Essays on Monetary Policy, Institutions and Terms of Trade Shocks in Emerging Market Economies

by

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Abstract

This thesis focuses on two important features of emerging market economies: institutional weaknesses and the exposure to commodity terms of trade shocks and how they shape the macroeconomic dynamics and the conduct of monetary policy. These issues are discussed in three essays. The first essay empirically evaluates the role of institutional structures in inflation targeting in emerging market economies (EMEs). The second essay theoretically investigates the appropriate monetary policy responses to commodity terms of trade shocks using a multi-sector New Keynesian dynamic stochastic general equilibrium (DSGE) model. Finally, the third essay empirically analyses the responses of different monetary policy regimes to commodity terms of trade shocks in emerging market economies.

The first essay investigates whether monetary, fiscal and financial institutional structures really matter for the achievement of inflation targets in emerging market economies. Particular emphasis is placed on the extent to which inflation deviations from target bands are affected by central bank independence, fiscal discipline and financial sector development. The study contributes to the literature by taking stock of the intrinsic role played by institutional structures in the achievement of inflation targets since the adoption of inflation targeting in EMEs. Using the panel ordered logit model, the analysis shows that improvement in central bank independence, fiscal discipline and financial systems reduces the probability of inflation target misses. Precisely, countries with more independent central banks tend to achieve inflation targets more frequently. A one percent increase in central bank independence increases the probability of achieving the target band by 0.16%, while reducing the probability of inflation being above the target band by 0.11%. Moreover, countries with weak fiscal institutions and less developed financial systems have a higher probability of missing their inflation targets. The improvement in institutional structures also enhances the effectiveness of monetary policy. The thesis also provides evidence that other macroeconomic and structural variables such as exchange rate gap, output gap, inflation target horizon and level of openness explain inflation target misses. The results suggest that there is need to continue to reform institutional structures in order to achieve sustainable price stability.

The second essay builds a multi-sector New Keynesian DSGE model to investigate the appropriate monetary policy rule for a small open commodity dependent emerging market economy which is prone to commodity terms of trade shocks. The model is calibrated to the South African economy. In this essay, the thesis contributes to the literature by incorporating the commodity sector in a dynamic stochastic general equilibrium setting and focusing on commodity terms of trade shocks. The essay shows that CPI inflation targeting performs relatively better than exchange rate targeting and non-traded inflation targeting both in terms of reducing macroeconomic volatility and enhancing welfare. The good performance of inflation targeting is enhanced by its flexibility, credibility and the presence of flexible exchange rates which help to insulate the economy from shocks. However, macroeconomic stabilisation by CPI inflation targeting comes at the cost of increased exchange rate volatility. In terms of welfare, the CPI inflation targeting rule generally delivers less welfare losses compared with non-traded inflation targeting and exchange rate targeting. The results suggest that EMEs can optimally respond to commodity terms of trade shocks using CPI inflation targeting.

Finally, the third essay empirically evaluates the responses of different monetary policy regimes practised in EMEs to commodity terms of trade shocks. In that spirit, the essay analyses the robustness of inflation targeting compared to monetary targeting and exchange rate targeting in the face of commodity terms of trade shocks using a panel VAR model. The essay contributes to the literature by demonstrating empirically that inflation targeting makes a difference in the face of commodity terms of trade shocks. The results show that in general, inflation targeting countries respond better to commodity terms of trade shocks with respect to stabilising inflation, output gap and interest rates. However, exchange rates are generally more volatile under inflation targeting countries than in other regimes. The essay also provides evidence that commodity terms of trade shocks resulted in higher volatility of macroeconomic variables during the pre-inflation targeting period than the post-inflation targeting period. Moreover, commodity terms of trade shocks account for larger variability of output gap and inflation in non-inflation targeting countries than in inflation targeting countries. The results suggest that the adoption of inflation targeting can reduce the adverse impact of commodity terms of trade shocks in EMEs.

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Dedication

I dedicate this work to my wife Ropafadzai, daughters Watidaishe Nissi and Kunashe Karis and my parents Dzingai and Rhoda Hove.

List of Acronyms and Abbreviations

AERC	African Economic Research Consortium
CBI	Central Bank Independence
CIT	CPI Inflation Targeting
CPI	Consumer Price Index
CSAE	Centre for the Study of African Economies
CTOT	Commodity Terms of Trade
DIIS	Danish Institute for International Studies
DIT	Domestic Inflation Targeting
DSGE	Dynamic Stochastic General Equilibrium
EMEs	Emerging Market Economies
ET	Exchange Rate Targeters
ERSA	Economic Research Southern Africa
GDP	Gross Domestic Product
GMM	Generalised Methods of Moments
IFS	International Financial Statistics
IMF	International Monetary Fund
IT	Inflation Targeting
MT	Monetary Targeting
MTM	Monetary Transmission Mechanism
NTIT	Non-Traded Inflation Targeting
OECD	Organisation for Economic Co-operation and Development
SARB	South African Reserve Bank
SUR	Seemingly Unrelated Regression
TIPS	Trade and Industrial Policy Strategies
VAR	Vector Autoregression
WDI	World Development Indicators
ZEPARU	Zimbabwe Economic Policy Analysis and Research Unit

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Chapter 1

Introduction

1.1 Overview of the thesis

Emerging market economies (EMEs) exhibit characteristics that are different from industrialised countries in at least two ways: (i) institutional weaknesses in the form of low central bank independence, weak fiscal institutions and low financial sector development and (ii) vulnerability to terms of trade shocks (Calvo and Mishkin, 2003; Mishkin, 2004).[1] These features have greatly shaped the macroeconomic dynamics and the conduct of monetary policy in EMEs. Weak institutional structures have made EMEs vulnerable to high inflation, currency crises and failure to achieve inflation targets (Cukierman et al., 1992; Campillo and Miron, 1996; Roger and Stone, 2005). Also, the exposure of EMEs to large terms of trade shocks has generated significant macroeconomic volatility in these economies (Mendoza, 1995; Kose, 2002; Ahmed, 2003). Consequently, the use of models which were developed within frameworks for developed countries does not clearly assist in understanding the implications of these characteristics for macroeconomic dynamics and the conduct of monetary policy in EMEs. As such, the clarity of these issues may lie with models designed and applied to fit the realities of EMEs.

This thesis focuses on the role of these characteristics in shaping the macro-

[1]The other characteristics of emerging market economies that distinguish them from industrialised countries are: vulnerability to sudden stops of capital flows, currency substitutions, liability dollarisation and labour market rigidities.

economic dynamics and the conduct of monetary policy in EMEs. These issues are discussed in three essays, where each essay constitutes a chapter. The first essay (presented in Chapter 2) looks at the role of monetary, fiscal and financial institutions in the achievement of inflation targets in EMEs. In this context, the essay evaluates the relevance of central bank independence, fiscal discipline and financial sector development on the achievement of inflation targets.

The focus on the role of institutional structures in inflation targeting is motivated by the recent literature which suggests that institutions are important for macroeconomic and price stability (see e.g Cukierman et al., 1992; Alesina and Summers, 1993; Acemoglu et al., 2003). In the context of macroeconomic policy, the development of this literature has revolved around the dynamic inconsistency hypothesis and fiscal theories of price level. These theories suggest that irresponsible monetary and fiscal policies may generate rapid money growth and high inflation which may lead to inflation target misses (see e.g Sargent and Wallace, 1981; Woodford, 2003; Roger and Stone, 2005). Also, less developed financial systems may induce fiscal dominance because the government may not finance its budget deficit through the capital markets, forcing it to rely on the central bank for funding (Neyapti, 2003). Unstable financial systems may generate fiscal instability and high inflation because of contigent bail out of banks. As a result, the central bank may fail to keep inflation under control.

If institutions matter for macroeconomic and price stability, then they should help inflation targeting (IT) countries to achieve their inflation targets. But in the context of EMEs, it has been observed that most countries which have adopted inflation targeting have continued to experience inflation target misses, leading to significant credibility losses (Roger and Stone, 2005). This is the case despite widespread reforms of their monetary, fiscal and financial institutions before or during inflation targeting adoption. This has raised the question of whether institutional structures really matter for inflation targeting in EMEs. The recurrence of inflation target misses in EMEs has made some authors such as Brito and Bystedt (2010), Mishkin (2004) and Fraga et al. (2003) to cast doubts on the success of inflation targeting in these economies. They point out that failure to achieve inflation targets can to a large extent be attributed to institutional shortfalls coupled with output-inflation volatility trade-offs from external shocks. On the other hand, Batini and Laxton (2006) and Lin and Ye (2009) argue that fragility and lack of good initial institutional conditions does not necessarily impede the successful implementation of inflation targeting in EMEs. They argue that most EMEs adopted inflation targeting in the absence of ideal institutional conditions. They stress that the feasibility and success of inflation targeting depends more on the authorities' commitment to price stability and their ability to plan and implement institutional changes after adopting inflation targeting.

Notwithstanding this discourse, there has been little systematic analysis done to evaluate the intrinsic role of institutional structures on inflation target outcomes. Most previous studies focus on the role of individual institutional arrangements on the average level of inflation in general (see e.g. Cukierman et al., 1992; De Haan and Zelhorst, 1990; Neyapti, 2003). But the desirability of institutional arrangements should be judged by their impact on the actual goals of policy makers, such as the achievement of inflation targets (Krause and Mendez, 2008). To my knowledge only a study by Gosselin (2008) provides some insights on the role of institutional structures on the achievement of inflation targets. However, it does not consider inflation target deviation from target bands, which is an important pattern of inflation targeting practice in EMEs. Also, most previous studies provide conflicting results, thereby adding to empirical ambiguity about the instrinsic role of institutional structures for inflation targeting.

Chapter 2 therefore fills this gap by investigating the role of institutional structures for inflation targeting. Specifically, the chapter contributes to literature by empirically evaluating the intrinsic role of monetary, fiscal and financial institutional structures for inflation targeting in EMEs. In this angle, the thesis places emphasis on the extent to which central bank independence, fiscal discipline and financial sector development explain the achievement of inflation targets or the deviations of inflation from target bands. In this regard, the study takes stock of the role played by institutional structures since the adoption of inflation targeting in EMEs while unraveling the important channels through which these institutional factors affect inflation targets. Thus the analysis provides a solid framework that is useful for understanding the role of institutional structures in monetary policy. Within the same framework, the chapter also explores whether these institutional structures enhance the effectiveness of monetary policy. To the best of my knowledge, this study is the first to examine the role of institutions in explaining inflation target deviations from target bands in EMEs.

This chapter also makes a methodological contribution to literature by applying the panel ordered logit technique to model the achievement of inflation target bands or deviation from target bands. This is a novel empirical strategy which addresses the nonlinearities in the policy responses by carefully identifying and distinguishing between various inflation target response thresholds, that is, below the target band, within the target band or above the target band. The model also deals with the problem of unobserved heterogeneity among emerging market economies while reducing the omitted variable bias by using fixed effects in the panel data context. Moreover, the chapter develops a new computational strategy to obtain marginal effects of different inflation target outcomes of a panel ordered logit model.

The study finds that central bank independence, fiscal discipline and financial sector development do explain inflation target deviations from the target bands. Using two proxies of central bank independence (CBI), legal CBI indices and turnover rate of central bank governors, the chapter shows that countries with more independent central banks tend to achieve inflation target bands more frequently. A one percent increase in legal CBI increases the probability of achieving the target band by 0.16%, while reducing the probability of being above the target band by 0.11%. Higher CBI reduces inflation target deviations by shaping central bank incentives and increasing the credibility of commitments to price stability. Furthermore, the chapter also finds evidence that fiscal discipline and high financial sector development reduces the chance of high inflation deviations from the target bands. Strong institutional structures also enhance the effectiveness of monetary policy in these countries. Despite the strong effects of institutional factors on inflation target deviations, the chapter also shows that some external and domestic factors such as exchange rate gap, output gap, inflation target horizon and degree of openness also explain inflation target deviations. The results suggest that emerging market economies should continue to reform their institutional structures to achieve sustainable price stability.

The second essay (presented in Chapter 3) focuses on the exposure of emerging market economies to commodity terms of trade shocks and the appropriate monetary policy responses to these shocks. The chapter develops a multi-sector DSGE model calibrated to the South African economy to provide theoretical evidence for the optimal monetary policy responses to commodity terms of trade shocks in EMEs. The focus on the exposure of EMEs to commodity terms of trade shocks is motivated by the observation that they are becoming a recurring source of exchange rate and macroeconomic volatility in EMEs (Mendoza, 1995; Kose, 2002). Recent empirical estimates have shown that terms of trade volatility is at least three times higher in EMEs than in developed countries (Aizenman et al., 2011; Loayza et al., 2007). In commodity exporting EMEs, commodity induced terms of trade shocks have proved to be large, volatile and persistent because of a high concentration of few primary commodities in their exports (Chen and Rogoff, 2003; Cashin et al., 2004). These shocks have created less favourable trade-offs between inflation and output variability while undermining the stability of inflation expectations. The risks they pose in EMEs are of considerable concern such that there is need for policy intervention.

Several small open economy models have been developed to evaluate alternative monetary policy regimes under various shocks such as productivity shocks, interest rate shocks and demand shocks (see e.g Aoki, 2001; Laxton and Pesenti, 2003; Parrado, 2004; Gali and Monacelli, 2005; Devereux et al., 2006). Aoki (2001) shows that the optimal monetary policy is the one that targets sticky price based inflation rather than broad inflation while Laxton and Pesenti (2003) conclude that inflation forecast based rules perform better than conventional Taylor rules in the face of shocks. Also, in a study based on standard terms of trade shocks and interest rate shocks, Devereux et al. (2006) demonstrate that CPI inflation targeting can stabilise inflation better than non-traded inflation targeting and exchange rate targeting. Under productivity shocks, Gali and Monacelli (2005) observe that domestic inflation targeting is the optimal monetary policy.

While the shocks considered in these studies explain the macroeconomic dynamics in EMEs, an important channel of fluctuations in these countries has to do with the fact that their exports are undiversified and dominated by few primary commodities. Yet, none of these studies consider the case for country specific commodity terms of trade shocks despite their potential in explaining large output, price and exchange rate fluctuations in EMEs (Cashin et al., 2004; Raddatz, 2007).

These studies also fail to account for high exchange rate and macroeconomic volatility especially in small open commodity dependent economies. Also, most of these studies suggest that monetary authorities should target domestic inflation rather than CPI inflation or exchange rate.[2] But the consideration of country-specific commodity terms of trade shocks in the presence of sticky prices may significantly change the conventional wisdom on monetary policy design because of complex dynamic economic systems and possible multiple transmission channels of these shocks. Hence, it is not immediately clear how commodity dependent EMEs should conduct monetary policy to stabilise their economies. Should central banks target CPI inflation, domestic non-traded inflation or exchange rates? Chapter 3 sets out to address this question.

Chapter 3 therefore contributes to the debate on optimal monetary policy by building a multi-sector New Keynesian dynamic stochastic general equilibrium (DSGE) model to evaluate the appropriate monetary policy responses to commodity terms of trade shocks. The key innovation of this chapter is the incorporation of the commodity sector in a multi-sector DSGE model which is calibrated to a typical commodity dependent emerging market economy, South Africa. This permits the explicit examination of the implications of commodity terms of trade shocks for macroeconomic dynamics under alternative monetary policy rules in EMEs. The analysis helps to deepen our understanding of the propagation mechanisms, induced macroeconomic dynamics and appropriate monetary policy responses to commodity terms of trade shocks. Clearly, this analysis offers a useful framework for thinking about monetary policy in commodity dependent emerging market economies.

The analysis shows that CPI inflation performs better than non-traded inflation (a version of domestic inflation) and exchange rate targeting with respect to macroeconomic stabilisation because of its flexibility, credibility and the presence of flexible exchange rates which help to insulate the economy from shocks. The thesis further demonstrates that the CPI rule generally achieves better welfare outcomes than other rules. Thus countries which are vulnerable to commodity

[2] However, some studies argue that domestic inflation targeting is not always optimal (see e.g. Svensson, 2000; De Paoli, 2009). Nonetheless, general consensus seems to be converging towards domestic inflation targeting as the optimal monetary policy.

terms of trade shocks should target CPI inflation to stabilise their economies. This is in contrast to some studies which show that domestic inflation targeting is the optimal monetary policy in small open economies (see e.g Gali and Monacelli, 2005; Devereux et al., 2006; Parrado, 2004). However, this macroeconomic stabilisation by CPI inflation targeting regime comes at the expense of increased exchange rate volatility. This implies that EMEs should also pay attention to exchange rate fluctuations in their economies.

The third essay (presented in Chapter 4) provides empirical evidence on the appropriate monetary policy responses to commodity terms of trade shocks in EMEs. This empirical analysis is motivated by three factors. Firstly, the heightened volatility of commodity prices in the 2000s culminating with a spike in 2008 has generated intense arguments about the desirability of a monetary policy regime that can practically accommodate commodity terms of trade shocks. Secondly, the recent widespread adoption of inflation targeting in many EMEs has raised questions about its relative suitability in dealing with commodity terms of trade shocks compared with other regimes such as monetary targeting and exchange rate targeting. Thirdly, the empirical analysis would compliment the theoretical DSGE analysis presented in Chapter 3 and contribute to the practical debate on the choice of monetary policy anchors for macroeconomic stabilisation in EMEs. This helps to evaluate if the case for inflation targeting is strong both in theory and in practice.

