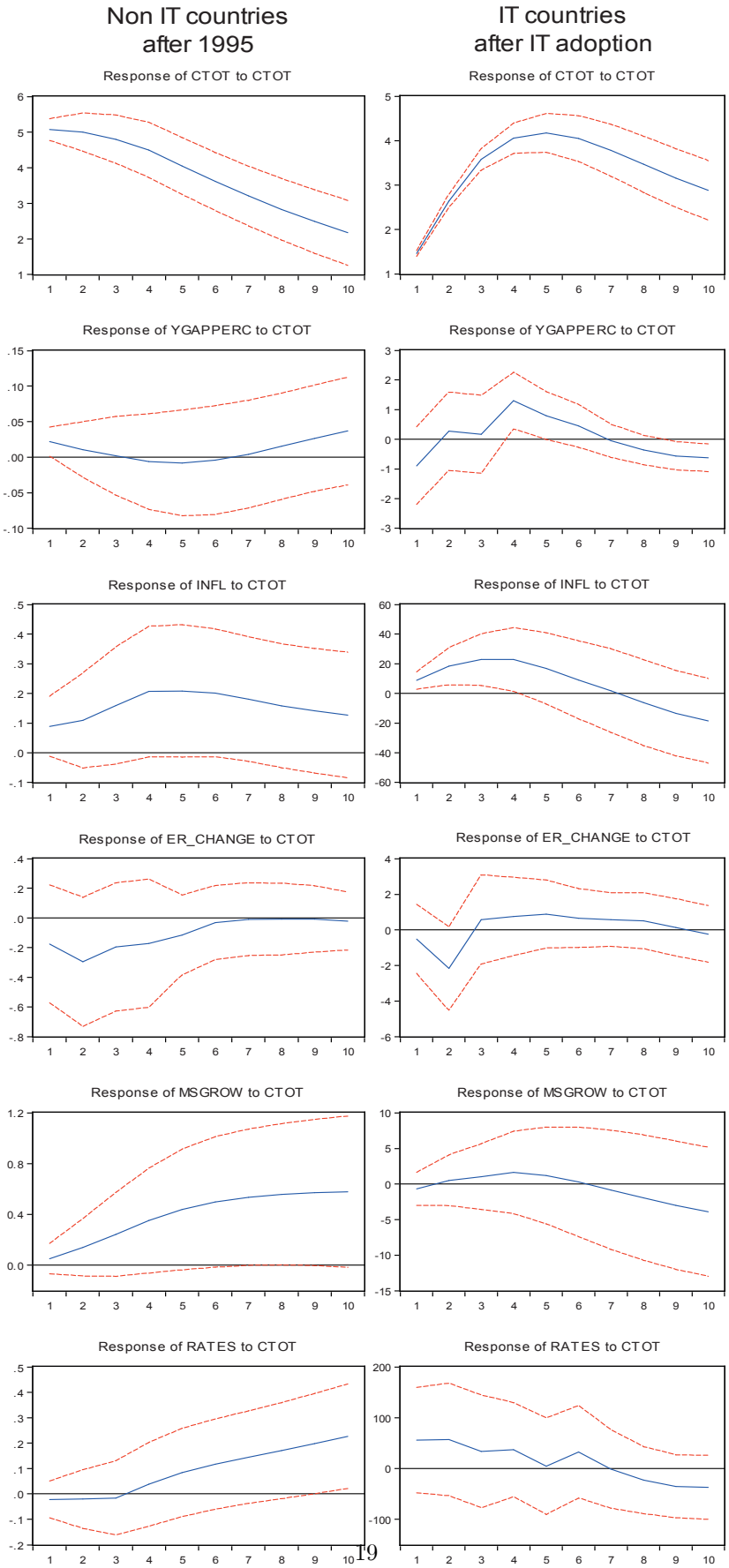
may be a reflection of IT central banks observing their mandate of stronger anti inflation stance. This result is consistent with view that central banks react to inflation when it becomes a problem but concentrate on other objectives when inflation is under control (Orphanides and Wieland, 2000).

Figure 3, 4th row also shows the response of nominal exchange rates to external shocks. Exchange rates appreciate by 0.5% on impact and further to 2% in the second quarter before it adjust to the longrun equilibrium. The result is consistent with what other empirical studies (see for example Broda 2004). The pattern is almost similar to inflation targeters before IT adoption implying a small difference in the response to shocks. For money supply growth, there is also no much difference before and after IT adoption. Interest rates movements shows interesting reactions following a shock for the period before IT adoption. There is an increase in interest rates, followed by a protracted decrease, whereas for the period after IT adoption, there is a slight increase, followed by protracted decrease to 0% at the 5th quarter and a further increase peaking at the 6th quarter. Interest rates are more volatile after IT adoption than before, showing their active role in stabilising other variables. The decrease in interest rates is there to dampen the real output fluctuations after a commodity terms of trade shock.

Figure 3 compares the responses of variables to a standard deviation positive shock to commodity terms of trade for inflation targeters during inflation targeting period and non inflation targeters after 1995. Output gap response is higher for inflation targeters than non targeters, showing that shocks to output may be more persistent in inflation targeting countries than non inflation targeters. Infact a terms of trade shock leads to a 1% significant drop in outputgap on impact before an increase which peaks at 1.1% in the 4th quarter and later a decrease in the longrun. Specifically, inflation rises by about 8% on impact and later fall at the 4th quarter in which the effect is statistically significant. For non inflation targeters after 1995, the adjustment process takes longer and the effect is not significant. Therefore inflation responds significantly less for inflation targeters than non targeters. This response is consistent with the view that inflation targeting regime facilitates the adjustment of economies to shocks by allowing first round effects to go through, but pay attention to second round effects which affects inflation expectations (Clarida et al., 1999). Mishkin and Schmidt-Hebbel (2007) found a similar result for the inflation response to oil price shocks. When central banks seeks to mitigate the inflationary consequences of terms of trade shocks, they face more protracted movements in real activity. Therefore there is no divine coincidence (that is the absence of a trade off between inflation stabilisation and output gap stabilisation). As noted by Blanchard and Gali (2007), stabilising inflation which is equivalent to targeting the natural level of output causes output variations that wipes away the divine coincidence.

The response of the exchange rate is shown in the 4th row of figure 3. There is basically a small difference in the response of exchange rates between the two regimes. It is also apparent from the figure that money supply growth rises by a larger magnitude for non inflation targeters than for inflation targeters. This may be a reflection of the active role of money supply in non inflation targeters, considering that 55% of non inflation targeting countries are monetary targeters. Following a commodity terms of trade shock, interest rates for non inflation targeters responds by raising their interest rates. Inflation targeters totally do the opposite, that is they decrease the interest rates, with the adjustment lasting up to the 6th quarter. This difference in response by these regimes may be due to the

Figure 3: Impulse responses of variables to commodity terms of trade shocks: Non inflation targeters and Inflation targeters



focus of their monetary policy frameworks for example inflation targeters focus on price stabilisation with some weight on output gap stabilisation.