In practice, the debate on the choice of monetary policy regimes has broadly centered around inflation targeting, monetary targeting and exchange rate targeting (see e.g. Poole, 1970; Bernanke and Woodford, 2004). In the 1970s and 1980s, fixed exchange rates formed key stabilisation policies (Frankel, 2010). However, due to financial and currency crises in many EMEs with fixed exchange rate regimes, more flexible exchange rate regimes became favourable because of the belief that they act as "shock absorbers" (Friedman, 1953; Mundell, 1961). However, later studies showed that flexible exchange rates alone without activist monetary policy may not adjust in the right direction to achieve the desired outcomes (see e.g Devereux, 2004). Because of these challenges, some economists recommended the adoption of monetary targeting regimes in the 1980s. However, due to unstable money demand functions associated with financial innovations, this regime was not a viable option for many countries.

The dawn of the 1990s saw many countries adopting inflation targeting, starting with New Zealand. The regime has been popular in recent years and has received a lot of attention, having been presumed to be successful in developed countries (Svensson, 1997; Bernanke et al., 1999; Mishkin and Schmidt-Hebbel, 2007). However, in EMEs its robustness especially in dealing with external shocks has not yet been established. Among researchers and policy makers, there is still limited consensus on whether inflation targeting is better than monetary targeting and exchange rate targeting in dealing with external shocks in EMEs. Some authors argue that inflation targeting is the best regime for EMEs because of its transparency, flexibility (Bernanke et al., 1999; Svensson, 2000; Cuche-Curti et al., 2008) and the fact that it is based on the trinity of flexible exchange rate, inflation target and monetary policy rule (Taylor, 2000). Comparing inflation targeters and non-inflation targeters, Mishkin and Schmidt-Hebbel (2007) demonstrate that inflation targeting makes a difference because of its credibility and flexibility in responding to oil price shocks. However, others view inflation targeting as a regime which is more vulnerable to external shocks when compared to other monetary policy regimes such as exchange rate targeting and monetary targeting (see e.g Kumhof, 2001; Stiglitz, 2008). From this perspective, I ask whether inflation targeting makes a difference in the face of commodity terms of trade shocks. This is the question addressed in Chapter 4.

Using the panel vector autoregression technique on 35 emerging market economies, this chapter tests whether inflation targeting performs better than monetary targeting and exchange rate targeting in stabilising EMEs in the face of commodity terms of trade shocks. The chapter contributes to the literature by providing empirical evidence concerning whether countries which have adopted inflation targeting have responded better to commodity terms of trade shocks than those which have not.[3] Most previous empirical studies have not explicitly identified the effects of commodity terms of trade shocks under alternative monetary policy regimes practised in EMEs (see e.g Broda, 2004; Mishkin and Schmidt-Hebbel, 2007). In addition, previous studies on monetary policy responses to external shocks lack

[3] In this case, better response entails the ability to dampen shocks and reduce volatility following commodity terms of trade shocks.

depth in analysis. For instance, Mishkin and Schmidt-Hebbel (2007) compare inflation targeters versus non-inflation targeters despite the existence of monetary policy heterogeneity among non-inflation targeters. The present study goes a step further and disaggregates non-inflation targeters into monetary targeters and exchange rate targeters and compares them with inflation targeters. In this way, the study provides analytical depth and consolidates evidence on experiences of EMEs' responses to external shocks. The study also sheds more light on how inflation targeting performs relative to alternative monetary policy regimes in EMEs.

While most previous studies on policy responses to external shocks use overall terms of trade indices (see e.g. Broda, 2004; Edwards and Yeyati, 2005), this study uses country specific terms of trade indices for two reasons. Firstly, they capture fluctuations of the exchange rate that are more exogenous to the business cycle than those indicated by the overall terms of trade indices (Aghion et al., 2004). Secondly, commodity terms of trade shocks have larger explanatory power on prices and output because commodities are the most volatile components of trade goods (Chen and Rogoff, 2003; Raddatz, 2007).

The chapter shows that inflation targeting outperforms monetary targeting and exchange rate targeting in dealing with commodity terms of trade shocks. Inflation targeting regimes seem to benefit from their flexible exchange rates, credibility and flexibility in responding to shocks. The results further demonstrate that output gap, inflation, exchange rates and interest rate responses to commodity terms of trade shocks are substantially higher during the period preceding IT adoption in comparison to the post IT adoption period. This demonstrates that inflation targeting makes a difference in small open economies which are susceptible to commodity terms of trade shocks. Through an analysis of variance decompositions, the chapter also provides evidence that commodity terms of trade shocks account for a larger variation in most variables under monetary targeting and exchange rate targeting compared with inflation targeting. The results suggest that the adoption of inflation targeting can reduce the impact of commodity terms of trade shocks in EMEs. The empirical analysis validates the results from the calibrated DSGE model that inflation targeting is the appropriate monetary policy in EMEs.

1.2 Published work

Some original work presented in this thesis has been presented at conferences and published. These are:

1. Hove, S., Touna Mama, A. and Tchana Tchana, F. (2011). "Do monetary, fiscal and financial institutions really matter for inflation targeting in emerging market economies?", *ERSA Working Paper Series* (Number 247)

2. Hove, S., Touna Mama, A. and Tchana Tchana, F. (2012). "Terms of trade shocks and inflation targeting in emerging market economies", *ERSA Working Paper Series* (Number 273)

3. Hove, S., Touna Mama, A. and Tchana Tchana F. (2012). "Monetary policy and commodity terms of trade shocks in emerging market economies",*ERSA Working Paper Series* (Number 307)

1.3 Organisation of the thesis

This chapter has established the area of focus, introduced the research issues and highlighted the contribution of the thesis. The research issues are dealt with in three main essays, where each essay constitutes a chapter. The first essay is presented in Chapter 2. It investigates whether monetary, fiscal and financial institutional structures proxied by central bank independence, fiscal discipline and financial sector development matter for inflation targeting in EMEs. Using the ordered logit model, the essay shows that institutional structures are important for the achievement of inflation targets, although other macroeconomic factors such as exchange rates and output gap also matter.

Chapter 3 develops a New Keynesian DSGE model calibrated to the South African economy to evaluate monetary policy responses to commodity terms of trade shocks. The model demonstrates that CPI inflation targeting rules result in lower volatility of many macroeconomic variables and lower welfare losses compared with exchange rate targeting and non-traded inflation targeting rules.

Chapter 4 tests the responses of alternative monetary policy regimes practised in EMEs to commodity terms of trade shocks using a panel VAR technique on

35 emerging market economies. This analysis provides an empirical validation of the results from a theoretical DSGE model. It shows that in general inflation targeting regimes perform better than monetary targeting regimes and exchange rate regimes in stabilising most macroeconomic variables.

Finally, Chapter 5 concludes the thesis by summarising the main findings of the three essays and discussing their policy implications. It also highlights possible extensions and areas for future research which arise from the findings of the thesis.

Chapter 2

Do monetary, fiscal and financial institutions really matter for inflation targeting in emerging market economies?

2.1 Introduction

During the 1990s many emerging market economies (EMEs) adopted inflation targeting (IT). However, they have continued to miss their inflation targets frequently and sometimes by wide margins, leading to loss of credibility. This problem persisted despite significant institutional reforms. This pattern has therefore raised questions about the intrinsic role of institutional structures in the achievement of inflation targets in EMEs.

Two views have emerged in the literature about the success of inflation targeting EMEs in terms of achieving their inflation targets. On one hand, some authors such as Brito and Bystedt (2010), Mishkin (2004) and Fraga et al. (2003) argue that the success of this regime in EMEs is limited because of institutional shortfalls and output as well as inflation volatility trade-offs from external shocks. On the other hand, Lin and Ye (2009) and Batini and Laxton (2006) argue that fragility and lack of good initial institutional conditions does not necessarily impede the successful implementation of inflation targeting in EMEs. They argue that most EMEs adopted IT in the absence of ideal institutional conditions. They also stress that the feasibility and success of IT depends more on the authorities' commitment to price stability and their ability to plan and implement institutional changes after adopting inflation targeting.

Despite the intensity of this debate, few papers have analysed the role of monetary, fiscal and financial institutional structures in the achievement of inflation targets.[1] However, Gosselin (2008) provides some insights. He uses pooled regressions to explain inflation target deviations from the mean on a sample of developed and developing IT countries. He finds that central bank independence and fiscal balances among other variables seem to explain inflation target deviations. However, his results are susceptible to heterogeneity bias because the institutional frameworks of developed and developing countries are different. In fact, pooling countries with different characteristics together may increase this bias especially if slope parameters of individual regressions differ across sections. Moreover, his study uses inflation deviations from the mean as indicators of IT performance. By this, he assumes that central banks set inflation target points. Yet in practice, most central banks especially in EMEs set inflation target bands (Svensson, 1997).[2] This may result in missing an important dimension in the setting of inflation targets and the role of institutions for inflation performance of IT in EMEs.

To the best of the my knowledge, no work has been done on the role of institutional factors in explaining inflation target deviations from the bands in EMEs. This chapter fills this gap by addressing the question of whether the ability to achieve inflation target bands is affected by central bank independence (CBI), fiscal discipline and financial sector development in EMEs. This is important because large and frequent inflation target misses can undermine monetary policy credibility. Within the same framework, the chapter also tests if these institutional structures enhance the effectiveness of monetary policy.

This chapter contributes to the existing literature in three ways. Firstly, it

[1] The deviation of inflation from the target bands can be considered as an indicator that the central bank has not been successful especially if it leads to credibility losses. However there are other indicators which can be considered in determining the overall success of an inflation targeting regime.

[2] In some cases central banks set inflation target points, but they include tolerance bands.

characterises and analyses inflation target deviations from the bands as opposed to deviations from the mean, pinning down institutional differences. Inflation target deviations from the bands are intuitively appealing as measures of central bank performance because most central banks consider inflation to be consistent with their long term inflation objectives if it is within the target band (Agenor, 2000). Also, inflation target bands may act as thresholds for accountability, where some central banks are required to issue explanatory statements when they miss the target bands (see e.g. Svensson, 1997; Bernanke et al., 1999).[3] In addition, Svensson (1997) argues that in practice, inflation targeting is flexible as central banks set inflation target ranges or tolerance intervals rather than target points only.[4] Finally, target bands suggest a nonlinearity in the policy response function, depending on whether inflation is within the bands or not. This is consistent with the apparent tendency of central banks to react to inflation when it becomes a problem, but concentrate on other objectives when it is under control (Orphanides and Wieland, 2000).

Secondly, the chapter isolates and focuses on EMEs. The characteristics of these countries are different from advanced countries. Unlike advanced countries, most EMEs have a long history of institutional shortfalls, high past inflation records and monetary policy mismanagement which could account for their current large inflation target deviations (Mishkin, 2004). Since these countries form a key group in the world economy, they provide an appropriate sample to test the role of institutional structures for IT performance.

Thirdly, the chapter uses a novel empirical strategy to estimate the effects of institutional variables as well as other macroeconomic variables on inflation target outcomes. Consistent with the nonlinearities in policy responses to different inflation target outcomes, the chapter models the achievement of inflation target bands or deviations from the bands by employing the panel ordered logit model. This technique addresses the nonlinearity issue by carefully identifying and distinguish-

[3]This is the case in Israel, Brazil, Thailand and the Philippines. Other inflation targeting advanced countries which issue public statements when they miss inflation target bands are the UK, Canada, Sweden and New Zealand. However some central banks use " escape" clauses in accountability arrangements.

[4]Svensson (1997) supports his argument by noting that the achievement of specific numerical inflation targets is impossible due to imperfect control of inflation.

ing between various inflation target response thresholds; that is, below the target band, within the target band and above the target band, as they are affected by institutional factors and other control variables. It also uses fixed effects to account for unobserved heterogeneity between countries. More importantly, the chapter develops a new computational strategy to obtain the marginal effects of different inflation target outcomes of an ordered logit model in the panel data context.

The empirical evidence shows that some institutional variables have significant predictive power on the probability of inflation missing the target bands. Precisely, countries with more independent central banks tend to achieve the inflation target bands frequently. In fact, two proxies of CBI are used: legal CBI indices and turnover rate of central bank governors. When the legal CBI is the measure of independence of central banks, the results show that it increases the probability of achieving inflation target bands by reducing mainly the probability of exceeding the upper target band. A 1% increase in CBI increases the probability of achieving the target band by 0.16%, while reducing the probability of being above the band by 0.11%. When the turnover rate of central bank governors is used, no significant effect on the probability of achieving or not achieving the target band is found. This result suggests instead that in EMEs, lower turnover of central bank governors may not necessarily be a sign of more independent central banks.

Also, using two proxies of fiscal discipline; budget deficit to GDP and the ratio of debt to GDP, the chapter finds that countries with weak fiscal institutions have a higher probability of having inflation higher than the upper target band. An increase in the budget deficits to GDP ratio increases the probability of being above the upper target bound while it reduces the probability of being under the lower target bound. When budget deficits to GDP are replaced with the domestic debt to GDP ratio, similar effects are observed. The chapter also investigates the importance of financial sector development in IT using two indicators; private credit to GDP ratio and liquid liabilities to GDP. The evidence shows that an increase in private credit to GDP ratio increases significantly the probability of inflation staying in the target band. But when liquid liabilities to GDP ratio are used, no significant effect is found.

Moreover, the chapter finds that policy interest rates are more effective in reducing inflation target misses in countries with independent central bank, fiscal discipline and a developed financial sector. This implies that monetary policy is likely to be more effective in emerging countries with better institutions. Although the findings of the chapter reveal that strong institutional structures improve the performance of inflation targeting in EMEs, some external and domestic factors also exert powerful effects on the achievement of inflation targets. These variables are: exchange rate gap, output gap, inflation target horizon and degree of openness.

The chapter is organised as follows: Section 2.2 outlines the relevant literature on institutional patterns and inflation performance. Section 2.3 presents the methodology, while section 2.4 presents the data and stylised facts. Section 2.5 reports and analyses the estimation results. Section 2.6 provides robustness and sensitivity analysis. Finally, section 2.7 presents the conclusion and policy recommendations.

2.2 Review of the literature

2.2.1 Central bank independence

There are at least two definitions of CBI in the literature: (i) according to Walsh (2003), CBI relates to the freedom of monetary policymakers from direct political or governmental influence in the conduct of monetary policy; (ii) Cukierman et al. (1992) defines it as the ability of the central bank to stick to the goal of price stability even at the cost of short term objectives.

Two influential theories plausibly explain how CBI can contribute to the achievement of inflation targets. Firstly, the public choice theory proposed by Buchanan and Wagner (1977) argues that central banks are exposed to strong political pressure to behave in accordance with government's preferences to expand the economy by loosening monetary policy at particular times, especially election periods. This may create a political monetary cycle in which money supply growth and inflation rises during elections but moderates during non-election periods. This theory suggests that CBI can reduce the pre-election manipulation of monetary policy and increase credibility of commitments to price stability by constraining the government's ability to inflate.

Secondly, the dynamic inconsistency theory by Kydland and Prescott (1977) and Barro and Gordon (1983) acknowledges the absence of precommitment in monetary policy as a source of inflationary bias. It argues that the best plan made in the present for some future period may no longer be optimal when that period actually arrives. This makes inflation sub-optimal because private sector wages and prices are formed before observing aggregate demand. This gives central banks an ex-post opportunism to temporarily boost output by allowing an unanticipated higher inflation which reduces the real wage of workers. Due to private expectations that inflation will be high, the policy maker's ability to pursue discretionary policy results in inflation without increase in output. This theory predicts that an independent central bank may be necessary to control money creation capacities, both directly by shaping central bank incentives and indirectly, through its credibility effects.

So far some empirical work has been done to test the role of central bank independence on inflation outcomes and find different results. Using both *de jure* and *de facto* measures of CBI for 72 countries for the period 1950-1989, Cukierman et al. (1992) find that legal CBI negatively affects inflation and its variability in developed countries.[5] They also observe that the turnover rate of central bank governors (a *de facto* measure of CBI) has no correlation with inflation in developed countries but has significant effects on inflation in developing countries.[6] Nevertheless, their study explains the role of CBI on inflation in general and not on achieving inflation targets, which is the focus of this chapter. Further, their study focuses on a small set of control variables and does not account for some important variables, such as exchange rate and trade openness.

Using data from 1985-1988 for 16 developed countries, Alesina and Summers (1993) also provide evidence of a strong negative relationship between inflation variability and CBI.[7] However, the analytical framework in their study is not rigorous as it only uses simple correlations based on cross sectional data which does not provide much information on long run relationships. Posen (1998) argues that

[5]They note that the key channel through which low CBI leads to inflation is through the provision of credit to government. See also Grilli et al, 1991, for further evidence of the effects of CBI on economic outcomes.

[6]Frequent changes of the central bank governor is a strong indication of low level of CBI, because it shows that the political authorities have more opportunity to have central bank governors that will follow their policies than governors that will not.

[7]Other recent studies e.g. Crowe and Meade (2008) found similar results.

any conclusion based on the negative correlation of CBI and inflation is not robust enough because correlation does not necessarily imply causation. Using a panel of 17 OECD countries from 1950-1989, he shows that CBI does not necessarily reduce the political manipulation of monetary policy or reduce the monetization of budget deficits. Hence, it does not lead to low inflation through the enhancement of commitments to price stability. The study focuses on developed countries with different institutional dynamics from developing countries hence its findings cannot necessarily be generalised to EMEs.

Most relevant for this chapter is the paper by Gosselin (2008) which studies 21 IT countries from 1990-2005.[8] It finds that CBI is negatively correlated with inflation deviations from the mean among other variables. However, it uses inflation target deviations from the target mean. This does not reflect the uncertainty in the inflation process and obscures a clear analysis of central bank performance with regard to inflation targets.

2.2.2 Fiscal discipline

Fiscal discipline entails managing competing and often excessive claims on limited public resources for macroeconomic stability, without running large and unsustainable budget deficits (Younger et al., 1998). There is a general consensus that fiscal discipline is important for the credibility and viability of price stability.[9] Theoretical foundations of the relationship between fiscal discipline and inflation outcomes relate to many hypothesis. For instance, the fiscal dominance hypothesis proposed by Sargent and Wallace (1981) postulates that fiscally dominant governments running persistent budget deficits may need to finance them with money printing. When a binding financing constraint forces the government to finance its budget deficits through inflation tax, any attempt to lower inflation today will require higher inflation tomorrow. This may occur because the central bank cannot influence the size of the government's budget deficit, but may be forced to finance the deficit by seigniorage revenue. This theory predicts that consistently

[8]The sample was composed of 8 industrial countries and 13 emerging market economies.

[9]This is the case especially in EMEs with low tax bases, inefficient tax collection systems and limited access to external borrowing which tend to increase dependence on seigniorage (see e.g. Catao and Terrones, 2005)

high budget deficits may result in persistent inflation target deviations through monetization of public deficits.

The debt dynamics hypothesis by Blanchard (2004) posits that in cases where interest payments on government's domestic debt or expectations of future money growth are high, inflation can rise persistently. Current debt levels may not lead to higher inflation now, but to higher inflation in the future because of high interest payments and expectations of future debt repayments.

Although theory provides coherent and similar predictions about the effects of fiscal balances on inflation, the empirical evidence so far is rather elusive. For example, De Haan and Zelhorst (1990) find a positive long-run relationship between inflation and budget deficits in high inflation countries on a panel of 7 developing countries from 1961-1985. Catao and Terrones (2005) make similar conclusions using a dynamic panel of 103 developing and developed countries from 1960-2001. However, using a panel of 133 countries for the period 1960-1995, Fischer et al. (2002) find a negative relationship between fiscal deficits and inflation which is only strong in high inflation countries and for high inflation episodes but no obvious relationship in low inflation episodes.

2.2.3 Financial sector development

Two channels through which financial sector development affects the achievement of inflation targets can be considered: (i) the role of the financial sector in reducing government reliance on seigniorage revenue (see e.g. Neyapti, 2003) and (ii) the credit channel transmission mechanism (see e.g. Bernanke and Blinder, 1988; Bernanke and Gertler, 1995). Neyapti's (2003) framework postulates that when the financial sector is not developed, fiscal dominance is rife because the government relies on the central bank for the financing of its budget deficits. The model predicts that the degree to which budget deficits are inflationary depends to a greater extent on the level of financial sector development. If the financial sector is small relative to the budget deficit, it may fail to absorb newly issued debt, forcing the central bank to monetise the deficits. According to this view, when financial markets are developed, it is easier for the government to finance its budget deficits from capital markets without relying on seigniorage.

The credit channel monetary transmission mechanism proposed by Bernanke and Blinder (1988) and Bernanke and Gertler (1995) focuses on the role of the financial sector in monetary policy. It posits that the direct effect of monetary policy on interest rates depends on the size of the external finance premium. Since the external finance premium affects the overall price of funds, credit market imperfections affect the consumption and investment decisions, and ultimately prices and output, through the economic agent's net worth (balance sheet) and bank lending channels.[10] This model suggests that the transmission of interest rate movements to affect output, price and ultimately inflation depends on the structure of the financial system. Deep financial systems transmit monetary impulses faster than shallow financial systems.

There are few empirical studies which investigate the role of financial sector development in monetary policy. Cottarelli and Kourelis (1994) test the effects of financial sector development on the speed of the monetary transmission process using a two-step procedure on a panel of 31 developed and developing countries. They conclude that higher financial sector development improves the speed of the transmission process. However, this result could be highly sensitive to influential observations particularly in developed countries which have arguably higher levels of financial sector development than developing countries.

Posen (1995) uses the financial opposition to inflation (FOI) on a sample of 32 developed and developing countries from 1960 to 1989 to study the effects of financial sector development on inflation. He finds that FOI has a negative predictive effect on inflation outcomes. He argues that the financial sector can support short-run stabilisation policies of the central bank by lobbying for anti-inflation practices.[11] Thus, the bigger the financial sector, the more the financial opposition to inflation the economy has.

Using GMM, Neyapti (2003) tests the effects of financial sector development and CBI on budget deficits and inflation in 54 developed and developing countries

[10]The balance sheet channel asserts that the borrower's net worth negatively affects the external finance premium,and hence affects economic variables. Bank lending channel relates to the effects of monetary policy on the external finance premium by shifting the cost and supply of intermediated credit.

[11]Thus, the central bank can only guarantee price stability as long as the financial sector supports such a policy.

from 1970-1989. She finds that when the financial sector is not developed, the positive effect of budget deficits on inflation is strong and CBI affects the degree of both current and future monetary accommodation of budget deficits. Although this analysis provides a framework for understanding the role of financial markets in price stability, it does not analyse its effects on inflation target deviations. On the other hand, Gosselin (2008) find no significant role of financial sector development in explaining inflation target deviations from the mean. However, his work does not test explicitly the interactions of financial variables and interest rates to determine if monetary policy effectiveness is enhanced by greater financial sector development.

2.3 Methodology

2.3.1 Panel ordered logit model specification

To test the role of institutional factors in inflation target outcomes, the inflation process is first specified as a function of institutional factors and control variables:

$$\begin{aligned} Inf_{it} &= \mu_i + Inst_{it}\delta + Z_{it}\gamma + \varepsilon_{it},\ i = 1, ..., N \text{ and } t = 1, ..., T_i \\ \varepsilon_{it} &\sim D(0,1). \end{aligned} \quad (2.1)$$

where Inf_{it} is inflation, $Inst_{it}$ is the vector of institutional variables, Z_{it} is a vector of control variables, μ_i is a vector of country specific unobserved effects that are assumed to be constant over time, δ and γ are vectors of slope coefficients that are common to all countries,[12] ε_{it} is a vector of error terms, i and t are country and time indices respectively, N is the total number of countries and T_i is the total number of time observations for country i. $D(0,1)$ is a probability distribution with mean 0 and standard deviation of 1.

The dependent variable to be estimated is the inflation target deviation. Since it is discontinuous and ordinal, it is more appropriate to estimate it with a discrete

[12] This assumption is very strong and may be relaxed in some frameworks such as seemingly unrelated regressions.

choice model. In this case, the panel ordered logit model is applied. Three ordinal categories are considered, that is: inflation below target band, within the target band and above the target band. Inflation target deviation takes a value of 0 if inflation is below the band (*negative deviation*), 1 if inflation is within the band (*no deviation*) and 2 if inflation is above the band (*positive deviation*). The panel ordered logit model is theoretically appealing because it can account for different inflation target response outcomes and model the nonlinearities in the policy responses to inflation target deviations. In addition, it converges quickly while providing a more flexible analytical framework.

Setting U_{it} as the upper target of inflation in country i at time t and L_{it} as the lower target, the inflation target deviation of country i at time t is thus given by:

$$Infdv_{it} = \begin{cases} 0 \quad if \quad Inf_{it} < L_{it} \\ 1 \quad if \quad L_{it} \leq Inf_{it} \leq U_{it} \\ 2 \quad if \quad Inf_{it} > U_{it}. \end{cases} \tag{2.2}$$

To simplify equations, the following notations are set:

$$Y_{it} = Infdv_{it} \text{ and } X_{it}\beta = \mu_i + Inst_{it}\delta + Z_{it}\gamma.$$

The response probabilities of the occurrence of each inflation target outcome are :

$$\begin{cases} P(Y_{it} = 0) = P(Inf_{it} \leq L_{it}) = F(L_{it} - X_{it}\beta), \\ P(Y_{it} = 1) = P(L_{it} \leq Inf_{it} \leq U_{it}) = F(U_{it} - X_{it}\beta) - F(L_{it} - X_{it}\beta) \\ P(Y_{it} = 2) = P(Inf_{it} > U_{it}) = 1 - F(U_{it} - X_{it}\beta). \end{cases} \tag{2.3}$$

The parameters are estimated by maximum likelihood and the log likelihood function of the logistic function is:

$$\ln(L) = \sum_{i=1}^{N}\sum_{t=1}^{T}\left\{ \begin{array}{c} 1_{[Y_{it}=0]}\ln[F(L_{it} - X_{it}\beta)] + 1_{[Y_{it}=1]}\ln[F(U_{it} - X_{it}\beta) - F(L_{it} - X_{it}\beta)] \\ +1_{[Y_{it}=2]}\ln[1 - F(U_{it} - X_{it}\beta)] \end{array} \right\} \tag{2.4}$$

where $F(.)$ is the cumulative probability distribution function of ε and $1_{[Y_{it}=j]}, j = 0, 1, 2$ is the indicator function of the set $[Y_{it} = j]$.

In discrete choice models, the parameters that are generally provided are the marginal effects because they have reasonable asymptotic properties and can be interpreted easily (Wooldridge, 2002). However, in the case of the panel data, there is no programme which can estimate them directly. Therefore, a three-step procedure which uses GLLAMM module to estimate marginal effects is developed. The procedure is explained in Appendix A.1.

2.4 Data and stylised facts

2.4.1 Data

The chapter uses quarterly panel data from 15 inflation targeting EMEs from 1991 to 2008. The panel is unbalanced because of different adoption dates for inflation targeting. Table A.1.2 shows the sample of IT emerging market economies and their characteristics. The dependent variable is the inflation target deviation, an ordinal discrete variable measured as the absolute deviation of inflation from target bands. Explicit inflation targets are considered for each country. For many countries, inflation targets are based on the headline consumer price index.[13]

The chapter focuses specifically on three institutional categories; monetary institutions, fiscal institutions and financial institutions which are proxied by CBI indicators, fiscal discipline indicators and financial sector development indicators respectively. CBI indicators used are legal CBI index (*lcbi*), which is a *de jure* measure of CBI and the turnover rate of central bank governors (*ltor)*, which is a *de facto* measure of CBI. For legal CBI the chapter uses the index which was developed by Cukierman et al. (1992) and updated by Polillo and Guillen (2005), Crowe and Meade (2008) and the author for more recent years. This measure is an aggregate index computed from sixteen different legal characteristics found in central bank laws.[14] It is conceptually attractive because it is a comprehensive measure

[13]Some countries e.g., Thailand set inflation targets in terms of core inflation. South Korea and the Czech Republic used to define their targets in terms of core inflation but have now moved to headline inflation.

[14]The legal characteristics: term of office, appointment, dismisal, other government responsi-

which captures the operating institutional framework and various structural aspects of central banks in each country. Higher indices indicate higher central bank independence. It is expected to be negatively related to positive inflation target deviations. It has also been widely used in the literature.[15] The turnover rate of central bank governors is used as an alternative because central banks may be more independent in practice than what is stated in their legislations (Cukierman et al., 1992).[16] It is expected to be positively related to inflation deviations.

Fiscal discipline is proxied by budget deficits as a percentage of GDP (*bdgdp*) and domestic debt as a percentage of GDP (*dbtgdp*). The primary fiscal balance to GDP is used because it is a relatively good principal component indicator of the level of fiscal discipline which assesses the orientation of fiscal policy over the fiscal year (Fischer et al., 2002). It accounts for the fact that the achievement of inflation targets may depend on the reform of fiscal institutions. Domestic debt to GDP is used as an alternative because countries with high debt to GDP ratios are likely to use seigniorage or inflate their debt in future (Reinhart and Rogoff, 2008). Fiscal balances are expected to raise the likelihood of inflation deviation from the upper target bound.

Financial sector development is measured by private credit to GDP ratio (*lpcgdp*) and alternatively by liquid liabilities to GDP ratio (*lllgdp*). Private credit to GDP is the value of all credit that financial intermediaries issue to the private sector as a share of GDP. It is the preferred measure of financial sector development in the literature because higher levels of private credit indicate larger involvement of the private sector in the economy. Liquid liabilities to GDP ratio is composed of currency plus demand and interest bearing liabilities of banks and non banks. It reflects the size of the financial sector relative to the economy (see e.g., Levine et al., 2000; Boyd et al., 2001). Higher ratios indicate higher financial sector de-

bilities of the governor, price stability objective, monetary policy formulation, conflict resolution, role of central bank in government, advance and limits of loans to government, decisions on terms of lending, beneficiaries, types of limits, loan maturity, restrictions on interest and ban on buying or selling government bonds in the market.

[15] (See e.g Campillo and Miron, 1996; Crowe and Meade, 2008; Jacome and Vazquez, 2008)

[16] Turnover rate of central bank governors is calculated as the number of governors in a certain period divided by the reference term of office. The higher the turnover, the higher the risk of influencing the executive branch, hence the lower the independence. Long tenure gives the governor the independent reputation that may solidify his resistance to political pressure.

velopment.

Based on the standard literature on inflation dynamics, the following control variables are chosen: output gap (*lygp*) to account for business cycle growth, exchange rate gap (*lexrg*) to account for the effects of exchange rates on inflation, terms of trade (*ltot*) to account for external shocks, openness (*lopen*) to control for the degree of exposure to external shocks, while lagged inflation(*inflg*) accounts for the persistence effects of inflation. Policy rates (*rts*) are there to capture central bank's monetary policy decisions. This follows from the understanding that in an inflation targeting framework, whenever inflation deviates from the target, central banks use interest rates to bring inflation within the target bands (Svensson, 1997). Inflation targeting horizon (*lhorzn*) is also controlled for. This is the period over which inflation is required to return to the target band following a shock (Roger and Stone, 2005). It is an important variable to consider since it relates to the design of IT with respect to its response to shocks. Since these control variables cover a wide range of characteristics of EMEs, they also help to reduce omitted variable bias, which has plagued most previous studies.

All variables are expressed in logarithms, except where a variable contains some negative values. This is done to reduce the risk of multicollinearity in the estimations and standardise the variances. The prefix *l* is added to the name of those variables in order to indicate that there are in logarithms. The main sources of data are International Financial Statistics (IFS), World Development Indicators (WDI), Datastream, Global Insight and various central bank websites, Cukierman et al. (1992), Polillo and Guillen (2005) and Crowe and Meade (2008). Table A.1.3 in the Appendix provides variable descriptions and their sources in detail.

2.4.2 Stylised facts

According to Roger and Stone (2005), inflation targeting countries have missed their target ranges about 40% of the time and EMEs have experienced more target misses of about 52.2%, compared with developed countries with 34.8% prior to 2005. Table 2.4.1 shows several stylized facts about the experience of EMEs in the achievement of inflation targets over the period 1991-2008. The average frequencies of inflation target misses are about 15% and 43% below and above the targets respectively. The Philippines, Poland and Peru experienced most frequent target deviations below the target band while Israel, the Philippines, South Africa and Turkey experienced more target deviations above the bands. Colombia, Chile, and the Czech Republic achieved their inflation targets most of the times. In terms of magnitudes, deviations above the target are more common, averaging 3.43% compared with deviations below the band which average -1%. Large deviations above the upper target bands are generally considered to be more harmful than deviations below the target bands in EMEs.[17]

Table 2.4.1: Inflation outcomes relative to target ranges

Country	Frequency			Magnitude		Duration	
	Below Target	Within Target	Above Target	Below Target	Above Target	Below Target	Above Target
Brazil	7.50	57.50	35.0	-2.14	5.33	3.00	7.00
Chile	15.28	45.83	38.5	-0.89	1.43	2.6.0	3.70
Colombia	0.00	61.11	38.89	0.00	1.06	0.00	3.60
Czech Republic	28.57	40.48	30.95	-1.70	2.33	2.70	3.30
Hungary	21.43	39.29	39.87	-0.77	3.30	2.00	5.00
Indonesia	0.00	37.50	62.50	0.00	5.40	0.00	5.00
Israel	12.50	13.89	73.61	-4.30	14.0	2.75	8.50
Mexico	0.00	47.50	52.50	0.00	1.30	0.00	3.50
Peru	30.00	45.00	25.00	-1.10	2.21	3.00	2.14
Philippines	42.86	10.71	46.43	-1.21	2.95	6.00	6.50
Poland	35.00	32.50	32.50	-0.64	1.70	2.80	4.30
South Africa	16.67	36.11	47.22	-1.50	3.20	2.00	3.50
South Korea	29.55	40.91	29.55	-0.79	1.87	3.25	2.60
Thailand	0.00	77.78	22.22	0.00	2.37	0.00	4.50
Turkey	0.00	41.67	66.67	0.00	2.95	0.00	11.00
Average	15.96	41.85	42.75	-1.00	3.43	2.01	4.94

Notes : Frequency in %, Absolute magnitude in %, Duration in Quarters.

Sources: Authors' calculations based on IFS, Datastream and Central Bank websites

In terms of persistence, Table 2.4.1 shows that inflation target deviations above the bands averages 4.9 quarters, which may reflect the average inflation target hori-

[17] Generally, economic agents prefer lower inflation to higher inflation, hence upper target misses may have more costs and lead to credibility loss. Also most central banks associate larger welfare losses with positive rather than negative inflation deviations. However, there is a threat of a zero lower bound if deviations below the band persist, but the risk has been considered to be minimal for most EMEs.