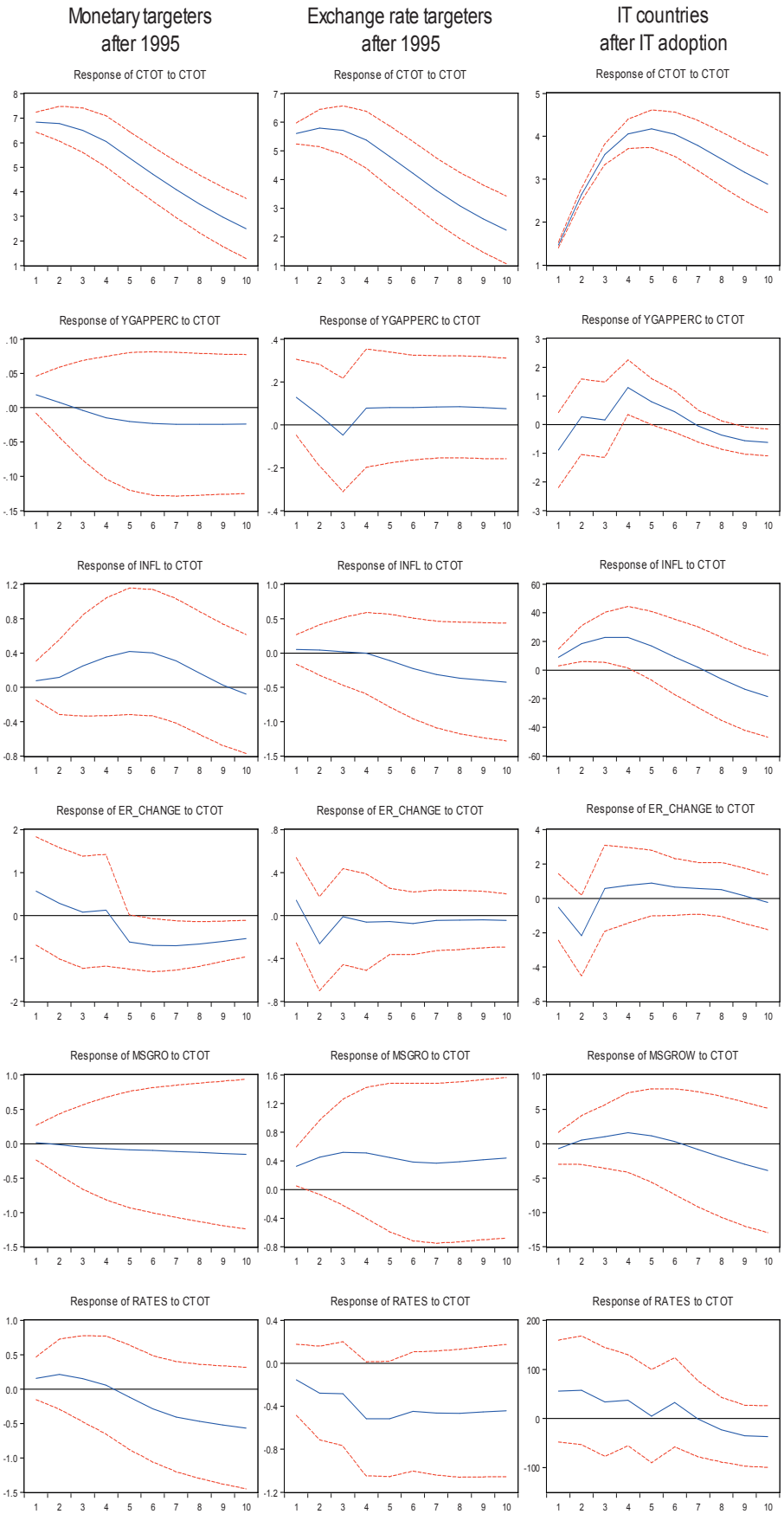
It is also important to analyse the whether there are any systematic differences for non inflation targeters themselves in their response to shocks in different time horizons that is before 1995 and after 1995. This helps us to see if there might be a time effect on the response to shocks in different periods. Figure 6 shows the results.

Following a commodity terms of trade shock, we observe more variability of the output gap before 1995 than after 1995. There seems to be no systematic difference in responses of inflation and money supply growth in the two horizons. However some differences are noticed for the responses of exchange rates and interest rates. Before 1995, a shock led to a depreciation of the exchange rate up to the 3rd quarter followed by an appreciation. Yet after 1995, a positive shock led to an appreciation followed by depreciation and the exchange rate stabilises in the 5th quarter. Interest rates are more stable before 1995 than after 1995. These mixed results shows that time is not necessarily a factor in the way variables respond to external shocks. Hence it is difficult to believe that inflation targeting countries were exposed to very different shocks from those of non inflation targeters. Thus the differences on the responses to shocks seems to be largely attributed to the different roles of monetary policy.

We also compare the response of economic variables to terms of trade shocks under monetary targeting and exchange rate targeting after 1995 versus inflation targeting during inflation targeting periods. We make this disaggregation because the sample of non inflation targeters is comprised of monetary targeters and exchange rate targeters. If these countries are lumped together as non inflation targeters impulse responses to shocks would be more generalised. Figure 4 show these results.

We observe wide variability in the output gap for inflation targeters than monetary targeters and exchange rate targeters. However the impulse responses for the output gap for the monetary targeters and exchange rate targeters are insignificant for all the horizons while that of inflation targeters are significant and stable in the longrun. A shock to commodity terms of trade leads to a negative output gap which later stabilises for exchange rate targeters. The response of inflation is significantly less volatile under inflation targeting than under monetary targeting. We notice an initial rise which peaks at 20% before protracted decrease in which the adjustment period is completed after 7 quarters. While inflation response for inflation targeters is significant up to the 4th quarter, it is not significant for monetary targeters and exchange rate targeters. This result may be attributed to the added role of flexible exchange rates as shock absorbers and help reduce the persistence of inflation (Edwards, 2006). Theoretically plausible considering the focus on stable inflation in inflation targeting countries. The exchange rate responses shows more stability under exchange rate targeters than under inflation targeting and monetary targeting. This is consistent with economic literature which predicts sluggish adjustments of the exchange rate in countries which targets the exchange rate. As noted by Gerlach and Gerlach-Kristen (2006) exchange rate targeters ensure stability of the nominal exchange rate against an anchor currency, implying that there are no direct responses to external shocks. We notice a decrease in money supply growth for monetary targeters, a steady rise for exchange rate targeters and an initial increase and then a decrease in IT countries following a commodity terms of trade shock. The response of interest rates exhibit more variability under inflation targeting since they are the instruments of

Figure 4: Impulse responses of variables to commodity terms of trade shocks: inflation targeters, monetary targeters and exchange rate targeters



monetary policy.

We also analyse the response of our main variables to an exchange rate shocks, considering that the exchange rate is likely to be the main transmission channel of external shocks to emerging market economies. This analysis provides a novel interpretation of exchange rates as possible shock absorbers. Figure 7 compares these responses to exchange rate shocks. The response of exchange rate shocks to the output gap shows no much difference for inflation targeters before and after IT adoption. The effect of these shocks on inflation reflects the degree of pass-through to domestic inflation. In this regard, there seems to be large statistically positive and significant pass-through effects before inflation targeting than after inflation targeting (3rd row, figure 7). This may show the role of inflation targeting and is consistent with Taylor (2000)'s proposition that a commitment to price stability results in a decline in passthrough effects. Aghion et al. (2009) noted that high exchange rate flexibility tend to dampen the impact of terms of trade shocks.

In figure 8 compares the responses to exchange rate shocks between inflation targeters countries after IT adoption and non inflation targeters after 1995. In terms of inflation pass-through effects, we observe a large inflation response for non inflation targeters of up to 1.1% compared with 0.3% for inflation targeters. This low pass-through effects may be a confirmation that inflation targeting ensures well anchored inflation expectations. In terms of interest rates, there seems to be a sharp rise on impact for non inflation targeters, but that is followed by a decrease in the rates. In contrast, for inflation targeters, there is a gradual rise in the interest rates which peaks at 0.4% in the 6th quarter. This shows how cautious inflation targeting countries are in responding to exchange rate shocks.

We compare the responses to exchange rate shocks of inflation targeters during inflation targeting, monetary targeters after 1995 and exchange rate targeters after 1995 in figure 9 . We observe that while there is a sharp significant increase in output gap for monetary targeters, the positive response for inflation targeters is small and not significant. For exchange rate targeters, there is a decrease in output gap (second row, figure 9). On the devaluations-inflation pass-through, there is infact a small statistically insignificant rise for exchange rate targeters than inflation targeters while there is a large positive and significant response of inflation up to the 5th quarter for monetary targeters. The low exchange rate pass-through for exchange rate targeters is intuitive because of sluggish adjustments in the exchange rates which essentially implies smaller exchange rate shocks. In terms of interest rates responses to exchange rate shocks, large and statistically significant positive responses is noticed in inflation targeting countries than monetary targeters and exchange rate targeters. The results generally suggests that anchoring of inflation expectations is important for inflation and output gap stability.

As part of innovation accounting, we also analyse variance decompositions to see the contribution of commodity terms of trade shocks to the variation of each variable in different monetary policy regimes. Table 8 (in the appendix) shows these variance decompositions in the shortrun and longrun.