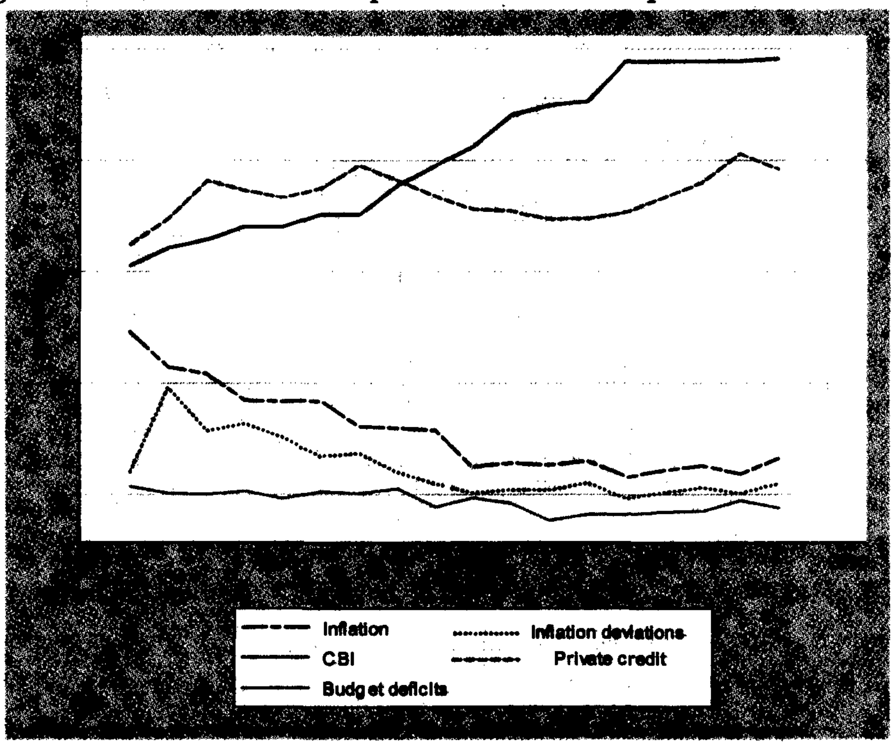
zon. A common trend is that countries tend to overshoot rather than undershoot their target bands. Generally, large, more frequent and persistent inflation target deviations are common in Brazil, Israel, South Africa and Thailand.

Figure 2.1, brings institutional dynamics into the picture by presenting their relationship with inflation target outcomes at an aggregate level in EMEs. On average there has been progressive improvement in monetary and financial institutional structures in emerging countries since the 1990s. This corresponds to a noticeable decrease in the magnitude of inflation target deviations. This pattern suggests that there could be a link between institutional structures and inflation target deviations. Two horizons can be identified in Figure 2.1. The first, is a disinflationary horizon from 1990-1999 which is associated with large and frequent inflation target deviations. For many countries, higher inflation deviations during this period are a reflection of previous hyperinflations, weak institutions and imbalances of previous monetary anchors which have not subsided (Petursson, 2004). The second is a more stable inflation horizon associated with low inflation and small inflation target deviations from 2000-2008, which may reflect an improvement in both institutional structures and monetary policy management.[18] This may suggest that improvement in institutional structures help in the achievement of inflation targets and price stability.

Figure A.1 in the Appendix shows institutional patterns and inflation target performance of individual EMEs. The figure shows that Chile and South Africa have strong monetary, fiscal and financial institutions as measured by central bank independence, budget deficit to GDP ratio and private credit to GDP ratio. On the other hand, Brazil, Thailand and South Korea have poor institutional frameworks. But in terms of inflation targeting performance, inflation has stayed within the target range most of the time in Chile, Thailand and South Korea, while in South Africa, Brazil, Israel and Poland it has often been outside the target range. In some countries, for example Brazil, the government has a history of poor support for price stability, where laws supporting CBI have been easily overturned (Albagli and Schmidt-Hebbel, 2003). It is therefore important to analyse the role of institutional patterns for inflation targeting performance in EMEs.

[18]The Great Moderation could also have contributed to general stability of inflation and low inflation target deviations in the 2000s.

Figure 2.1: Institutional developments and inflation performance in EMEs



2.4.3 Panel data estimation issues

The estimation of the panel ordered logit model raises several issues which should be dealt with before estimating the regressions. First, there is the possibility of endogeneity of institutional variables. For example, legal reform of central banks may be a response to high inflation rates. Also, as pointed out by Neyapti (2003), another possible source of endogeneity is that high budget deficits may force monetary authorities to tighten monetary policy in order to reduce inflation. In addition, price stabilisation due to inflation targeting may improve financial development (Boyd et al., 2001). The chapter uses the Hausman technique to test for potential endogeneity of the key institutional variables that is, legal CBI, private credit to GDP and budget deficits to GDP. As is common in the literature, first lags of these variables are used as instruments in the test for endogeneity. The Hausman test statistic obtained is 1.81 with a p-value of 0.97, hence the null hypothesis of no endogeneity is accepted.

Secondly, non-stationarity of variables is an issue since the panel data has a time series dimension. In this case, stationarity is tested using the Fisher-type test as suggested by Maddala and Wu (1999). This test involves combining the p-values of the test statistics for unit root in each cross-sectional unit to generate a test statistic. The null hypothesis is that there are unit roots against the alternative that at least one is stationary. This test is more appropriate because it can be applied to unbalanced panels. Table C.1.5 shows the results. Legal CBI was not stationary in levels, but became stationary after first differencing, but the rest of the variables were stationary in levels. The section also tests for the possibility of cointegration of legal CBI and inflation target deviations using the Persyn and Westerlund (2008) technique. Using robust p-values, the test finds no cointegration.[19]

Thirdly, there is need to check for the presence of multicollinearity of variables and heteroskedasticity of the residuals. The presence of multicollinearity is inferred using the correlation coefficients. Table A.1.4 presents the pairwise correlation matrix for all the variables. Not much multicollinearity is suspected in the explanatory variables because of relatively low correlations between most variables. The fact that most of the variables are in logs may also have reduced some multicollinearity. To deal with possible heteroskedasticity in the regression, robust standard errors are considered.

2.5 Empirical results

This section presents and discusses the estimation results. The discussion of results is based on marginal effects which indicates the probability of having inflation falling in each inflation target category following a unit change in each variable.

2.5.1 Central bank independence

The institutional variables were added to the ordered logit regression one at a time. The results for two CBI measures; legal CBI (*lcbi*) and turnover rate of central bank governors (*ltor*) are shown in Table 2.5.1.

[19] See Table A.1.6

Table 2.5.1: Ordered logit results: the effects of central bank indepedence

	Model 1			Model 1'		
Variables	mfx_0	mfx_1	mfx_2	mfx_0	mfx_1	mfx_2
lygp	-0.181***	-0.0681**	0.249***	-0.181***	-0.0779**	0.259***
	(0.0572)	(0.0478)	(0.0476)	(0.0604)	(0.0537)	(0.0480)
lexrg	-0.419***	-0.223***	0.642***	-0.419***	-0.225***	0.644***
	(0.0727)	(0.0698)	(0.0800)	(0.0756)	(0.0716)	(0.0821)
ltot	-0.0280	-0.0842*	0.112**	-0.0278	-0.0853*	0.113**
	(0.0285)	(0.0423)	(0.0482)	(0.0281)	(0.0427)	(0.0494)
lopen	-0.163***	-0.0320	0.195***	-0.154***	-0.0378	0.192***
	(0.0479)	(0.0437)	(0.0278)	(0.0504)	(0.0509)	(0.0300)
lhorzn	-0.182***	0.0553	0.126**	-0.183***	0.0541	0.129**
	(0.0418)	(0.0484)	(0.0576)	(0.0405)	(0.0446)	(0.0586)
rts	-0.00999**	0.000134	0.00985	-0.00965**	-1.47e-05	0.00966
	(0.00414)	(0.00371)	(0.00584)	(0.00411)	(0.00382)	(0.00583)
inflg	-0.0127***	-0.0141***	0.0268***	-0.0128***	-0.0142**	0.0270***
	(0.00348)	(0.00468)	(0.00785)	(0.00352)	(0.00479)	(0.00801)
lcbi	0.0502**	0.159**	-0.109**			
	(0.0637)	(0.0681)	(0.0567)			
ltor				0.00848	0.0154	-0.0239*
				(0.0118)	(0.0172)	(0.0153)
Constant	-0.00169**	-0.00235**	0.00404**	-0.00143*	-0.00291**	0.00434**
	(0.000761)	(0.00107)	(0.00168)	(0.000711)	(0.00108)	(0.00168)
Observations	586	586	586	586	586	586
Number of countries	15	15	15	15	15	15
R^2	0.439	0.489	0.527	0.434	0.477	0.525

Robust standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

Model 1 is the ordered logit model including lcbi.

Model 1' is the ordered logit model including ltor.

mfx_0, mfx_1 and mfx_2 are marginal effects of having inflation below the band, within the band and above the band respectively.

Model 1 presents the results of the regression which includes CBI and all control variables. In this model, the results show that higher legal CBI reduces the probability of having inflation above the target band while increasing the probability of having inflation within the target band as well as below the target band. Quantitatively, a 1% increase in legal CBI index results in a decrease in the probability of having inflation above the target by 0.11%, while increasing the probability of achieving the target band by 0.16%. The probability of having inflation below the target also increases by 0.05% as CBI increases. The results suggest that countries with more aggressive central bank reforms have better chances of achieving inflation targets, which may reflect a stronger ability to commit to price stability (Cukierman et al., 1992). This is consistent with the dynamic inconsistency hypothesis which suggests that higher CBI may reduce the political manipulation of monetary policy and eliminate the policy makers' appetite for surprise inflation. These results are in line with other studies, for example Gosselin (2008), who considers inflation deviations from the mean.

When the turnover rate of central bank governors is a measure of CBI, there is no significant effect on the probability of achieving the target band and the signs of marginal effects are contrary to expectations. The result suggests instead that in EMEs, lower turnover of central bank governors may not necessarily be a sign of a high central bank independence possibly because it is not a comprehensive measure of CBI, as it focuses on one central bank feature. Mas (1995) argues that a low turnover rate of central bank governors may rather indicate less CBI instead because the subservient governor can stay in office longer than a governor who tries to resist political pressure.[20] However, the results contradict the conclusions by Cukierman et al. (1992) and Jacome and Vazquez (2008) who find that it is insignificant in explaining inflation outcomes in developing countries. In fact, Cukierman et al. (1992) suggests that legal CBI and the turnover rate of central bank governors may be measuring orthogonal aspects of CBI.

Table 2.5.4 shows results when all institutional variables are included in the regression together. The results show that the marginal effects for legal CBI increases and are significant. This improvement in the results may suggest that these

[20] Walsh (2003) argues that in countries where the rule of law is embedded in political culture, there can be a wide gap between legal CBI and actual CBI.

institutional variables are complementary. For example, a credible central bank may commit not to finance the fiscal deficit, which may strengthen fiscal authorities' incentive to balance the budget (Grilli et al., 1991). However, the turnover rate of central bank governors remains insignificant.

2.5.2 Fiscal discipline

Table 2.5.2 presents the results when fiscal institutional variables are used. Model 2 shows regressions with budget deficits to GDP ratio while Model 2' shows results when domestic debt to GDP ratio is used instead.

The results show that a 1% increase in budget deficit increases the likelihood of inflation being above the target band by about 0.007%, while it reduces the likelihood of inflation being below the target band and of being within the band by 0.005% and 0.001% respectively. The effects are significant at the 1% level. This is intuitive for EMEs considering their perceived poor fiscal institutions (Catao and Terrones, 2005). The results are consistent with Sargent and Wallace (1981)'s fiscal dominance hypothesis and the empirical findings of De Haan and Zelhorst (1990) and Catao and Terrones (2005) which show that high budget deficits may lead to high inflation while fiscal consolidation enhances the achievement of inflation targets. The evidence suggests that countries that seek a low inflation path should ensure that their fiscal positions do not lead to fiscal dominance.

When the ratio of debt to GDP is the variable which captures fiscal discipline, the observation is that its increase reduces the probability of being in the target band mainly by increasing significantly the probability of being above the upper bound. A 1% increase in debt to GDP ratio significantly increases the probability of exceeding the upper bound by 0.006%. At the same time, an increase in debt significantly decreases the probability of undershooting the lower bound by 0.002% while the probability of inflation staying within the target bound also decreases by about 0.0036%. Consistent with earlier work (see e.g. Campillo and Miron, 1996), the results support the view that unsustainable public debt makes monetary authorities reluctant to raise interest rates to fight inflation because such increases would raise the cost of debt service.

When institutional variables are included together in the regression, as shown in

Table 2.5.2: Ordered logit results: the effects of fiscal discipline

	Model 2			Model 2'		
Variables	mfx_0	mfx_1	mfx_2	mfx_0	mfx_1	mfx_2
lygp	-0.131*	-0.164*	0.295***	-0.155**	-0.0633*	0.218***
	(0.0700)	(0.0992)	(0.0568)	(0.0659)	(0.0527)	(0.0473)
lexrg	-0.411***	-0.287***	0.698***	-0.407***	-0.268***	0.675***
	(0.0719)	(0.0675)	(0.0866)	(0.0759)	(0.0869)	(0.0847)
ltot	0.00666	-0.0959*	0.0892	-0.0465	-0.0203	0.0668*
	(0.0243)	(0.0536)	(0.0524)	(0.0416)	(0.0394)	(0.0367)
lopen	-0.136**	-0.0647**	0.200**	-0.158**	-0.0492**	0.207**
	(0.0503)	(0.0513)	(0.0310)	(0.0559)	(0.0551)	(0.0280)
lhorzn	-0.194***	0.119	0.0750*	-0.169***	0.0472	0.122**
	(0.0445)	(0.0780)	(0.0533)	(0.0410)	(0.0599)	(0.0542)
rts	-0.0101**	0.000366	0.00969*	-0.00948*	0.000131	0.00934
	(0.00409)	(0.00446)	(0.00547)	(0.00455)	(0.00413)	(0.00555)
inflg	-0.0126***	-0.0133**	0.0259***	-0.0134***	-0.0139**	0.0273***
	(0.00329)	(0.00458)	(0.00746)	(0.00406)	(0.00471)	(0.00844)
bdgdp	-0.00524***	-0.00136***	0.0066***			
	(0.000600)	(0.00118)	(0.000599)			
dbtgdp				-0.00210***	-0.00358***	0.00568***
				(0.000263)	(0.000273)	(0.000419)
Constant	-0.00137**	-0.00308**	0.00445**	-0.00166**	-0.00226*	0.00392**
	(0.000619)	(0.00123)	(0.00156)	(0.000671)	(0.00118)	(0.00166)
Observations	586	586	586	586	586	586
R^2	0.422	0.264	0.578	0.340	0.271	0.540
Number of countries	15	15	15	15	15	15

Robust standard errors in parentheses

*** $p<0.01$, ** $p<0.05$, * $p<0.1$

Model 2 is the ordered logit model including budget deficit to GDP ratio

Model 2' is the ordered logit model including domestic debt to GDP ratio.

mfx_0, mfx_1 and mfx_2 are marginal effects of having inflation below the band, within the band and above the band respectively.

Table 2.5.4, the marginal effects are magnified for both budget deficits to GDP and domestic debt to GDP. For example, the likelihood of overshooting the target band significantly increases by 0.0068% and 0.0057% following a 1% increase in budget deficits and debt respectively. This lends further support for fiscal consolidation as a condition of sustained price stability and the achievement of inflation targets.

2.5.3 Financial sector development

The effects of financial sector development are indicated by the private credit to GDP ratio (*lpcgdp*) and liquid liability to GDP (*lllgdp*). The results are presented in Table 2.5.3. Model 3 reports the results for private credit to GDP ratio while model 3' replaces the private credit to GDP by liquid liabilities to GDP.

The results show that an increase in the private credit to GDP ratio increases significantly the probability of inflation staying in the target band and of having inflation below the target bound. On the other hand an increase in private credit to GDP reduces the probability of having inflation above the target band. In fact, a 1% increase in private credit to GDP translates into an increase of 0.12% in the probability of staying in the target band as well as 0.06% of having inflation below the lower bound. Also, an increase in private credit to GDP reduces the probability of inflation overshooting the upper bound by 0.055%. The marginal effects are statistically significant. Consistent with the findings of Neyapti (2003), these results suggest that countries with deep financial markets can easily finance their budget deficits in the capital markets without resorting to inflationary financing. However, when liquid liabilities to GDP ratio are used, no significant effects are found and its sign is also contrary to what is generally expected.

Table 2.5.4, reports the results when all institutional variables are used together in the regression. The results show that the marginal effects of private credit to GDP and liquid liabilities to GDP are not very different from those reported in Table 2.5.3. In fact, an increase in private credit to GDP still displays negative significant effects of having inflation above the target bound while increasing the probability of achieving inflation targets. Liquid liabilities are still insignificant, possibly indicating that they are not robust in measuring financial sector development or that the credit channel of monetary policy transmission is weak in EMEs.