The table shows that about 3.9% of the variation of longrun variation of the output gap for inflation targeters before IT adoption is explained by commodity terms of trade shocks compared to 4.8% after IT adoption. This output gap variation explained by commodity terms of trade shocks is generally higher for monetary targeters and

exchange rate targeters than inflation targeters. Commodity terms of trade shocks explain 6.8% and 9.56% of the inflation variation for inflation targeters in the shortrun and longrun respectively. The role of inflation targeting is clearly noticed when we compare inflation targeters and non inflation targeters in which commodity terms of trade shocks explain generally higher variations of variables for non inflation targeters. However there are mixed results when we compare the variations of other variables under monetary targeting, exchange rate targeting and inflation targeting. The lower contribution of commodity terms of trade shocks to inflation both in the short run and long for inflation targeters than monetary targeters is also a clear result.

The effect of the exchange rate regime in place is also noticed in the case of exchange rate targeters in which the contribution of terms of trade shocks accounts for less than 7% of exchange rate volatility in the longrun, compared to higher contribution in the case of inflation targeters and monetary targeters. The variation of inflation due to commodity terms of trade shocks is smallest for exchange rate targeters. This result concur with the results from earlier impulse responses analysis and is consistent with previous studies (see e.g. Broda 2004). Mendoza(1995) found far much higher contributions of terms of trade shocks to exchange rate variations using calibrations of the a real business cycle model. The active role of the interest rates in inflation targeting countries is also observable in our results with high contributions of terms of trade shocks to their variability.

Overall, the our results shows that inflation targeting stabilises inflation at the expense of other real variables in the face of external shocks. However the output gap becomes significantly stable in the longrun. There is no systematic difference in response with respect to other variables to commodity terms of trade except that there is active use of interest rates in IT countries. Also exchange rates appreciate following favourable external shocks and depreciate under unfavourable external shocks. Inflation targeters seems to have lower pass-through effects than non targeters, showing the importance of anchored inflation expectations. Commodity terms of trade shocks generally explain lower variation of varibales in inflation targeters than in other regimes.

4.1 Robustness checks

To test if the empirical results are indeed robust, we conduct robustness and sensitivity tests. The first robustness test entails using the broad terms of trade index instead of the commodity terms of trade index. Figure 10 in the appendix provides comparative responses of variables to a broad terms of trade shock for inflation targeters and non inflation targeters.

The figure shows that the output gap responds positively and significantly for non inflation targeters while it resembles stead positive and insignificant response for both inflation targeters after inflation targeting and non targeters after 1995. This contrasts our original findings where it was more volatile after inflation targeting. In the case of inflation, it rises on impact and drops thereafter following a trade shock both before and after inflation targeting but increases in the case of non inflation targeters. Inflation targeters display low response variability than non targeters. Similar to our earlier findings, exchange appreciates following a terms of trade shock, but for non inflation targeters it displays a contemporaneous depreciation. The response of money supply growth for

inflation targeters after IT adoption and non targeters after 1995 display similar results of responding positively to a broad terms of trade shock. However, interest rates rise for inflation targeters following a broad terms of trade shock in contrast to earlier findings.

We also compare the variables responses to broad terms of trade shocks for inflation targeters during inflation targeting, monetary targeters and exchange rate targeters after 1995 in figure 11 in the appendix. Similar profiles of output gap responses to broad terms of trade shocks with earlier findings are observed. Positive effects are noticed for monetary and exchange rate targeters while an initial positive response which decreases in the shortrun is observed for inflation targeters. The exchange rate depreciate on impact but appreciate thereafter for monetary and exchange rate targeters, but an appreciation is noticed for inflation targeters. Similar to the earlier findings, small responses of the exchange rate are noticed in the case of exchange rate targeters than monetary and inflation targeters. The response of money supply growth is similar in all 3 regimes but monetary targeters display low volatility. Interest rates rise on impact and display higher variability for inflation targeters while the response is more stable for monetary and exchange rate targeters. As in earlier results, this is expected because interest rates are varied inorder to bring other variables to stability.

An alternative ordering of variables within the panel VAR framework was also considered basing any other possible contemporaneous economic effects. For example exchange rates were ordered before inflation and interest rates were ordered before money supply growth. These different alternative orderings did not change the results.

To further test the robustness of our results, we change the lag structure to 2 lags instead of 4 lags. We found that the results are broadly similar to those using the lag of 4 lags. However when we increased the lag length to more than 4 lags, we notice that the responses of variables tend to be more variable than when the lag structure is less than 4 lags. This confirms that the optimal lag length is actually 4 as indicated by various criteria. However the paper's conclusions did not change in the sense that this had an effect across all estimations.

5 Conclusion

In this paper, we evaluate and compare stabilisation properties and responses of different monetary policy regimes in the face of commodity terms of trade shocks. We do this inorder to determine if inflation targeting is better than other regimes during turbulent times. We use country specific commodity terms of trade indices which are expected to capture a larger set of fundamental relative price shocks that are indicated by movement in one commodity (such as oil price) alone as was used in previous studies. We specified a panel VAR and analyzed the aggregated impulse response functions of economic variables to this shock. We therefore make a contribution by using country specific commodity terms of trade indices considering their importance in driving macroeconomic dynamics in emerging market economies.

Our results demonstrated with new evidence that in general, countries which have adopted inflation targeting seem to respond better to terms of trade shocks than countries which have not, especially with respect to their

response to inflation. Although the inflation-outputgap variability tradeoff was acknowledged by our results in the short-run, there is a longrun stability of the output gap for inflation targeters compared to monetary targeters and exchange rate targeters. Our results also confirms that inflation targeting countries have lower devaluation-inflation pass-through effects than other non inflation targeters. However when we separated the non inflation targeters into monetary targeters and exchange rate targeters, we found that exchange rate targeters have low inflation pass throughs than inflation targeters and monetary targeters. We observed small systematic differences in response of money supply growth and exchange rates to external shocks between different regimes, but high variability of interest rates was also observed for inflation targeters. The results are generally robust to to different sensitivity tests.

Our results suggests that although terms of trade shocks may cause more output variability, tightening of monetary policy may also explain its variability. Also the act of stabilising inflation in the short run goes with a cost of succumbing to a high output gap variability. The results also suggest that increasing the flexibility of exchange rates can provide a further insulation against shocks since they may act as shock absorbers. Although terms of trade shocks may have undesirable effects on macroeconomic variables, the adoption of inflation targeting can make the effects manageable in the longrun. This analysis shows that to some extent inflation targeting matter for macroeconomic stabilisation.

References

Aghion, P., Angeletos, G., Banerjee, A. and Manova, K. (2004). Volatility and growth: Financial development and the cyclical composition of investment, *Unpublished working paper, Harvard University* .

Aghion, P., Bacchetta, P., Ranciere, R. and Rogoff, K. (2009). Exchange rate volatility and productivity growth: the role of financial development, *Journal of Monetary Economics* **56**(4): 494–513.

Ahmed, S. (2003). Sources of economic fluctuations in latin america and implications for choice of exchange rate regimes, *Journal of Development Economics* **72**(1): 181–202.

Aizenman, J., Hutchison, M. and Noy, I. (2008). Inflation targeting and real exchange rates in emerging markets.

Andrews, D., Rees, D., Pagan, A., Lewis, C., Finlay, R., Norman, D. et al. (2009). Macroeconomic volatility and terms of trade shocks, *RBA Research Discussion Papers* .

Aoki, K. (2001). Optimal monetary policy responses to relative-price changes, *Journal of Monetary Economics* **48**(1): 55–80.

Ball, L. (1998). Policy rules for open economies, *NBER working paper* .

Barro, R. and Sala-I-Martin, X. (2004). Economic growth, *Massachusetts Institute of Technology, London* .

Batini, N. and Haldane, A. (1998). Forward-looking rules for monetary policy, *NBER working paper series* .

Batini, N. and Tereanu, E. (2009). What should inflation targeting countries do when oil prices rise and drop fast?, *IMF Working Paper* .

Bernanke, B. and Blinder, A. (1992). The federal funds rate and the channels of monetary transmission, *The American Economic Review* pp. 901–921.

Bernanke, B., Gertler, M., Watson, M., Sims, C. and Friedman, B. (1997). Systematic monetary policy and the effects of oil price shocks, *Brookings Papers on Economic Activity* **1997**(1): 91–157.

Bernanke, B., Laubach, T., Mishkin, F. and Posen, A. (1999). *Inflation targeting: lessons from the international experience*, Princeton University Press.

Bernanke, B. and Mihov, I. (1998). Measuring monetary policy, *Quarterly journal of economics* **113**(3): 869–902.

Binder, M., Hsiao, C. and Pesaran, M. (2005). Estimation and inference in short panel vector autoregressions with unit roots and cointegration, *Econometric Theory* **21**(04): 795–837.

Blanchard, O. and Gali, J. (2007). The macroeconomic effects of oil shocks: Why are the 2000s so different from the 1970s?, *NBER working paper series* .

Broda, C. (2004). Terms of trade and exchange rate regimes in developing countries, *Journal of International Economics* **63**(1): 31–58.

Caballero, R. (2002). Coping with chile's external vulnerability: a financial problem, *MIT Dept. of Economics Working Papers* (01-23).

Calvo, G. and Mishkin, F. (2003). The mirage of exchange rate regimes for emerging market countries, *Journal of Economic Perspectives* **17**(4): 99–118.

Calvo, G. and Reinhart, C. (2000). When capital inflows suddenly stop: Consequences and policy options, *Reforming the international monetary and financial system* p. 175.

Cashin, P. and McDermott, C. (2002). Terms of trade shocks and the current account: evidence from five industrial countries, *Open Economies Review* **13**(3): 219–235.

Cashin, P., McDermott, C. and Pattillo, C. (2004). Terms of trade shocks in africa: are they short-lived or long-lived?, *Journal of Development Economics* **73**(2): 727–744.

Clarida, R., Gali, J. and Gertler, M. (1999). The science of monetary policy: a new keynesian perspective, *Journal of economic literature* **37**(4): 1661–1707.

Cochrane, J. (2005). Time series for macroeconomics and finance, *Manuscript, University of Chicago* .

Collier, P. and Goderis, B. (2007). Commodity prices, growth, and the natural resource curse: Reconciling a conundrum, *The Centre for the Study of African Economies Working Paper Series* .

Collier, P. and Gunning, J. (1999). *Trade Shocks in Developing Countries: Africa*, Oxford University Press, USA.

Corden, W. (1984). Booming sector and dutch disease economics: survey and consolidation, *Oxford Economic Papers* **36**(3): 359–380.

Cuche-Curti, N., Dellas, H. and Natal, J. (2008). Inflation targeting in a small open economy, *International Finance* **11**(1): 1–18.

Deaton, A. and Miller, R. (1995). *International commodity prices, macroeconomic performance, and politics in Sub-Saharan Africa*, International Finance Section, Department of Economics, Princeton University.

Debelle, G. (1999). Inflation targeting and output stabilization, *Reserve Bank of Australia* .

Dehn, J. (2000). The effects on growth of commodity price uncertainty and shocks, *World* .

Edwards, S. (2006). The relationship between exchange rates and inflation targeting revisited, *NBER working paper series* (12163).

Edwards, S. and Yeyati, L. (2005). Flexible exchange rates as shock absorbers, *European Economic Review* **49**(8): 2079–2105.

Enders, W. (2004). *Applied econometric time series*, J. Wiley.

Frankel, J. (2007). *On the rand: determinants of the South African exchange rate*, NBER.

Gerlach, S. and Gerlach-Kristen, P. (2006). Monetary policy regimes and macroeconomic outcomes: Hong kong and singapore, *BIS Working Paper* (204).

Goncalves, C. and Salles, J. (2008). Inflation targeting in emerging economies: What do the data say?, *Journal of Development Economics* **85**(1-2): 312–318.

Hoffmaister, A. and Roldos, J. (2001). The sources of macroeconomic fluctuations in developing countries: Brazil and korea, *Journal of Macroeconomics* **23**(2): 213–239.

IMF (2005). Does inflation targeting work in emerging market economies?, *World Economic Outlook* .

Kim, S. and Roubini, N. (2000). Exchange rate anomalies in the industrial countries: A solution with a structural var approach, *Journal of Monetary Economics* **45**(3): 561–586.

Kose, M. (2002). Explaining business cycles in small open economies: 'how much do world prices matter?', *Journal of International Economics* **56**(2): 299–328.

Kumhof, M. (2001). A critical view of inflation targeting: Crises, limited sustainability, and aggregate shocks, *Central Bank of Chile Working Paper* (127).

Lane, P. (2003). Business cycles and macroeconomic policy in emerging market economies, *International Finance* **6**(1): 89–108.

Loayza, N. and Raddatz, C. (2007). The structural determinants of external vulnerability, *The World Bank Economic Review* **21**(3): 359.

Love, I. and Zicchino, L. (2006). Financial development and dynamic investment behavior: Evidence from panel var, *The Quarterly Review of Economics and Finance* **46**(2): 190–210.

Lutkepohl, H. (2005). *New introduction to multiple time series analysis*, Springer.

Maddala, G. and Wu, S. (1999). A comparative study of unit root tests with panel data and a new simple test, *Oxford Bulletin of Economics and statistics* **61**(Supplement 1): 631–652.

Mendoza, E. (1995). The terms of trade, the real exchange rate, and economic fluctuations, *International Economic Review* **36**(1): 101–137.

Mishkin, F. and Schmidt-Hebbel, K. (2007). Does inflation targetting make a difference?, *NBER working paper series* .

Mundell, R. (1961). A theory of optimum currency areas, *The American Economic Review* pp. 657–665.

Orphanides, A. and Wieland, V. (2000). Inflation zone targeting, *European Economic Review* **44**(7): 1351–1387.

Pesaran, M. and Shin, Y. (1998). An autoregressive distributed-lag modelling approach to cointegration analysis, *Econometrics and Economic Theory in the 20th Century: The Ragnar Frisch Centennial Symposium*, Cambridge Univ Pr, p. 371.

Raddatz, C. (2007). Are external shocks responsible for the instability of output in low income countries, *Journal of Development Economics* **84**: 155–187.

Raddatz, C. (2008). *Africa at a turning point? Growth, Aid and external shocks*, The World Bank, chapter Have External Shocks Become More Important for Output Fluctuations in African Countries?, pp. 343–374.

Sims, C. (1980). Macroeconomics and reality, *Econometrica* pp. 1–48.

Sims, C., Stock, J. and Watson, M. (1990). Inference in linear time series models with some unit roots, *Econometrica* **58**(1): 113–144.

Spatafora, N. and Warner, A. (1995). Macroeconomic effects of terms-of-trade shocks: the case of oil-exporting countries, *World Bank Policy Research Working Paper* (1410).

Stock, J. and Watson, M. (2001). Vector autoregressions, *Journal of Economic perspectives* **15**(4): 101–115.

Svensson, L. (1997). Inflation forecast targeting: Implementing and monitoring inflation targets, *European Economic Review* **41**(6): 1111–1146.

Svensson, L. (2000). Open-economy inflation targeting, *Journal of international economics* **50**(1): 155–183.

Taylor, J. (1979). Estimation and control of a macroeconomic model with rational expectations, *Econometrica* pp. 1267–1286.

Taylor, J. (2000). Low inflation, pass-through, and the pricing power of firms, *European Economic Review* **44**(7): 1389–1408.

Tytell, I. and Spatafora, N. (2009). Commodity terms of trade: The history of booms and busts, *IMF Working Papers* .

Woodford, M. (2004). Inflation targeting and optimal monetary policy, *Federal Reserve Bank of St. Louis Review* **86**(4): 15–41.