Table 2.5.3: Ordered logit results: the effects of financial sector development

	Model 3			Model 3'		
Variables	mfx_0	mfx_1	mfx_2	mfx_0	mfx_1	mfx_2
lygp	-0.184***	-0.191*	0.251***	-0.186***	-0.0722*	0.258***
	(0.0599)	(0.183)	(0.0483)	(0.0591)	(0.0551)	(0.0504)
lexrg	-0.424***	-0.208**	0.627***	-0.417***	-0.211***	0.628***
	(0.0743)	(0.0774)	(0.0844)	(0.0727)	(0.0694)	(0.0805)
ltot	-0.0269	-0.0554	0.112**	-0.0281	-0.0883*	0.116**
	(0.0284)	(0.0385)	(0.0492)	(0.0272)	(0.0417)	(0.0458)
lopen	-0.159**	-0.0861**	0.196**	-0.166**	-0.0366**	0.203**
	(0.0492)	(0.0530)	(0.0297)	(0.0487)	(0.0494)	(0.0300)
lhorzn	-0.188***	0.114	0.128**	-0.185***	0.0555	0.130**
	(0.0396)	(0.0732)	(0.0583)	(0.0390)	(0.0472)	(0.0594)
rts	-0.00955**	0.00294	0.00974	-0.00950**	0.000193	0.00931
	(0.00409)	(0.00485)	(0.00577)	(0.00406)	(0.00382)	(0.00577)
inflg	-0.0129**	-0.0145**	0.0270**	-0.0129**	-0.0141**	0.0270**
	(0.00359)	(0.00514)	(0.00799)	(0.00348)	(0.00469)	(0.00786)
lpcgdp	0.0604**	0.120**	-0.0552**			
	(0.0172)	(0.0363)	(0.0361)			
lllgdp				-0.0777	-0.0798	0.157
				(0.0640)	(0.138)	(0.119)
Constant	-0.00110	-0.00375**	0.00462**	-0.00103	-0.00252*	0.00355*
	(0.000704)	(0.00134)	(0.00183)	(0.000614)	(0.00139)	(0.00184)
Observations	586	586	586	586	586	586
Number of countries	15	15	15	15	15	15
R^2	0.341	0.253	0.526	0.339	0.276	0.528

Robust standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

Model 3 is the ordered logit model including private credit to GDP ratio

Model 3' is the ordered logit model including liquid liabilities to GDP ratio

mfx_0, mfx_1 and mfx_2 are marginal effects of having inflation below the band, within the band and above the band respectively.

Table 2.5.4: Ordered logit results: the effects of all instititutional variables

	Model 4			Model 4'		
Variables	mfx_0	mfx_1	mfx_2	mfx_0	mfx_1	mfx_2
lygp	-0.126*	-0.174*	0.301***	-0.152**	-0.0803	0.232***
	(0.0678)	(0.0933)	(0.0538)	(0.0668)	(0.0540)	(0.0488)
lexrg	-0.413***	-0.285***	0.697***	-0.408***	-0.281***	0.689***
	(0.0722)	(0.0777)	(0.0908)	(0.0788)	(0.0889)	(0.0851)
ltot	0.00639	-0.0945	0.0881	-0.0509	-0.0192	0.0700*
	(0.0230)	(0.0545)	(0.0519)	(0.0406)	(0.0401)	(0.0349)
lopen	-0.145***	-0.0671	0.212***	-0.156**	-0.0541	0.210***
	(0.0476)	(0.0455)	(0.0309)	(0.0570)	(0.0552)	(0.0287)
lhorzn	-0.191***	0.120	0.0713*	-0.165***	0.0449	0.120**
	(0.0486)	(0.0821)	(0.0546)	(0.0430)	(0.0599)	(0.0554)
rts	-0.0103**	0.000130	0.0102*	-0.00936*	0.000193	0.00916
	(0.00408)	(0.00438)	(0.00564)	(0.00446)	(0.00422)	(0.00568)
inflg	-0.0124***	-0.0131**	0.0255***	-0.0134***	-0.0140**	0.0273***
	(0.00319)	(0.00447)	(0.00719)	(0.00395)	(0.00477)	(0.00838)
lcbi	0.0508**	0.161**	-0.111**			
	(0.0630)	(0.0744)	(0.0570)			
bdgdp	-0.00525***	-0.00157*	0.00682***			
	(0.000642)	(0.00122)	(0.000598)			
lpcgdp	0.0552**	0.113**	-0.0579**			
	(0.0164)	(0.0353)	(0.0346)			
ltor				0.0133	0.0165	-0.0299*
				(0.0127)	(0.0148)	(0.0151)
lllgdp				-0.0751	-0.0516	0.127
				(0.0743)	(0.158)	(0.117)
dbtgdp				-0.00201***	-0.00370***	0.00572***
				(0.000263)	(0.000278)	(0.000422)
Constant	-0.00136*	-0.00296**	0.00433**	-0.00131*	-0.00198	0.00329*
	(0.000671)	(0.00134)	(0.00172)	(0.000641)	(0.00148)	(0.00177)
Observations	586	586	586	586	586	586
Number of countries	15	15	15	15	15	15
R^2	0.422	0.277	0.582	0.333	0.273	0.541

Robust standard errors in parentheses, *** p<0.01, ** p<0.05, * p<0.1
Model 4 is the ordered logit model including baseline institutional variables lcbi, bdgdp and lpcgdp
Model 4' is the ordered logit model including alternative institutional variables ltor, dbtgdp and lllgdp
mfx_0, mfx_1 and mfx_2 are marginal effects of having inflation below the band, within the band and above the band respectively.

2.5.4 Control variables

The discussion of control variables is based on Table 2.5.4. In this case, the most important variables which explain inflation target deviations are discussed. These are: exchange rate gap, output gap, openness and inflation target horizon. The results show that a 1% increase in the exchange rate gap increases the probability of having inflation above the target by 0.7%, while decreasing the probability of achieving the target band by 0.28%. The probability of having inflation below the target band also decreases by 0.41%. These marginal effects are significant at 1%. This outcome suggests that countries which experience sharp exchange rate fluctuations and high exchange rate pass-through effects have problems in meeting their inflation targets. This is probably the case for countries like South Africa where most target misses were experienced during periods of high exchange rate volatility (Roger and Stone, 2005).

The output gap also explains inflation deviations from target bands. This means that inflation in EMEs is very sensitive to demand shocks and explains why central banks also include the output gap in their loss functions. The evidence also suggests that central banks should move interest rates more to offset demand shocks and bring inflation back in the target band.

The degree of openness seems to increase the chances of overshooting the upper target bound while reducing chances of undershooting the lower bound. This result contrasts with that of Campillo and Miron (1996) which shows a negative effect on inflation outcomes. The results in this chapter imply that EMEs being small and open, are greatly exposed to external shocks and global inflationary pressures (Fraga et al., 2003). Another possibility is that openness of EMEs has not reduced the incentives by policy makers to pursue expansionary monetary policies.

For inflation target horizon, the results show that specifying a longer inflation target horizon increases the chances of having inflation above the upper target while lowering the chances of having inflation below the lower target bound. The results suggest that long target horizons increase the time over which inflation can stay out of the target range, as central banks allow inflation to return to target slowly. This may also highlight the fact that central banks are flexible in dealing with inflation deviations from the target bands.

2.5.5 Effectiveness of monetary policy

It is often argued that institutional structures affect inflation target outcomes by enhancing the effectiveness of monetary policy (Cecchetti and Krause, 2001). This section tests this hypothesis by interacting institutional variables with interest rates. The results are shown in Table 2.5.5. The results show that policy interest rates are more effective in reducing inflation target deviations in countries that have more independent central banks when legal CBI indices are used. As emphasised by Bernanke et al. (1999), this implies that CBI contributes to monetary policy strength and credibility by shaping the central bank incentives thereby reducing the possibility of inflation surprises.

The marginal effects of the interacted fiscal variables are all significant. This suggests that strong fiscal institutions improve the effectiveness of monetary policy by reducing fiscal dominance and the need to finance budget deficit. This underscores the need for fiscal discipline if sustainable price stability is to be achieved. Moreover, the results show that financial sector development enhances the effectiveness of monetary policy when private credit to GDP is interacted with policy interest rates. Intuitively, more developed financial systems transmit monetary policy faster to affect prices and output than less developed financial systems. This result is consistent with the findings of Cottarelli and Kourelis (1994) which show that the speed of the monetary policy transmission process increases with the level of development of the financial sector. Also, the developed financial sector can make monetary policy more effective by supporting short run stabilisation policies of the central bank through lobbying for anti-inflation practices (Posen, 1995). In general, these results support the view that monetary policy is likely to be more effective in countries with mature institutions.

Table 2.5.5: Ordered logit results: interaction effects

	Model 5			Model 5'		
Variables	mfx_0	mfx_1	mfx_2	mfx_0	mfx_1	mfx_2
lygp	-0.164**	-0.105**	0.268**	-0.207**	-0.0593**	0.266**
	(0.0628)	(0.0677)	(0.0512)	(0.0916)	(0.0862)	(0.0565)
lexrg	-0.443***	-0.276***	0.720***	-0.385***	-0.278***	0.663***
	(0.0688)	(0.0791)	(0.0805)	(0.0942)	(0.0912)	(0.0979)
ltot	-0.0108	-0.0924*	0.103**	-0.0521	-0.0212	0.0733*
	(0.0236)	(0.0455)	(0.0470)	(0.0447)	(0.0360)	(0.0361)
lopen	-0.141**	-0.0410	0.182***	-0.120	-0.0330	0.153***
	(0.0543)	(0.0445)	(0.0362)	(0.0700)	(0.0559)	(0.0444)
lhorzn	-0.195***	0.0724	0.122**	-0.232***	0.0520	0.180***
	(0.0450)	(0.0574)	(0.0473)	(0.0456)	(0.0566)	(0.0359)
inflg	-0.0122***	-0.0134***	0.0256***	-0.0156**	-0.0108**	0.0264**
	(0.00338)	(0.00461)	(0.00755)	(0.00625)	(0.00439)	(0.00982)
lcbi*rts	0.00548**	0.194**	-0.189**			
	(0.0444)	(0.0620)	(0.0659)			
lpcgdp*rts	0.120*	0.108*	-0.0118*			
	(0.0265)	(0.0411)	(0.0380)			
bdgdp*rts	-0.000231***	-0.000153***	0.000383***			
	(3.85e-05)	(5.09e-05)	(1.62e-05)			
ltor*rts				0.00589**	0.00724**	-0.0131**
				(0.00165)	(0.00182)	(0.00258)
dbtgdp*rts				0.000267***	0.000356***	-0.000623***
				(8.23e-05)	(7.37e-05)	(6.52e-05)
lllgdp*rts				-0.00104	-0.0146	0.0156*
				(0.00617)	(0.00861)	(0.00530)
Constant	-0.000715	-0.00305***	0.00376**	-0.00157	-0.00208*	0.00365**
	(0.000552)	(0.000991)	(0.00129)	(0.00119)	(0.00101)	(0.00149)
Observations	586	586	586	586	586	586
R^2	0.358	0.297	0.562	0.364	0.213	0.512
Number of countries	15	15	15	15	15	15

Robust standard errors in parentheses, *** p<0.01, ** p<0.05, * p<0.1

Model 5 is the ordered logit model when interest rates are interacted with lcbi,bdgdp and lpcgdp.

Model 5' is the ordered logit model when interest rates are interacted with ltor, dbtgdp and lllgdp.

mfx_0, mfx_1 and mfx_2 are marginal effects of having inflation below the band, within the band and above the band respectively.

2.6 Robustness and sensitivity analysis

This section discusses various robustness and sensitivity tests of the results. It deals with an investigation of the sensitivity of the results to alternative model specifications, various sample periods and to the exclusion of the financial crisis period. To test if the results are sensitive to alternative specifications and distributional assumptions of the error terms, the random effects ordered probit model is specified.[21] The results are presented in Table A.1.7. The results show that legal CBI still affects negatively and significantly the probability of having inflation above the target band while affecting positively and significantly the probability of achieving inflation targets. The turnover rate is still insignificant and exhibits signs contrary to expectations. For fiscal variables, the magnitudes of the effects are marginally larger than those in the baseline case, but the conclusions are basically consistent. For financial sector development indicators, the results are qualitatively similar to the baseline case. This evidence therefore confirms that the results are not very sensitive to model specification and distributional assumptions.

To test the sensitivity to subsamples, the model is estimated for two subperiods: the 1990s and the 2000s. This helps to account for different inflation episodes which were observed in Figure 2.1. The 1990s were associated with disinflations while the 2000s experienced more stable inflation (Roger and Stone, 2005). This can influence the results in two ways. First, the strength of the nominal anchor may vary depending on whether inflation targets are stable or not (Mishkin and Schmidt-Hebbel, 2007). Second, the global macroeconomic conditions could have changed in the two periods which could affect the achievement of inflation targets (Cecchetti and Krause, 2001). Table A.1.8 shows the results for the 1991-1999 subsample. The results show that legal CBI still explains inflation target deviations, confirming results from the baseline model. The turnover rate of central bank governors has no significant effect on inflation target outcomes. There is also evidence that both fiscal deficits and domestic debt have strong and significant effects on inflation deviations in the 1990s. However, both private credit to GDP ratio and liquid liabilities to GDP seem to have less significant effects on inflation target outcomes. The last result is in line with the findings from previous studies which

[21] The ordered probit model assumes normal distribution of the error process.

confirm its weak impact on inflation target deviations (see e.g Gosselin, 2008). A possible explanation for this weak effect is that, many EMEs have adopted IT in the presence of weak financial systems.

The estimation for the 2000-2008 subsample is presented in Table A.1.9. The results show that the statistical significance of legal CBI has become weaker. However, the turnover rate exhibits strong significant effects on inflation target outcomes. The results suggest that what mattered during the 2000s was actual CBI rather than legal CBI. The significant effect of legal CBI in the 1990s compared to the 2000s also suggests that the contribution of CBI to IT is greater during disinflations than during stable inflation periods. Also, most central bank reforms were carried out during the 1990s rather than in the 2000s, which could have improved monetary policy credibility in dealing with inflation. The fiscal variables seem to have strong effects on inflation target outcomes. This robustly confirms the baseline results. For financial institutional indicators, the results show that private credit to GDP has strong effects on inflation target outcomes, while liquid liabilities to GDP seem to be less significant.

There is a possibility that the financial crises from 2007 could affect the results through their effect on fiscal balances, financial institutional variables and macroeconomic variables. To test this effect, the 2007-2008 period is excluded from the sample to see if the results remain stable. The results are presented in Table A.1.10. The results show that legal CBI still explains inflation target outcomes. The turnover rate of central bank governors is now significant. This provides further support for the view that the conduct of monetary policy must remain independent of political pressure in order to achieve sustainable price stability. Consistent with the baseline results, both budget deficits to GDP ratio and domestic debt to GDP ratio exhibit significant effects on inflation target outcomes. However, the marginal contributions to the likelihood of all inflation response categories are lower than those in the baseline specification. Also, private credit to GDP significantly affects inflation target outcomes while liquid liabilities to GDP have expected signs and are significant in all response categories. One possible explanation for this result is that these measures are better indicators of financial sector development in EMEs during stable periods than during crises.

2.7 Conclusion

This chapter analysed the role of institutional structures in the achievement of inflation targets. It focuses on inflation deviations from the target bands rather than deviations from the mean. The panel ordered logit model is used to achieve this goal. The results show that improvement in central bank independence, fiscal discipline and financial sector development help to reduce the probability of missing the target bands. These results support the view that monetary, fiscal and financial institutional structures matter for inflation targeting in EMEs, once macroeconomic and other factors are controlled for. The analysis also demonstrates that improvement in these institutional structures enhances the effectiveness of monetary policy. These institutional factors are not orthogonal, in fact, they reinforce each other since their combined impact is quite large.

Although these institutional structures explain inflation target outcomes in EMEs, other factors also matter. The results show that control variables such as output gap, exchange rate gap, openness, lagged inflation and inflation target horizon also explain inflation target outcomes. This suggests that inflation in EMEs is sensitive to macroeconomic developments, which may explain why some countries with good institutional structures have often missed their inflation targets.

The findings suggest that the process of institutional reform of central banks, fiscal institutions and financial institutions should continue for countries to achieve sustainable price stability. What is needed is an institutional framework that can respond, adapt and perform effectively while inducing responsible government behaviour and restraining abuses of macroeconomic policies. The results also suggest that policymakers should pay attention to both domestic and external factors, since both account for inflation target deviations even in countries where these institutions are good. More importantly, the strong effects of the exchange rate gap on inflation target outcomes suggest that EMEs must consider their greater vulnerability to exchange rate shocks in the monitoring of inflation and the formulation of monetary policy. These findings have important implications for both countries preparing to adopt inflation targeting and the current inflation targeters in terms of institutions that support price stability.

Chapter 3

Monetary policy and commodity terms of trade shocks in emerging market economies: A DSGE analysis

3.1 Introduction

For many years, commodity terms of trade shocks have been shaping the macroeconomic outlook of most emerging market economies (EMEs) (Mendoza, 1995; Kose, 2002). These shocks have proved to be very volatile and persistent, especially in commodity exporting emerging countries, resulting in significant macroeconomic volatility. The recurrence of large commodity terms of trade shocks has called into question the ability of alternative monetary policy frameworks to stabilise emerging market economies and enhance welfare.

Several studies have analysed the macroeconomic implications of alternative monetary policy regimes under domestic and external shocks in small open economies (see e.g. Laxton and Pesenti, 2003; Gali and Monacelli, 2005; Medina and Soto, 2005; Devereux et al., 2006). They largely focus on shocks such as productivity shocks, interest rate shocks and demand shocks. While these shocks are important for EMEs, an important channel of fluctuations in EMEs has to do with the fact that their exports are undiversified and dominated by a few primary commodities. As such, most studies did not explain the case for country specific commodity terms of trade shocks.[1] Because of the high volatility and persistence of commodity terms of trade shocks, their consideration may help to account for the high volatility of exchange rates and other macroeconomic variables observed in most EMEs (Chen and Rogoff, 2003). Also, the consideration of commodity terms of trade shocks in the presence of sticky prices may significantly change the conventional wisdom on optimal policy in EMEs. Chen and Rogoff (2003) emphasise that rigidities may prevent standard terms of trade from adequately incorporating contemporaneous shocks that would induce immediate exchange rate and macroeconomic responses. More importantly, commodity terms of trade shocks may induce unfavourable trade-offs between inflation and output gap variability. The risks they pose in EMEs call for policy intervention.