APPENDIX

Table 1: List and composition of countries in the sample

IT	NON IT		Geographical distribution of countries			
	MT	ET	Latin America	Asia	Europe	Africa
Brazil	Algeria	China	Brazil	Indonesia	Czech Republic	South Africa
Chile	Argentina	Cote D'Ivoire	Chile	Israel	Hungary	Algeria
Colombia	Croatia	Ecuador	Colombia	Philippines	Poland	Egypt
Czech Republic	Dominican Rep	Lebanon	Mexico	South Korea	Turkey	Nigeria
Hungary	Egypt	Malaysia	Peru	Thailand	Croatia	Tunisia
Indonesia	India	Morocco	Argentina	India	Russia	Cote D'Ivoire
Israel	Nigeria	El Salvador	Dominican Rep	Pakistan	Ukraine	Morocco
Mexico	Pakistan	Ukraine	Uruguay	China		
Peru	Russia	Venezuela	Ecuador	Lebanon		
Philippines	Tunisia		El Salvador	Malaysia		
Poland	Uruguay		Venezuela			
South Africa						
South Korea						
Thailand						
Turkey						

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

Figure 5: Commodity terms of trade indices by region

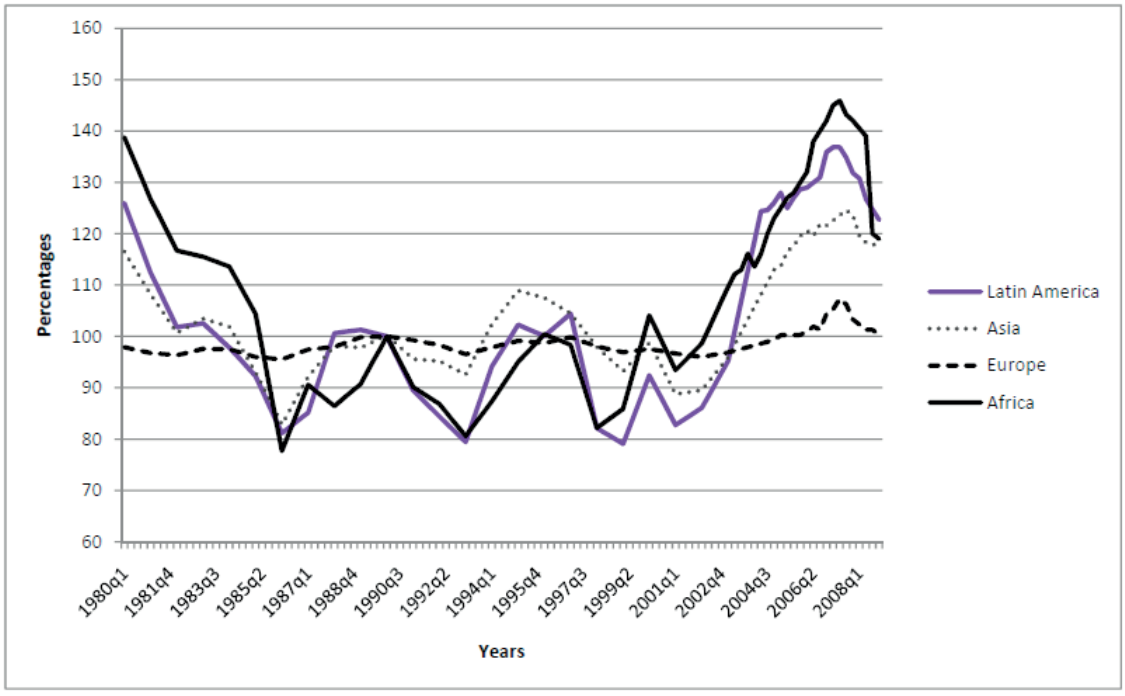


Table 2: Variables and Data Sources

Varibale	Sources
Commodity terms of trade indices	Based on Deaton and Miller (1995), updated data obtained from Raddatz (2008) and Tytell and Spatafora(2009)
Output Gap	Computed from the Hodrick Prescott filter with a smoothing parameter 1600 Data obtained from IFS and World Development Indicators
Inflation	Datastream, IFS and World Development Indicators
Exchange rates	IFS and World Development Indicators
Money supply growth	IFS and World Development Indicators
Interest rates	IFS and Central Bank websites.
Broad terms of trade indices	World Development Indicators and United Nations Conference on Trade and Development (UNCTAD)

Figure 6: Impulse responses of variables to commodity terms of trade shocks: Non inflation targeters before and after 1995

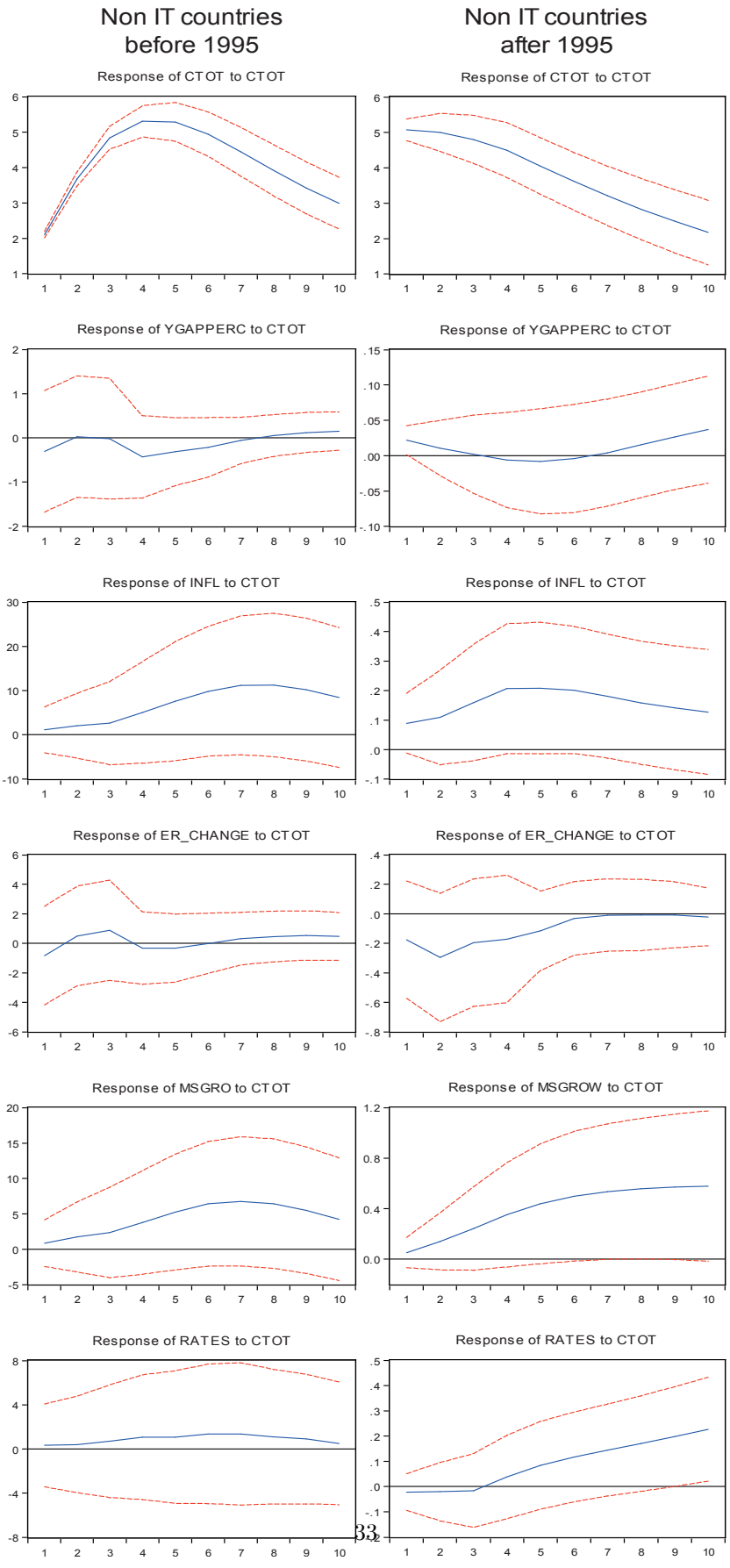


Figure 7: Impulse responses of variables to exchange rate shocks: IT countries before and after inflation targeting

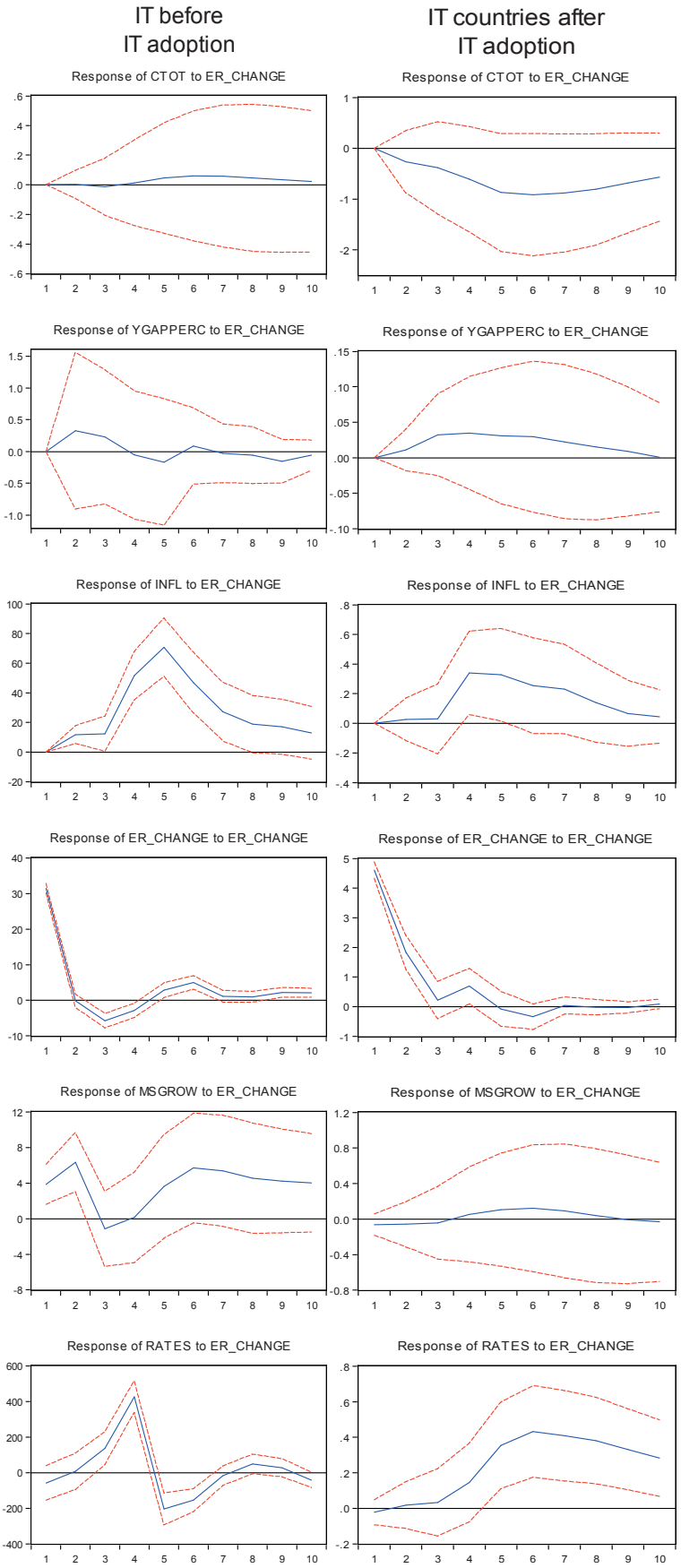


Figure 8: Impulse responses of variables to exchange rate shocks: Inflation targeters and non inflation targeters

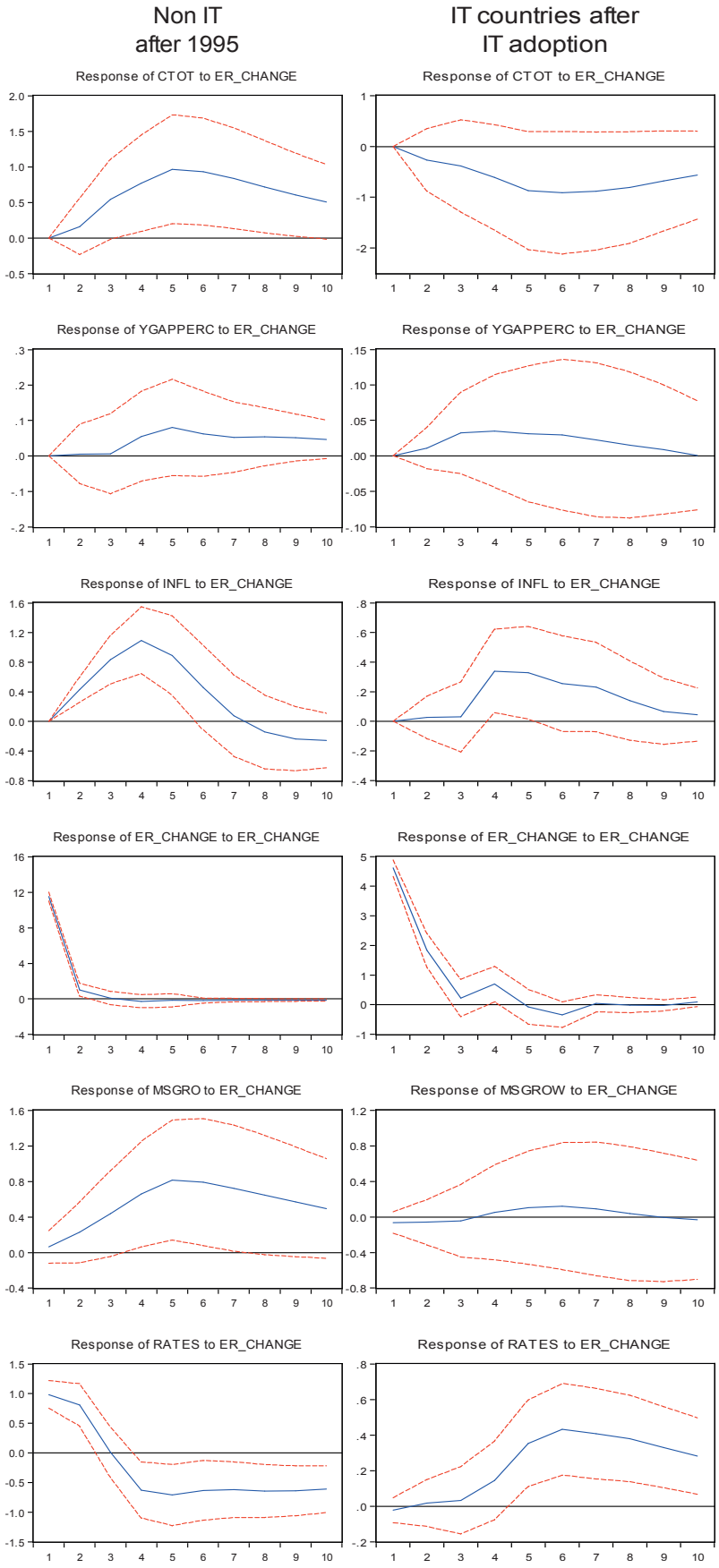


Figure 9: Impulse responses of variables to exchange rate shocks: Inflation targeters, monetary targeters and exchange rate targeters