On policy responses to external shocks, the literature has given much prominence to the role of flexible exchange rates (see e.g. Friedman, 1953; Chia and Alba, 2006). But the challenge is that flexible exchanges without activist monetary policy may not adjust in the right direction to achieve the desired outcomes, resulting in negative welfare effects (Devereux, 2004). Also, the fluctuations of the flexible exchange rates may generate inefficient relative price movements in the short-run (Ortiz and Sturzenegger, 2007). Therefore, policy responses should go beyond exchange rate choice and consider monetary policy as well. Indeed, recent studies have shown that monetary policy regimes such as inflation targeting can play a role in dampening cyclical macroeconomic fluctuations and improve welfare in small open economies (see e.g. Svensson, 2000; Cuche-Curti et al., 2008). The choice of monetary policy regimes also matters because wages and prices of non-tradable goods are sticky in the short-run and the speed at which relative prices adjust depends crucially on the monetary policy regime. Although the role of monetary policy can be ascertained, the question that remains is, which monetary policy regime is effective in dealing with commodity terms of trade shocks in EMEs.

This chapter develops a multi-sector New Keynesian dynamic stochastic general equilibrium (DSGE) model to evaluate the appropriate monetary policy responses

[1]See e.g Gali and Monaceli, 2005; Devereaux et. al., 2006;Broda, 2004, Mendoza, 1995

to commodity terms of trade shocks in EMEs. Precisely, the chapter evaluates the relative merits of CPI inflation targeting (CIT) rule compared with non-traded inflation targeting (NTIT) rule and exchange rate targeting (ET) rule in the face of commodity terms of trade shocks in commodity dependent EMEs. Within the same framework, the chapter also examines the monetary policy implications of productivity shocks in the commodity sector. The model is framed in the new open economy macroeconomics (NOEM), which integrates nominal rigidities and monopolistic competition.[2] It builds closely on the work of Devereux et al. (2006) and Gali and Monacelli (2005) and extends their models by incorporating the commodity sector to account for country specific commodity terms of trade shocks in a broader monetary model using the framework of Cashin et al. (2004). The model is calibrated to South Africa, a typical commodity dependent emerging market economy. This economy is ideal for this analysis because it has a significant portion of trade (about 30% of GDP) which is concentrated in primary commodities such as gold, platinum and diamonds. In South Africa, commodity exports account for about half of export earnings (Stokke, 2008), while the Rand is considered as a commodity currency because of its sensitivity to the movement of commodity prices (Cashin et al., 2004).

The multi-sector DSGE set up allows the distinction between non-traded inflation and CPI inflation which provides a richer framework for analysing dynamic macroeconomic responses to commodity shocks. The choice of a DSGE model is motivated by several factors. For instance, DSGE models are micro-founded in the sense that they are explicitly derived from the constrained optimising behavior of households and firms in the economy (Tovar, 2008). Further, their structural nature permits clear identification, interpretation and discussion of alternative policy interventions and their transmission mechanisms (Smets and Wouters, 2003). Finally, as argued by Woodford (2003), DSGE models help to overcome the Lucas critique because the estimated deep structural parameters are less likely to change when policies change.

This chapter contributes to the literature in two main ways. First, it incorporates the commodity sector in the multi-sector DSGE model of a small open commodity dependent emerging market economy. This allows explicit examina-

[2] See Lane (2001) for a detailed survey of the new open economy macroeconomics.

tion of the country-specific commodity terms of trade shocks and their implications for monetary policy. This characterisation especially in a dynamic equilibrium setting is not common to many small open economy models. The study demonstrates that the incorporation of the commodity sector in the model changes the conventional wisdom on optimal monetary policy in EMEs. The view that non-traded inflation targeting (a version of domestic inflation targeting) is the optimal monetary policy in small open economies does not hold. The chapter argues that CPI inflation targeting is the appropriate monetary policy for commodity dependent emerging market economies because it stabilises both output and inflation. Its stabilising power is attributed to its forward looking nature, credibility and a flexible exchange rate which help to insulate the economy from external shocks.

Secondly, using the central bank loss functions, the chapter evaluates the welfare implications of alternative monetary policy regimes to determine the optimal monetary policy in countries which are prone to commodity shocks. This is important because different monetary policy rules contain important trade-offs which affect welfare. Most work done on commodity dependent emerging economies such as South Africa do not evaluate the welfare implications of alternative monetary policy rules (see e.g Steinbach et al., 2009; Alpanda et al., 2010). Thus, this chapter offers guidance for the formulation of monetary policy in South Africa; a commodity dependent emerging market economy.

The analysis shows that commodity terms of trade shocks have less impact on some macroeconomic variables under CIT than under NTIT and ET rules. However, the stabilisation of the economy by CIT comes at the expense of high real and nominal exchange rate fluctuations. The analysis also shows that the economy achieves less volatility in aggregate and sectoral output, consumption and CPI inflation under CIT rule. On the other hand, NTIT rule delivers less volatility in non-tradable inflation. The comparison of welfare shows that CIT rule results in less welfare loss than other rules when the central bank prefers to stabilise inflation, interest rates and exchange rates. However, when the central bank cares more about output stabilisation, it achieves less welfare loss by targeting non-traded inflation, but the difference with CPI inflation targeting is very small.

The rest of the chapter is structured as follows. Section 3.2 provides some review of related literature. Section 3.3 develops the model while section 3.4 describes the calibration of parameters and solution of the model. Section 3.5 analyses the results. Section 3.6 provides the sensitivity analysis and section 3.7 concludes the chapter and provides policy recommendations.

3.2 Review of the literature

There are many studies that have examined the design of monetary policy in small open economies using DSGE models. Much previous work has focused on the analysis of monetary policy rules in the face of several shocks. Given the diverse conclusions and the specificity of focus of individual studies, it is important to briefly review some relevant studies.

Aoki (2001) develops a two sector model in which different price rigidities exist, to analyse the effects of relative price changes on inflation outcomes. He finds that the optimal monetary policy is the one that targets the sticky price rather than broad inflation measure. Laxton and Pesenti (2003) use a small open economy model and show that inflation-forecast-based rules perform better than conventional Taylor rules in stabilising output and inflation because of their forward looking nature. Also, in a DSGE model, Parrado (2004) shows that domestic inflation targeting yields better outcomes than CPI targeting, while flexible exchange rates performs better than fixed exchange rates in terms of stabilising the economy. However, these studies did not consider some peculiar features of small open economies such as exposure to commodity terms of trade shocks.

Gali and Monacelli (2005) also study the macroeconomic implications of CPI inflation targeting, domestic inflation targeting and exchange rate targeting in a small open economy under productivity shocks. They show that domestic inflation targeting yields better stabilisation outcomes than CPI and exchange rate targeting especially with respect to inflation and output gap. But this good performance of domestic inflation targeting comes at the expense of higher nominal and real exchange rate volatility. In terms of welfare, they show that domestic inflation targeting outperforms CPI inflation targeting and exchange rate targeting. While their study is an important contribution to the understanding of optimal monetary policy rules in EMEs, the model lacks a multi-sector dimension which distinguishes between traded and non-traded goods. Also, it does not evaluate alternative monetary policy responses to commodity terms of trade shocks, which are an important source of economic fluctuations in EMEs. This thesis argues that the sectoral structure can significantly affect monetary policy outcomes and welfare because of different propagation mechanisms which they imply for the model.

Santacreu (2005) develops a multi-sector Bayesian DSGE model for New Zealand, and shows that if the central bank cares more about inflation stabilisation, it should react to CPI inflation, but if it is more concerned about output stabilisation, it should react to non-traded inflation. Nevertheless, the model does not take explicit account of the commodity sector which is important for many EMEs. The present study takes this into account.

Similarly, Devereux et al. (2006) examine alternative monetary policy responses to terms of trade and foreign interest rate shocks in a small open economy model calibrated to the Asian economies. They find that CPI inflation targeting is better than non-traded inflation targeting and exchange rate targeting in stabilising output, but it stabilise the economy at the expense of high exchange rate fluctuations. They also find that financial constraints propagate external shocks but do not alter the ranking of monetary policy rules. In terms of welfare, they show that non-traded inflation targeting performs better that CPI inflation targeting and exchange rate targeting. However, they neither incorporate the commodity sector nor consider commodity terms of trade shocks which may have significant implications for macroeconomic dynamics in EMEs.

In the context of South Africa, DSGE models are very limited and have been developed to analyse different issues. For example Steinbach et al. (2009), Liu et al. (2009), Alpanda et al. (2010) and Alpanda et al. (2011) develop DSGE models to evaluate business cycle characteristics, forecasting and the role of the exchange rate in shaping the South African business cycle. A common shortfall of these models is that they do not incorporate the commodity sector, despite the importance of this sector in shaping South Africa's macroeconomic dynamics. Moreover, none of these studies is in a multi-sectoral setting which arguably helps to address some questions and debates which cannot be tackled by one sector based models.

3.3 The model

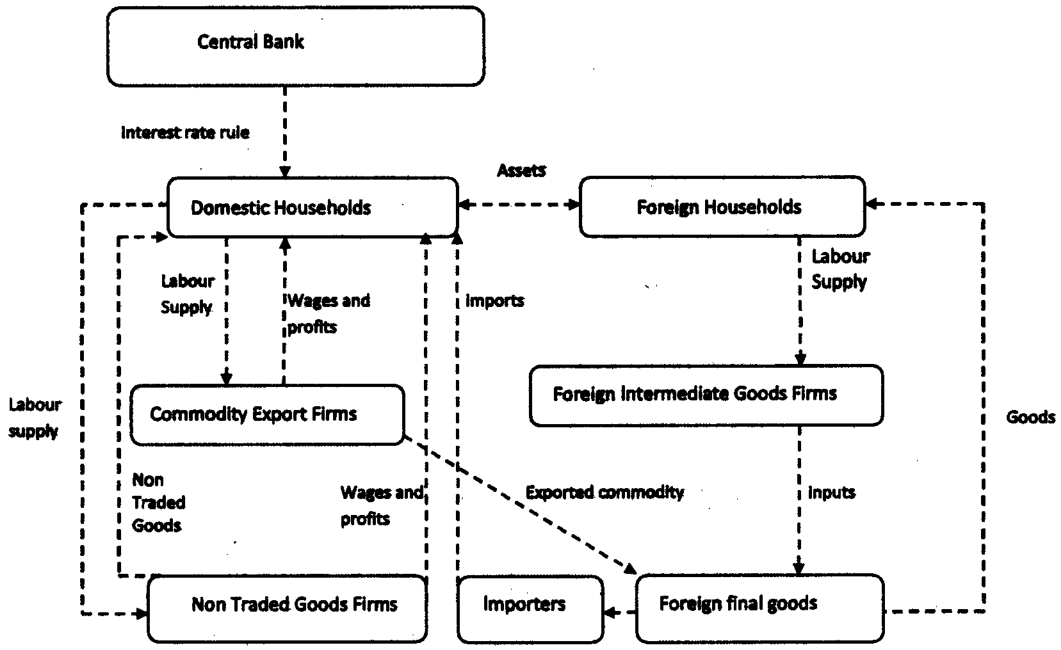
3.3.1 Basic outline of the model

The model describes a small open commodity exporting emerging market economy which has three domestic economic actors: consumers, firms and monetary authorities. There is one external sector which is the rest of the world. There are two production sectors in the domestic economy: traded and non-traded sectors. The traded sector (commodity export sector) produces primary commodities which are completely exported. This sector is meant to characterise the production and export of commodities, especially minerals in South Africa. The non-traded sector produces final goods which are consumed domestically. The commodity export sector is perfectly competitive while the non-traded goods sector faces monopolistic competition. The asymmetric consideration of the two sectors allows deeper analysis of their linkages in the presence of commodity terms of trade shocks. The external traded sector supplies imports to the domestic economy.

The model also features nominal rigidities in the form of Calvo (1983), staggered price setting in the non-traded sector. The nominal friction allows the model to reproduce realistic inflation dynamics and makes the framework suitable for the evaluation of monetary policy (Clarida et al., 1999). Capital stock is assumed to be constant.[3] Consumers own firms and supply labour to the firms in return for profits and wages. Labour is assumed to be perfectly mobile across sectors which implies that nominal wages are similar in traded and non-traded sectors. The economy is assumed to be small relative to the rest of the world. Monetary policy is modelled as a Taylor rule that incorporates interest rate smoothing. The basic structure of the economy is described in Figure 3.1.

[3] McCallum and Nelson (1999) argue that the capital stock may be irrelevant for the dynamics of the small open economy because its variation contributes very little to the business cycle fluctuations, at least in the US. Also, the inclusion of capital may make the analysis complex.

Figure 3.1: Flow chart of the economy



3.3.2 Consumers

There is a representative household who maximises its intertemporal utility subject to an intertemporal budget constraint. The household utility function is:

$$U = E_0 \sum_{t=0}^{\infty} \beta^t \left(\frac{C_t^{1-\sigma}}{1-\sigma} - \eta \frac{L_t^{1+\psi}}{1+\psi} \right) \tag{3.1}$$

where β is the subjective discount factor, η is the marginal disutility of work, σ is the inverse of the elasticity of substitution between consumption and labour and ψ is the inverse of wage elasticity of labour supply. σ, and ψ are strictly positive while $0 < \beta < 1$. L_t is the total labour supply in both traded and non-traded sectors. C_t is a composite consumption index composed of non-tradable goods and tradable goods (imports) which takes the constant elasticity of substitution

(CES) function of the form:

$$C_t = \left[\alpha^{\frac{1}{\rho}} C_{Nt}^{\frac{\rho-1}{\rho}} + (1-\alpha)^{\frac{1}{\rho}} C_{Tt}^{\frac{\rho-1}{\rho}}\right]^{\frac{\rho}{\rho-1}} \tag{3.2}$$

where α and $1-\alpha$ are shares of non-traded and imported goods in total consumption respectively. Implicitly, it is a measure of the degree of openness. C_{Nt} is the consumption of non-traded goods, C_{Tt} is the consumption of imports, $\rho > 0$, is the elasticity of substitution between traded and non-traded goods. The implied consumer price index is ;

$$P_t = \left(\alpha P_{Nt}^{1-\rho} + (1-\alpha) P_{Tt}^{1-\rho}\right)^{\frac{1}{1-\rho}} \tag{3.3}$$

where P_{Nt} and P_{Tt} are prices of non-traded and import goods respectively. When $\rho = 1$, the CPI takes the Cobb-Douglas form:

$$P_t = P_{Nt}^{\alpha} P_{Tt}^{1-\alpha} \tag{3.4}$$

Thus, the consumer price index is a weighted sum of the prices of traded and non-traded goods.

Consumption of non-traded goods and imports is differentiated and the elasticity of substitution across varieties is λ. The consumption indices are represented by the following Dixit and Stiglitz (1977) aggregator:

$$C_{Nt} = \left[\int_0^1 C_{Nt}(i)^{\frac{\lambda-1}{\lambda}} di\right]^{\frac{\lambda}{\lambda-1}} \tag{3.5}$$

$$C_{Tt} = \left[\int_0^1 C_{Tt}(i)^{\frac{\lambda-1}{\lambda}} di\right]^{\frac{\lambda}{\lambda-1}} \tag{3.6}$$

where $\lambda > 1$. The consumer's intertemporal budget constraint is:

$$P_t C_t \leq W_t L_t + \Pi_t + D_t - E_t(Q_{t+1} D_{t+1}) \tag{3.7}$$

where W_t is wages, Π_t is profits and D_t is the portfolio of assets. D_{t+1} is the nominal payoff of period $t+1$ of the portfolio held at the end of time t and Q_{t+1} is the stochastic discount factor. Minimising expenditure on the total composite demand, the optimal allocations give the following demand functions for non-traded goods and imports.

$$C_{Nt} = \alpha \left(\frac{P_{Nt}}{P_t}\right)^{-\rho} C_t \tag{3.8}$$

$$C_{Tt} = (1-\alpha) \left(\frac{P_{Tt}}{P_t}\right)^{-\rho} C_t \tag{3.9}$$

The household optimisation problem gives the following first order conditions:

$$C_t^{\sigma} \eta L_t^{\psi} = \frac{W_t}{P_t} \tag{3.10}$$

$$\beta R_t E_t \left(\left(\frac{C_{t+1}}{C_t}\right)^{-\sigma} \left(\frac{P_t}{P_{t+1}}\right) \right) = 1 \tag{3.11}$$

where R_t is thus the gross interest rate of the bond. Equation (3.10) is the intratemporal optimal condition which shows the equalisation of marginal utility of consumption to the marginal value of labour. Equation (3.11) is the consumption Euler equation which represents the trade-off to the economy of moving consumption across time. Log-linearising equation (3.10) and (3.11), gives:

$$\sigma c_t + \psi l_t = w_t - p_t \tag{3.12}$$

$$c_t = E_t c_{t+1} - \frac{1}{\sigma}(r_t - E_t \pi_{t+1}) \tag{3.13}$$

where small letters denote log deviation from steady state.[4]

3.3.3 Firms

Domestic production

There are two sectors in the domestic economy; the traded sector (commodity export sector) and the non-traded sector. The domestic traded sector produces primary commodities which are all exported. Firms in the traded sector operate

[4]Going foward, small letters will be used to denote log deviation from steady state and the log-linearisation is around the steady state.

under perfect competition and use the following linear technology:

$$Y_{Xt} = A_{Xt}L_{Xt} \tag{3.14}$$

where A_{Xt} is a productivity variable and L_{Xt} is labour in the commodity export sector. A_{Xt} follows an AR(1) process such that in logarithms, it is:

$$lnA_{Xt} = \rho_X lnA_{Xt-1} + \epsilon_{Xt} \tag{3.15}$$

where $\epsilon_{Xt} \sim N(0,1)$. Cost minimisation in the export commodity sector gives the following marginal cost:

$$MC^R_{Xt} = \frac{W_t}{A_{Xt}P_{Xt}} \tag{3.16}$$

where MC^R_X is the real marginal cost in the commodity export sector. Log-linearising equation (3.16) gives:

$$mc^R_{Xt} = w_t - a_{Xt} - p_{Xt}. \tag{3.17}$$

Equation (3.16) shows the choice of employment which achieves cost minimisation in the commodity export sector.