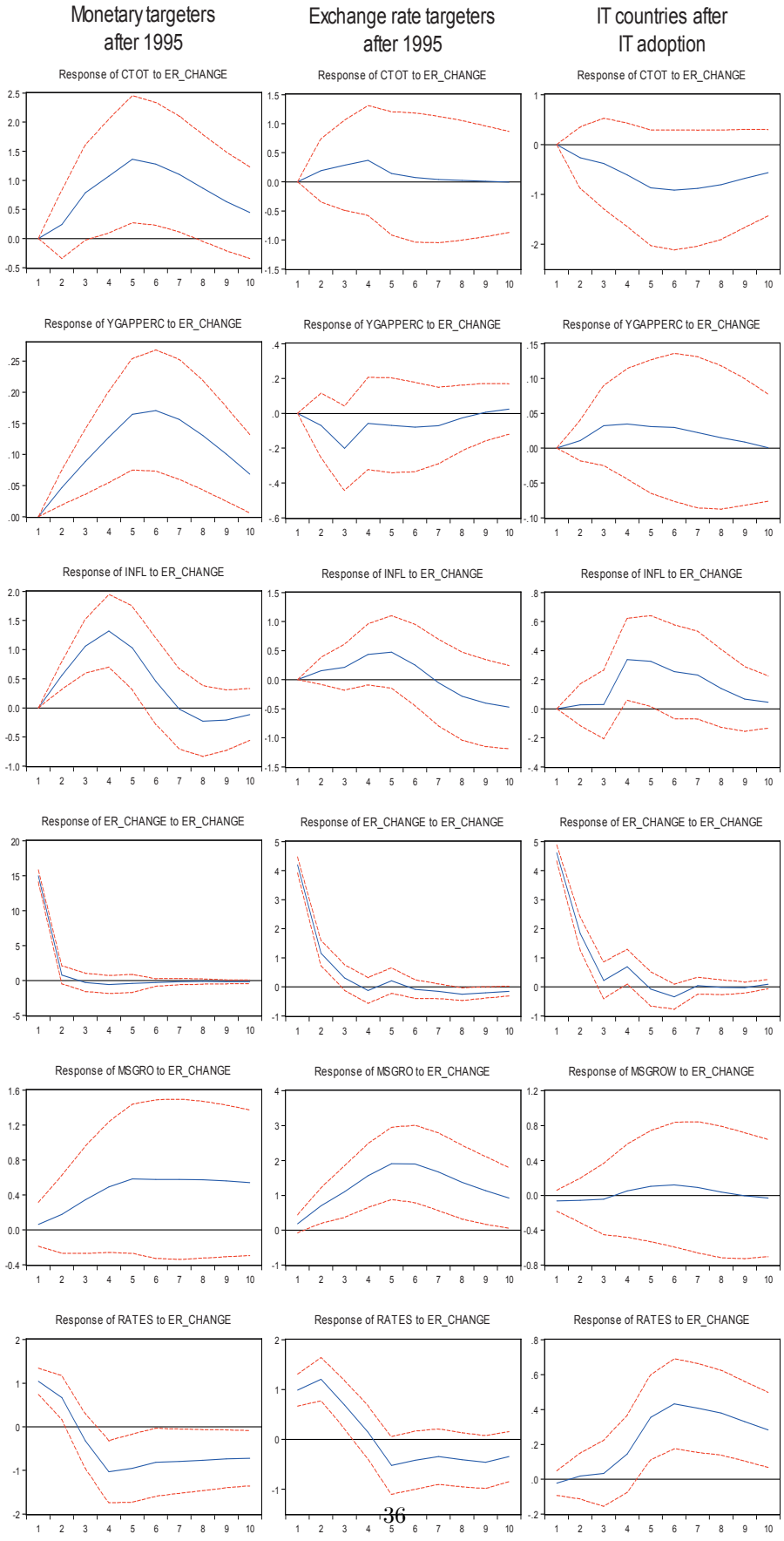


Figure 10: Impulse responses of variables to broad terms of trade shocks: Inflation targeters before and after targeting and non inflatlion targeters after 1995

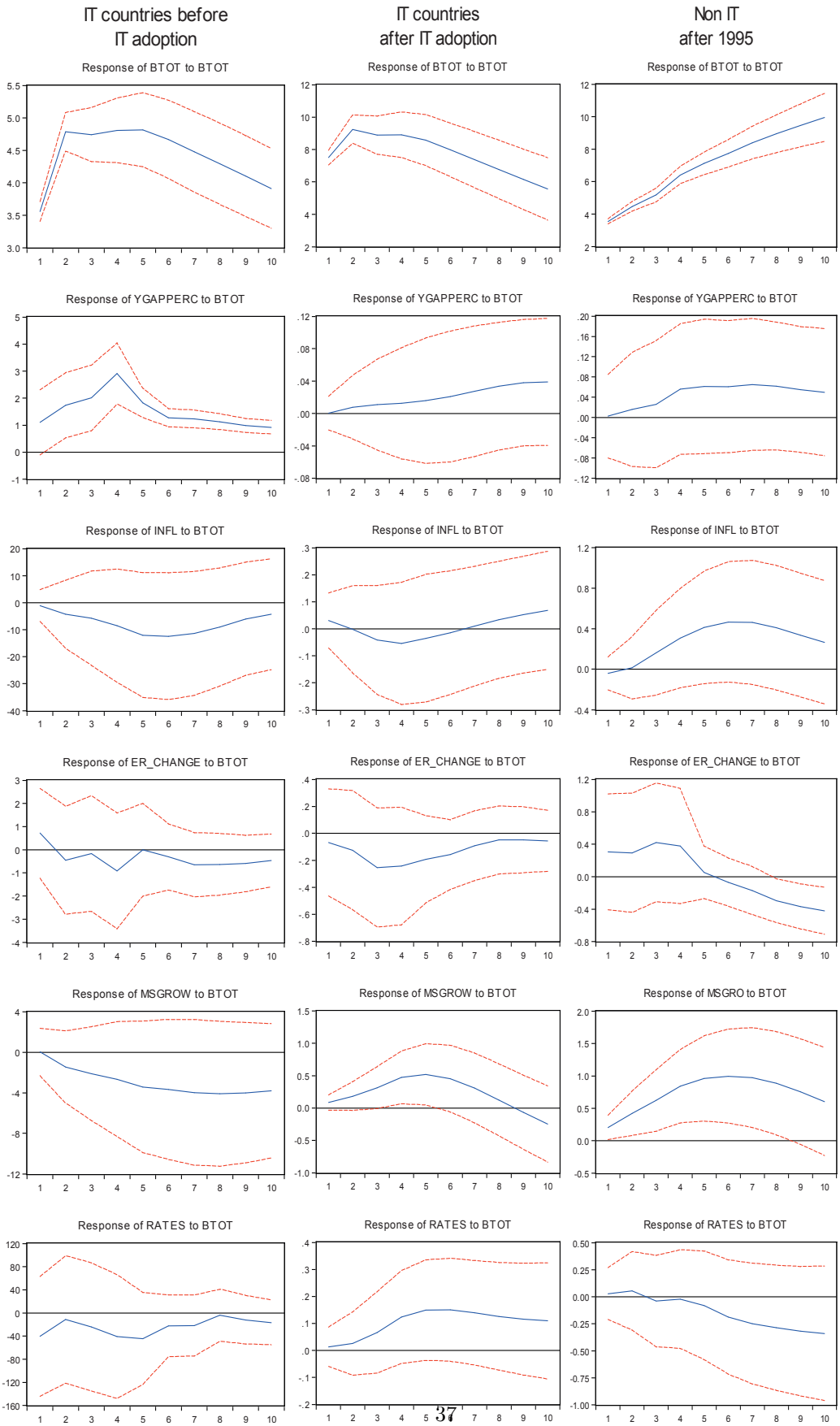


Figure 11: Impulse responses of broad terms of trade shocks: Inflation targeters, monetary targeters and exchange rate targeters after 1995