Firms in the non-traded sector face monopolistic competition and produce differentiated non-traded goods using the linear production technology:

$$Y_{Nt} = A_{Nt}L_{Nt} \tag{3.18}$$

where A_{Nt} is a productivity variable and L_{Nt} is labour in the non-traded sector. A_{Nt} follows an AR(1) process such that in logarithms, it is :

$$lnA_{Nt} = \rho_N lnA_{Nt-1} + \epsilon_{Nt} \tag{3.19}$$

where $\epsilon_{Nt} \sim N(0,1)$. Cost minimisation in the non-traded sector leads to the following optimality condition:

$$MC^R_{Nt} = \frac{W_t}{A_{Nt}P_{Nt}} \tag{3.20}$$

where MC_N^R is the real marginal cost in the non-traded sector. Log-linearising the marginal cost in the traded sector gives:

$$mc_{Nt}^R = w_t - a_{Nt} - p_{Nt} \tag{3.21}$$

Because of perfect competition in the traded sector, the price of tradable goods can be expressed as a function of wages and productivity only. Also, the price of non-traded goods can be expressed as a function of wages, productivity and marginal costs.

$$P_{Xt} = \frac{W_t}{A_{Xt}} \tag{3.22}$$

$$P_{Nt} = \frac{W_t}{A_{Nt} MC_{Nt}^R} \tag{3.23}$$

Since wages are equalised between sectors, the relative price of non-traded goods to traded goods can be expressed as follows:

$$P_{Nt} = \frac{A_{Xt}}{A_{Nt} MC_{Nt}^R} P_{Xt} \tag{3.24}$$

This shows that the relative price of non-traded goods to primary commodities is determined by technological factors and marginal cost.

Foreign production

Following Cashin et al. (2004), the foreign economy is assumed to be composed of three production sectors that is non-traded sector, intermediate goods sector, and final goods sector. All foreign production sectors operate under perfect competition. Labour is mobile across sectors such that wages are equalised across sectors. Firms in the foreign non-traded goods sector use linear production technologies as follows:

$$Y_{Nt}^* = A_{Nt}^* L_{Nt}^* \tag{3.25}$$

where A^*_{Nt} is a productivity variable and L^*_{Nt} is labour in the foreign non-traded sector.[5] $A^*_{N_t}$ follows an AR(1) process such that in logarithms, it is:

$$lnA^*_{N_t} = \rho_{N^*_t} lnA^*_{N_{t-1}} + \epsilon^*_{N_t} \tag{3.26}$$

where $\epsilon^*_{N_t} \sim N(0,1)$. Firms in the foreign intermediate goods sector also use the following linear production technology:

$$Y^*_{It} = A^*_I L^*_{It} \tag{3.27}$$

where $A^*_{I_t}$ is a productivity variable and L^*_{It} is labour in the foreign intermediate sector. $A^*_{I_t}$ follows an AR(1) process such that in logarithms, it is:

$$lnA^*_{I_t} = \rho_{A^*_{I_t}} lnA_{I^*_{t-1}} + \epsilon^*_{I_t} \tag{3.28}$$

where $\epsilon^*_{I_t} \sim N(0,1)$. Because all foreign sectors are assumed to be perfectly competitive, the price of foreign non-traded goods can be expressed as a function of relative productivity and the price of foreign intermediate goods as:

$$P^*_{Nt} = \frac{A^*_{It}}{A^*_{Nt}} P^*_{It} \tag{3.29}$$

where P^*_{It} is price of intermediate inputs. The final good is assumed to be a tradable good and its production uses two intermediate inputs. The first input is the intermediate good which is produced in the foreign economy. The second is the commodity which is exported by the domestic economy and other primary commodity producing countries. The traded good is thus produced using the following Cobb-Douglas technology:

$$Y^*_{T_t} = \vartheta (Y^*_{It})^{\nu} (Y^*_{Xt})^{1-\nu}$$

Cost minimisation leads to the following per unit cost:

$$P^*_{Tt} = (P^*_{It})^{\nu} (P^*_{Xt})^{1-\nu} \tag{3.30}$$

[5]Going foward, the foreign variables will be indicated by asterisks.

Foreign consumption is assumed to be similar to that in the domestic economy, such that the implied consumer price index is:

$$P_t^* = P_{Nt}^{*\alpha^*} P_{Tt}^{*1-\alpha^*} \tag{3.31}$$

3.3.4 Real exchange rate, commodity terms of trade and inflation

The real exchange rate is defined as the domestic price of a basket of consumption relative to foreign price of a basket of consumption:

$$Q_t = \frac{\varepsilon_t P_t}{P_t^*}. \tag{3.32}$$

The law of one price is assumed to hold for both exports and imports such that:

$$P_{Xt} = \frac{P_{Xt}^*}{\varepsilon_t} \tag{3.33}$$

$$P_{Tt} = \frac{P_{Tt}^*}{\varepsilon_t} \tag{3.34}$$

The real exchange rate is decomposed so that it has a commodity terms of trade component. From equation (3.32), and after some algebra, the following version of the real exchange rate can be derived:[6]

$$Q_t = \left(\frac{A_{Xt}}{A_{It}^*}\frac{A_{Nt}^*}{A_{Nt}}\frac{P_{Xt}^*}{P_{It}^*}\right)^{\alpha}\left(\frac{1}{MC_{Nt}^R}\right)^{\alpha} \tag{3.35}$$

where $\frac{P_{Xt}^*}{P_{It}^*}$ is the commodity terms of trade index, defined as the price of primary commodity with respect to the intermediate foreign good. $\frac{A_{Xt}}{A_{It}^*}$ shows the productivity differential between the export and import sectors and $\frac{A_{Nt}^*}{A_{Nt}}$ is the productivity differential between domestic and foreign non-traded sectors. The two productivity ratios capture the Balassa-Samuelson effect where an increase in productivity in the tradable sector (commodity sector) tends to increase wages in both the tradable and non-tradable sectors and results in an increase in the price

[6]See Appendix B.2

of non-traded goods relative to tradables and an appreciation of the real exchange rate (Cashin et al., 2004). This is a version of real exchange rate which is almost similar to the real exchange rate decomposition of Cashin et al. (2004). The difference is that this expression contains the marginal cost term which follows from the assumption of monopolistic competition in the non-traded sector.

Commodity terms of trade is defined as:

$$F_t = \frac{P^*_{Xt}}{P^*_{It}} \tag{3.36}$$

which can be log-linearised to give:

$$f_t = p^*_{Xt} - p^*_{It}. \tag{3.37}$$

Lagging and taking the difference of equation (3.37) results in:

$$f_t = f_{t-1} + \pi^*_{Xt} - \pi^*_{It}. \tag{3.38}$$

Substituting equation (3.37) into (3.35), the real exchange rate can be written as:

$$Q_t = \left(\frac{A_{Xt}}{A^*_{It}}\frac{A^*_{Nt}}{A_{Nt}}F_t\right)^{\alpha}\left(\frac{1}{MC^R_{Nt}}\right)^{\alpha} \tag{3.39}$$

in which the log-linearised version is:

$$q_t = \alpha(a_{Xt} - a^*_{It} + a^*_{Nt} - a_{Nt} + f_t - mc_{Nt}). \tag{3.40}$$

Foreign traded inflation can be derived from equation (3.30) by taking the lag and the difference:

$$\pi^*_{Tt} = \nu\pi^*_{I_t} + (1-\nu)\pi^*_{X_t}. \tag{3.41}$$

From equation (3.4), CPI inflation in the domestic economy can be derived as:

$$\pi_t = \alpha\pi_{N_t} + (1-\alpha)\pi_{Tt}. \tag{3.42}$$

From equation (3.34), imported inflation equation can be derived as:

$$\pi_{Tt} = \pi^*_{Tt} - \Delta e_t. \tag{3.43}$$

Substituting π^*_{Tt} from equation (3.41) into equation (3.43) gives the modified imported inflation equation:

$$\pi_{Tt} = \nu\pi^*_{I_t} + (1-\nu)\pi^*_{X_t} - \Delta e_t. \tag{3.44}$$

3.3.5 International risk sharing and uncovered interest parity

Complete international markets are assumed where domestic agents have access to foreign securities. This means that the expected nominal return from riskless bonds in the home currency terms is the same as the expected domestic currency return from foreign bonds.[7] This permits the derivation of the international risk sharing condition where consumption risk is perfectly shared between domestic and foreign agents as follows:

$$\beta E_t \left(\frac{C_{t+1}}{C_t}\right)^{-\sigma} \left(\frac{P_t}{P_{t+1}}\right) = \beta E_t \left(\frac{C^*_{t+1}}{C^*_t}\right)^{-\sigma} \left(\frac{\varepsilon_t P^*_t}{\varepsilon_{t+1} P^*_{t+1}}\right). \tag{3.45}$$

As in Gali and Monacelli (2005), solving and iterating equation (3.45) gives :[8]

$$C_t = \Omega Q_t^{\frac{1}{\sigma}} C^*_t \tag{3.46}$$

where Ω is a constant that represents initial asset positions. Log-linearising results in:

$$c_t = c^*_t + \frac{1}{\sigma} q_t \tag{3.47}$$

[7] The assumption of complete international markets helps to eliminate foreign asset movements from the open economy dynamics. This makes steady state unique, where consumption is independent of past shocks (Parrado 2004)

[8] See the derivation in Appendix B.3

Under complete international markets, the uncovered interest parity condition can be derived as:

$$E_t Q_{t+1}(R_t - R_t^* \frac{\varepsilon_{t+1}}{\varepsilon_t}) = 0 \tag{3.48}$$

Log-linearising around the steady state gives:

$$r_t - r_t^* = E_t \Delta e_{t+1}. \tag{3.49}$$

Equation (3.49) is the uncovered interest parity condition which relates expected variations of nominal exchange rates to interest rate differentials.

3.3.6 Domestic price setting

Non-traded good firms follow Calvo (1983) price setting where they adjust their prices with only some probability. That is in period t, $1 - \theta_N$ firms set prices optimally and θ_N keep prices unchanged, where $\theta_N \in (0, 1)$. θ_N measures the degree of nominal rigidity. The larger this parameter, the less frequently prices are adjusted. The general price index at each period evolves according to:

$$P_{Nt} = \left\{(1 - \theta_N) P_{Nt}^{new^{1-\varepsilon}} + \theta_N P_{Nt-1}{}^{1-\varepsilon}\right\}^{\frac{1}{1-\varepsilon}} \tag{3.50}$$

where P_{Nt}^{new} is the price level of an optimising firm. The firms that reoptimise their prices at time t maximize their current values of dividend streams subject to sequences of demand constraints:

$$\begin{aligned} & Max \sum_{t=0}^{\infty} (\theta_N)^k E_t \left\{Q_{t+k} Y_{t+k} \left(P_{Nt}^{new} - MC_{Nt+k}^n\right)\right\} \\ s.t\ Y_{t+k} \ \leq & \left(\frac{P_{Nt}^{new}}{P_{Nt+k}}\right)^{-\varepsilon} (C_{Nt+k} + C_{Nt+k}^{new}) \end{aligned} \tag{3.51}$$

where MC_{Nt+k}^n is the nominal marginal cost and $\theta_N^k E_t Q_{t+k}$ is the effective stochastic discount factor. The first order condition for the problem is:[9]

$$\sum_{t=0}^{\infty} (\theta_N)^k E_t \left\{ Q_{t+k} Y_{t+k} \left(P_{Nt}^{new} - \frac{\varepsilon}{\varepsilon - 1} MC_{Nt+k}^{n} \right) \right\} = 0 \tag{3.52}$$

Further computations lead to the following New Keynesian Phillips curve equation for the non-traded sector:

$$\pi_{Nt} = \beta E_t \pi_{Nt+1} + \lambda_{Nt} mc_{Nt}^{R} \tag{3.53}$$

where $\lambda_{Nt} = \frac{(1-\beta\theta_N)(1-\theta_N)}{\theta_N}$. The equation shows that inflation is a function of next period's expected inflation and the real marginal cost.

3.3.7 Monetary policy rules

The model is closed by describing how monetary policy is conducted. Recent work has modelled monetary policy as an interest rate feedback rule of a Taylor (1993) type where the central bank adjusts policy interest rates in response to economic conditions (see e.g. Clarida et al., 2000; Benigno, 2004). Taylor rules have become so popular in describing monetary policy for several reasons. First, they are consistent with the principles of optimal monetary policy and capture well the behavior of monetary policy in many countries (see e.g. Clarida et al., 2000; Woodford, 2003; Lubik and Schorfheide, 2007). These rules are robust and consistent with the main principles of optimal monetary policy (Clarida et al., 1999; Woodford, 2003). Second, Taylor rules have been found to provide determinacy, implying that they ensure a unique stationary rational expectations equilibrium of the model (Clarida et al., 1999). Third, they are flexible in nesting a wide range of alternative monetary policy strategies. As in Ortiz and Sturzenegger (2007) and Lubik and Schorfheide (2007), the following generalised Taylor rule is considered:

$$R_t = R_{t-1}^{\rho_r} \left\{ \left(\frac{Y_t}{\overline{Y}} \right)^{\omega_1} \left(\frac{\pi_t}{\overline{\pi}} \right)^{\omega_2} \left(\frac{\pi_{Nt}}{\overline{\pi_N}} \right)^{\omega_3} \left(\frac{\varepsilon_t/\varepsilon_{t-1}}{\overline{\varepsilon}} \right)^{\omega_4} \right\}^{1-\rho_r} . \tag{3.54}$$

[9] see Appedix B.4 for the derivation

The log-linearised version of the monetary policy rule is:

$$r_t = \rho_r r_{t-1} + (1-\rho_r)(\omega_1 y_t + \omega_2 \pi_t + \omega_3 \pi_{Nt} + \omega_4 \Delta e_t) + \epsilon_{r,t} \tag{3.55}$$

where ω_1, ω_2, ω_3 and ω_4 allow monetary authorities to control output, CPI inflation, non traded inflation and nominal exchange rate respectively. To allow for the comparison of different monetary policy regimes, the parameters are changed so that one monetary policy regime can be specified at a time.[10] ρ_r is the smoothing parameter. The smoothing parameter is included in this specification to capture inertia in interest rates, as observed by several empirical studies (see e.g. Clarida et al., 2000; Sack and Wieland, 2000). Clarida et al. (2000) argue that policy reaction functions without interest rate smoothing are too restrictive to describe the actual interest rate changes in most central banks. Also, Sack and Wieland (2000) note that the presence of uncertainty about the relevant model parameters, the structure of the economy and concerns about the soundness of the financial system may motivate central banks to have interest rate smoothing.

3.3.8 Equilibrium

In equilibrium, the markets for non-traded goods, traded goods and labour must clear. The goods market clearing condition in the domestic economy requires that total domestic production which is made up of non-traded output and exported output is equal to total demand. That is:

$$Y_t = Y_{Nt} + Y_{Xt} \tag{3.56}$$

where $Y_{Nt} = C_{Nt}$ and $Y_{Xt} = C_{Xt}$. Log-linearising (3.56) :

$$y_t = y_{Nt}\left(\frac{\overline{Y}_{Nt}}{\overline{Y}}\right) + y_{Xt}\left(\frac{\overline{Y}_{Xt}}{\overline{Y}}\right) \tag{3.57}$$

[10] For CPI targeting rule, it is considered that $\omega_3 = \omega_4 = 0$, for non-traded inflation targeting rule $\omega_2 = \omega_4 = 0$ and for exchange rate targeting rule, $\omega_2 = \omega_3 = 0$.

Using $Y_{Nt} = C_{Nt}$ and combining with equation (3.8) results in:

$$y_{Nt} = -\rho(1-\alpha)\left[p_{Nt} - e_t - p^*_{Mt}\right] + c_t. \tag{3.58}$$

Equation (3.58) is the equilibrium condition for the non-traded sector. The equilibrium condition for the commodity export sector is given by:

$$Y_{Xt} = Y^*_{Xt} = C^*_{X_t}. \tag{3.59}$$

Using the equation for the consumption of exports, it can be shown that:

$$Y_X = \left(\frac{1-\nu}{\nu}\right)^{\nu} Y^*_{Tt}\left(\frac{P^*_{Xt}}{P^*_{It}}\right)^{\nu} \tag{3.60}$$

and the log-linearised version of (3.60) is:

$$y_{x_t} = y^*_{Tt} + \nu(p^*_{Xt} - p^*_{It}) \tag{3.61}$$

Thus, the equilibrium condition depicting the IS equation for the domestic economy is given by[11]:

$$y_t = \left(\frac{\overline{Y}_{Nt}}{\overline{Y}}\right)\left(-\rho(1-\alpha)\left[p_{Nt} - e_t - p^*_{Mt}\right] + c_t\right) + \left(\frac{\overline{Y}_{Xt}}{\overline{Y}}\right)\left(y^*_{Tt} + \nu(p^*_{Xt} - p^*_{It})\right) \tag{3.62}$$

where $\frac{\overline{Y}_{Nt}}{\overline{Y}}$ and $\frac{\overline{Y}_{Xt}}{\overline{Y}}$ are steady state ratios of labour in the non-traded goods and exports to total income.