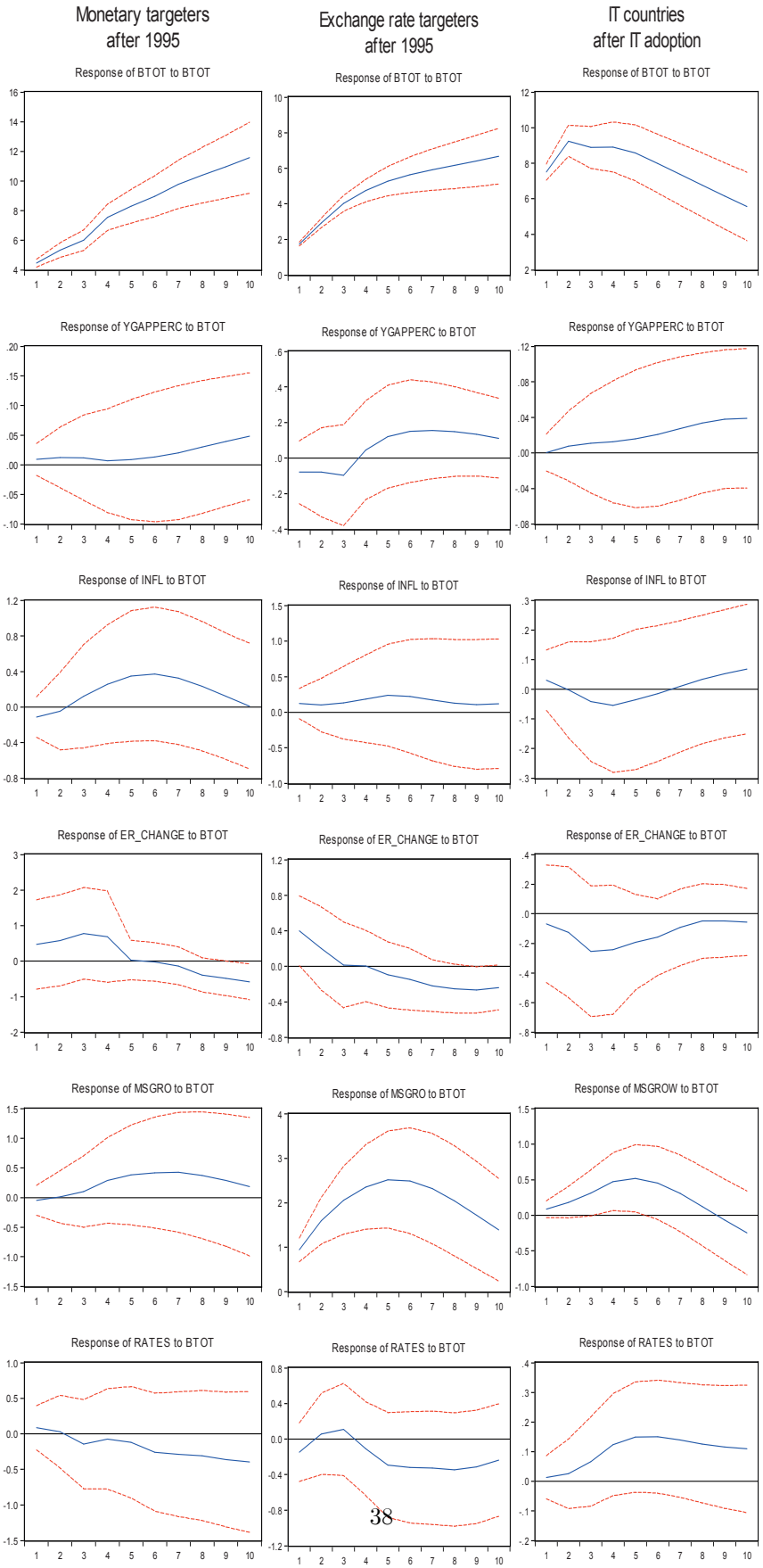


Table 3: Summary statistics of inflation targeters before and after adopting inflation targeting

	Inflation Targeters Before Inflation targeting					Inflation Targeters After Inflation targeting				
Variables	Obs	Ave	Std Dev	Min	Max	Obs	Ave	Std Dev	Min	Max
CTOT	1136	100.34	1.548	93.56	105.64	604	100.38	2.25	95.92	110.54
inflation	1136	109.17	528.93	-0.59	7481.64	604	5.44	3.85	-3.2	23.85
ygapperc	1136	-0.021	13.70	-9.874	9.3	604	0.04	1.2	-7.2	4.54
er_change	1136	10.54	48.37	-100	1181.21	604	0.351	0.351	1.18	11059
msgro	1136	73.21	169.21	-13.008	1184.916	604	12.66	7.99	-4.42	37.24
rates	1136	168.42	140.2	2.4	6184	604	8.5	5.3	1.25	41.95

Table 4: Summary statistics of inflation targeters vs non inflation targeters

	Inflation targeters after inflation targeting adoption					Non Inflation targeters for 1995-2008				
Variables	Obs	Ave	Std Dev	Min	Max	Obs	Ave	Std Dev	Min	Max
CTOT	604	100.38	2.25	95.92	110.54	1120	100.25	5.99	70.53	130.59
inflation	604	5.44	3.85	-3.2	23.85	1120	11.45	24.12	-2.2	376.74
ygapperc	604	0.04	1.2	-7.2	4.54	1120	-0.06	8.2	-8.7	7.4
er_change	604	0.351	5.13	1.18	11059	1120	1.72	11.72	-34.68	292.64
msgro	604	12.66	7.99	-4.42	37.24	1120	20.02	15.89	-50.81	115.50
rates	604	8.5	5.3	1.25	41.95	1120	14.79	16.26	1.066	135.63

Source: Authors calculations

Table 5: Summary statistics of inflation targeters vs monetary and exchange rate targeters after 1995

	Inflation targeters During inflation targeting					Monetary targeters After 1995					Exchange rate targeters After 1995				
Variables	Obs	Ave	Std Dev	Min	Max	Obs	Ave	Std Dev	Min	Max	Obs	Ave	Std dev	Min	Max
CTOT	604	100.3	2.25	95.92	110.5	616	99.93	6.79	70.53	130.6	504	101	4.8	82.5	115.8
inflation	604	5.44	3.85	-3.2	23.85	616	10.65	19.67	-1.16	222.5	504	12.4	28.62	-2.2	376.7
ygapperc	604	0.04	1.2	-7.2	4.54	616	-0.16	5.9	-3.6	6.4	504	0.1	10.3	-8.7	7.4
er_change	604	0.351	5.13	1.18	11059	616	2.23	15.022	-30.8	292.6	504	1.11	5.38	-34.7	33.25
msgro	604	12.7	7.99	-4.42	37.24	616	21.92	15.06	-11.3	91.82	504	17.7	16.29	-50.8	115.8
rates	604	8.54	5.33	1.25	41.95	616	14.83	16.25	1.07	118.4	504	14.7	16.29	2.7	135.6

Table 6: Panel Unit root tests based on the Fisher Type Test

Variable	ctot	btot	ygapperc	infl	er_change	msgro	rates
$\chi 2$	97.81	161.39	179.60	208.12	1397.19	97.97	318.58
P.Value	0.016	0.000	0.000	0.000	0.000	0.015	0.000

Table 7: Panel VAR lag order selection criteria

Lag	LogL	LR	FPE	AIC	SC	HQ
0	-119090.1	NA	9.87e+18	60.76	60.77	60.77
1	-103880	30364.05	4.29e+15	53.02	53.09	53.06
2	-102046.2	3657.29	1.71e+15	52.10	52.23	52.14
3	101090.4	1902.430	1.07e+15	51.63	51.81	51.69
4	-100531.8	1109.98*	8.21e+14*	51.37*	51.60*	51.45*

* indicates lag order selected by creterion

LR= Sequential modified LR test statistics, FPE= Final prediction error

AIC= Akaike information criterion, SC= Schwartz information criterion

HQ= Hannan- Quin information criterion

Table 8: Variance decompositions

	Output gap		Inflation		Exchange rate		Money supply		Interest rates	
	shortrun	longrun	shortrun	longrun	shortrun	longrun	shortrun	longrun	shortrun	longrun
IT countries										
Before IT adoption	2.7	3.9	5.3	12.20	2.68	3.70	3.79	3.61	1.02	1.38
After IT adoption	3.42	4.8	6.8	9.56	13.2	15.83	3.12	12.02	6.06	18.97
IT and Non IT										
Non IT after 1995	2.27	3.07	10.13	12.34	12.03	8.37	5.56	1.9	4.2	4.95
IT after IT adoption	3.42	4.8	6.8	9.56	13.2	15.83	3.12	12.02	6.06	18.97
Non IT before and after 1995										
Before 1995	5.18	6.41	5.38	11.67	8.21	7.32	5.6	3.18	2.6	8.28
After 1995	2.27	3.07	10.13	12.34	12.03	8.37	5.56	1.9	4.2	4.95
IT, MT and ET										
MT after 1995	6.3	7.4	11.0	8.29	10.7	8.56	11.03	8.17	5.30	2.45
ET after 1995	9.66	7.52	6.13	4.77	7.4	6.38	4.76	4.34	4.46	12.07
IT after IT adoption	3.42	4.8	6.8	9.56	13.2	15.83	3.12	12.02	6.06	18.97

This table reports the total shortrun and longrun variance of each variable which is explained by commodity terms of trade shocks.