The supply side of the model is given by the marginal cost equations in both the commodity export sector and the non-traded sectors. For the commodity export sector, marginal cost is given by:

$$mc^R_X = w_t - p_X - a_X \tag{3.63}$$

Combining equation (3.63) with (3.12), (3.4) and (3.34) gives the new expression

[11] IS equation depicts the locus of all combinations of income and interest rate for which the goods market is in equilibrium.

for the marginal cost in the commodity export sector:

$$mc_X^R = \sigma c_t + \psi l_t + (1-\alpha)(p_{Tt}^* - e_t) + \alpha p_{Nt} - p_{Xt}^* + e_t - a_X \tag{3.64}$$

In the non-traded sector, the marginal cost is given by:

$$mc_{Nt}^R = w_t - p_{Nt} - a_{Nt} \tag{3.65}$$

Combining equation (3.65) with (3.12), (3.4) and (3.34) gives the final marginal cost function:

$$mc_X^R = \sigma c_t + \psi l_t + \alpha p_{Nt} + (1-\alpha)(p_{Tt}^* - e_t) - p_{Nt} - a_{Nt} \tag{3.66}$$

The labour market must clear. The labour market clearing condition is:

$$L_t = L_{Xt} + L_{Nt} \tag{3.67}$$

Log-linearising equation (3.67) and substituting (3.18) and (3.14) into (3.67) gives:

$$l_t = \frac{L_X}{L}(y_{Xt} - a_{Xt}) + \frac{L_N}{L}(y_{Nt} - a_{Nt}) \tag{3.68}$$

where $\frac{L_X}{L}$ and $\frac{L_N}{L}$ are steady state labour in the traded and non-traded sectors respectively. Finally, some equations characterising the foreign economy are:

$$y_t^* = \alpha^* y_{Nt}^* + (1-\alpha^*) y_{Tt}^* \tag{3.69}$$

$$y_{Nt}^* = -\rho^* p_{Nt}^* + \rho^*(\alpha^* p_{Nt}^* + (1-\alpha^*) p_{Tt}^*) + y_t^* \tag{3.70}$$

$$y_{Tt}^* = \nu y_{It}^* + (1-v) y_{Xt} \tag{3.71}$$

$$r_t^* = \rho_{r^*} r_{t-1}^* + \epsilon_{r^*,t} \tag{3.72}$$

The general equilibrium is characterised by a sequence of y_t, y_{nt}, y_{Xt}, c_t, r_t, π_t, π_{Nt}, π_{Tt}, a_{Nt}, a_{Xt}, p_{Nt}, e_t, q_t, mc_{Nt}, mc_{Xt}, f_t, l_t, y_t^*, y_{Nt}^*, y_{Xt}^*, y_{It}^*, y_{Tt}^*, r_t^*, π_{Tt}^*, π_{It}^*, π_{Xt}^*, p_{Xt}^*, p_{Nt}^*, p_{Tt}^*, p_{It}^*, a_{It}^*, a_{Nt}^* that gives the solution to equations describing the domestic and foreign economies.

3.4 Calibration and solution

In order to solve the model, the values of parameters need to be determined. The model is calibrated to match the key features of the South African quarterly data for the period 1990-2008. Other parameters are obtained from previous studies on the South African economy and business cycle literature. The benchmark parameters are described in Table 3.4.1.

The elasticity of substitution between traded goods and non-traded goods is set at 1 following Devereux et al. (2006) and Santacreu (2005). The discount factor is set at 0.99 implying that the real interest rate is about 4% per annum in steady state.[12] Following Alpanda et al. (2010), the inverse of the elasticity of labour supply is assumed to be 6 which reflects that in steady state, the gross wage mark-up is about 1.2 over the marginal rate of substitution. As suggested by Steinbach et al. (2009), the elasticity of substitution between consumption and labour for South Africa is set at 1.

The import share in consumption is set at 0.2, consistent with estimates by Steinbach et al. (2009) for South Africa for the period 2002-2007. They find that the import penetration ratio to total GDP is about 30% and the import penetration in consumption is about 7.5% during this period. This implies that the share of non-traded goods in consumption is about 0.8. However, these parameters are changed through experiments in sensitivity analysis. The productivity parameter in the non-traded goods sector is set at 0.74 based on estimates by Alpanda et al. (2010). Following Ricci et al. (2008), the productivity parameter in the commodity export sector is set at 0.85 while the foreign productivity parameter in the non-traded goods and the intermediate goods sectors are both set at 0.8.

As in Alpanda et al. (2010) and Steinbach et al. (2009), the degree of nominal price rigidity is set at 0.75, which suggest that prices are adjusted on average after 4 quarters in South Africa. This allows the model to generate realistic impulse responses. The weight on CPI inflation and non-traded inflation in the Taylor rule, ω_2 and ω_3 are both set initially at 1.5 while the weight on output, ω_1 is set at 0.5 following Steinbach et al. (2009). As in Ortiz and Sturzenegger (2007),

[12] The real interest rate is generally consistent with the average real interest rate during the period under consideration.

Table 3.4.1: Calibration of parameters

Parameter	Description	value
ρ	Elasticity of substitution between traded and non-traded goods	1
α	Share of non-traded goods in consumption	0.8
β	Subjective discount factor	0.99
σ	Inverse of the elasticity of substitution between consumption and labour	1
ψ	Inverse of the elasticity of labour supply	6
θ_N	Stickiness parameter in the non traded sector	0.75
$\rho_{\pi_t^*}$	Persistence parameter for foreign inflation	0.5
ρ_{r^*}	Persistence parameter for foreign interest rate	0.8
ρ_r	Smoothing parameter for Taylor rule	0.73
ρ_N	Persistence parameter of labour productivity in the non traded sector	0.74
ρ_X	Persistence parameter of labour productivity in the commodity export sector	0.85
$\rho_{I_t^*}$	Persistence parameter of labour productivity in the foreign intermediate sector	0.8
$\rho_{N_t^*}$	Persistence parameter of labour productivity in the foreign non-traded sector	0.8
ν	share of exported commodity (by domestic economy) in foreign production	0.26
$\rho_{P_{X^*}}$	Persistence parameter of world price of export commodity	0.8
$\rho_{P_{I^*}}$	Persistence parameter of foreign price of intermediate good	0.8
λ	Elasticity of substitution across varieties	10
ω_1	Weight on output in the Taylor rule	0.5
ω_2	Weight on CPI inflation in the Taylor rule	1.5
ω_3	Weight on domestic inflation in the Taylor rule	1.5
ω_4	Weight on exchange rate in the Taylor rule	0.05

the weight on the exchange rate ω_4, and smoothing parameter ρ_r are calibrated at 0.05 and 0.73 respectively. The value of the smoothing parameter is expected to capture recent efforts by the South African Reserve Bank (SARB) to reduce interest rate volatility and make monetary policy more predictable. Most steady state parameters are obtained from equilibrium relations in the model

The linearised model is solved using DYNARE programme which uses the Blanchard and Kahn (1980) algorithm (see Juillard, 2001).[13] The analysis focuses mainly on commodity terms of trade shocks but later considers productivity shocks in the commodity export sector for comparison purposes.

3.5 Results analysis

This section analyses the impulse responses of selected macroeconomic variables to commodity terms of trade shocks and productivity shocks in the export sector under the following alternative monetary policy rules: CPI inflation targeting (CIT) rule, non-traded inflation targeting (NTIT) rule and exchange rate targeting (ET) rule. These monetary policy rules are assessed based on the degree to which they minimise volatility of selected macroeconomic variables as reflected by their impulse response functions. It also proceeds to provide analysis of volatility and welfare under different monetary policy rules.

3.5.1 Impulse response analysis

Commodity terms of trade shocks

Figure 3.2 presents impulse responses to a one standard deviation positive shock to commodity terms of trade. The figure shows that the commodity terms of trade shock results in higher output in the export sector. Output in the non-traded sector falls initially and the effects diminishes slowly over time. The fall in the output of the non-traded sector could be attributed to the movement of resources

[13] The DYNARE programme can derive the reduced-form representation of the model and then provides standard moments based on assumptions about the stochastic processes. Blanchard and Kahn (1980) show that if the number of eigen values outside the unit circle is equal to the number of non-predetermined variables, then there exists a unique rational expectations solution to the system.

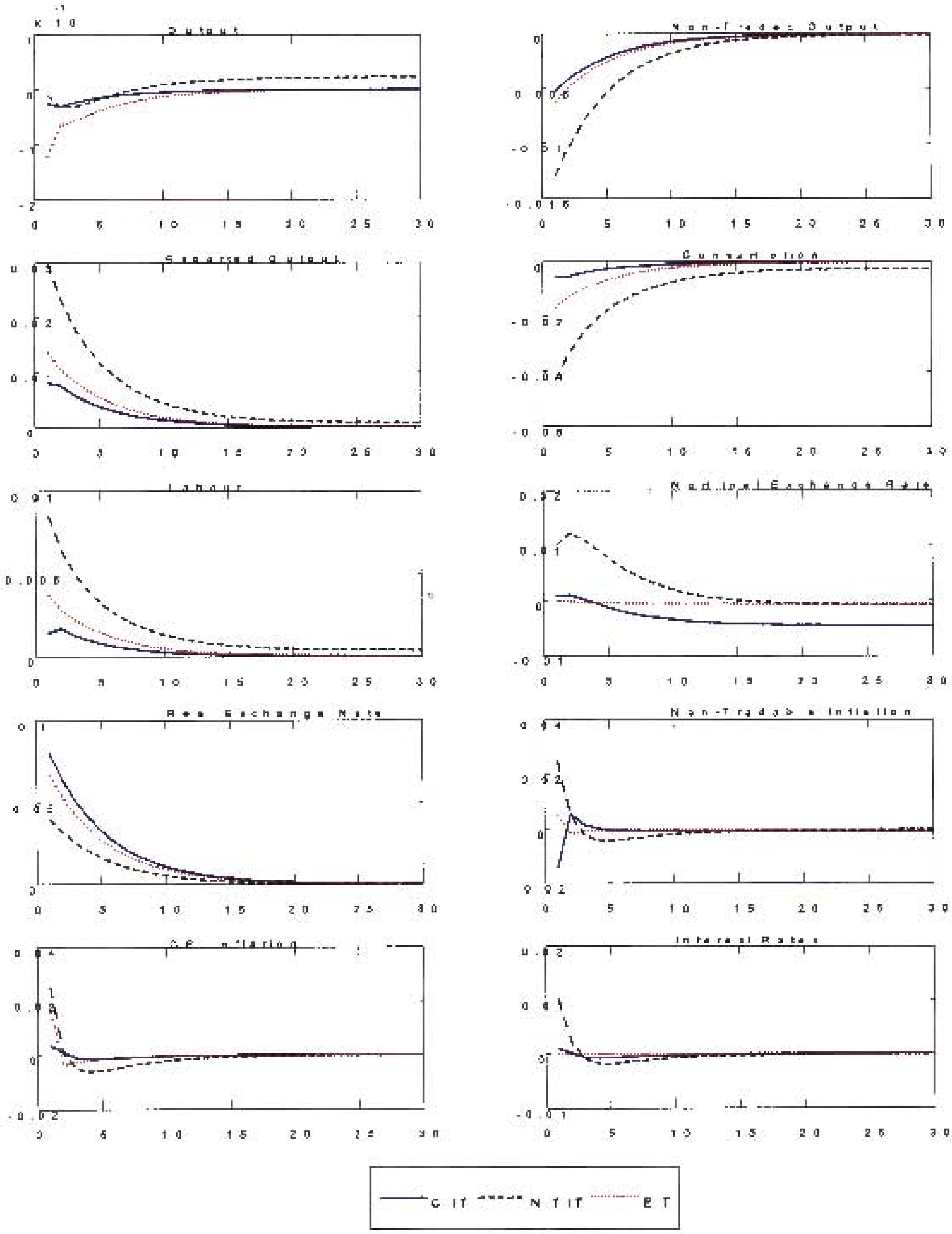
tion of the country-specific commodity terms of trade shocks and their implications for monetary policy. This characterisation especially in a dynamic equilibrium setting is not common to many small open economy models. The study demonstrates that the incorporation of the commodity sector in the model changes the conventional wisdom on optimal monetary policy in EMEs. The view that non-traded inflation targeting (a version of domestic inflation targeting) is the optimal monetary policy in small open economies does not hold. The chapter argues that CPI inflation targeting is the appropriate monetary policy for commodity dependent emerging market economies because it stabilises both output and inflation. Its stabilising power is attributed to its forward looking nature, credibility and a flexible exchange rate which help to insulate the economy from external shocks.

Secondly, using the central bank loss functions, the chapter evaluates the welfare implications of alternative monetary policy regimes to determine the optimal monetary policy in countries which are prone to commodity shocks. This is important because different monetary policy rules contain important trade-offs which affect welfare. Most work done on commodity dependent emerging economies such as South Africa do not evaluate the welfare implications of alternative monetary policy rules (see e.g Steinbach et al., 2009; Alpanda et al., 2010). Thus, this chapter offers guidance for the formulation of monetary policy in South Africa; a commodity dependent emerging market economy.

The analysis shows that commodity terms of trade shocks have less impact on some macroeconomic variables under CIT than under NTIT and ET rules. However, the stabilisation of the economy by CIT comes at the expense of high real and nominal exchange rate fluctuations. The analysis also shows that the economy achieves less volatility in aggregate and sectoral output, consumption and CPI inflation under CIT rule. On the other hand, NTIT rule delivers less volatility in non-tradable inflation. The comparison of welfare shows that CIT rule results in less welfare loss than other rules when the central bank prefers to stabilise inflation, interest rates and exchange rates. However, when the central bank cares more about output stabilisation, it achieves less welfare loss by targeting non-traded inflation, but the difference with CPI inflation targeting is very small.

The rest of the chapter is structured as follows. Section 3.2 provides some review of related literature. Section 3.3 develops the model while section 3.4 describes

Figure 3.2: Impulse responses to commodity terms of trade shock



to the booming commodity export sector. Aggregate output also falls initially and the effects die out over time. While the response of traded output raises aggregate output, the response of non-traded output acts to decrease initial output. Thus the pattern of aggregate output reflects the bigger impact coming from the non-traded sector. Over time, the commodity terms of trade shock generates a wealth effect which increases demand for non-traded goods. The increase in demand for non-traded goods results in overheating of the economy which puts pressure for non-traded goods prices to increase. The increase in prices of non-traded goods results in increase in CPI inflation and non-traded inflation. Central banks respond to the rise in inflation by raising interest rates. Due to monetary contraction, aggregate consumption decreases on impact but grow back to steady state over time, possibly reflecting intertemporal consumption smoothing. As expected, the increase in commodity terms of trade induces appreciation of the nominal exchange rate that translates into an appreciation in the real exchange rate. The appreciation of the exchange rate reflect the fact that the substitution effect of domestic demand towards foreign goods which could potentially offset the appreciation is very small.

The response patterns of most variables depend on the monetary policy regime in place. The shock leads to a fall in aggregate output, and the largest fall occurs under ET rule and smallest under CIT rule. For sectoral output, non-traded output falls on impact while export output increases in response to booming commodity prices. The response of non-traded output is greater under NTIT rule and smallest under CIT. This is contrary to conventional wisdom that a rule that places large weight on a price index that is sensitive to exchange rate movements (CIT rule) is likely to induce large fluctuations in sectoral output.

The commodity terms of trade shock results in an increase in traded output under NTIT rule with positive and mild responses under CIT. The effect on non-traded output is also persistent under NTIT rule possibly due to nominal rigidities in the non-traded sector. In all rules, labour supply increases. The dynamic response pattern of the labour supply function traces the pattern of the exported output, possibly reflecting the existence of the resource movement effect. Since labour is mobile between sectors, the boom in the commodity export sector raises the value of the marginal product of labour, resulting in the increase in labour in that sector. However, the response of labour supply is strong under NTIT rule, moderate under ET rule and weak under CIT rule. This can be explained by the resource movement effect where the booming commodity export sector attracts labour from the non-traded sector.

The commodity terms of trade shock also causes a large appreciation of the nominal exchange rate under NTIT and ET. As pointed out by Obstfeld and Rogoff (1996), this is intuitive because under flexible exchange rate, the presence of sticky prices makes the adjustment to terms of trade shocks to take place through changes in the nominal exchange rates. As expected, the commodity terms of trade shock triggers an initial appreciation of real exchange rates in all regimes. Possibly this reflects the "commodity currency" effect which was highlighted by Cashin et al. (2004). In their study of commodity currencies and real exchange rates, they find strong evidence of a long-run relationship between real exchange rate and commodity terms of trade for commodity exporting countries. The larger impact of the commodity terms of trade shock on the real exchange rate is much larger and persistent under CIT than under NTIT and ET. The larger impact on real exchange rate under CIT could be attributed to the presence of the floating exchange rates under CIT regime which implies active use of the exchange rate channel to stabilise variables such as CPI inflation and output (Svensson, 2000). As emphasised by Bouakez (2005), the greater real exchange rate persistence may be rationalised by the presence of the marginal cost (which is the inverse of the mark up) in the real exchange rate equation, which amplifies the volatility and persistence of the real exchange rate. Under ET, the real exchange rate is less volatile due to fixed nominal exchange rate. According to Mussa (1986), this reflects excess smoothness of the exchange rate. The stability of the exchange rate under ET can also be a result of the central bank absorbing part of the proceeds of export revenue by building reserves. Devereux et al. (2006) and Parrado (2004) find similar results where CIT exhibit greater contemporaneous real exchange rate and nominal exchange rate responses than in exchange rate pegs.

Non-traded inflation increases contemporaneously and falls thereafter especially under NTIT and ET rules following a commodity terms of trade shock. The response of non-traded inflation is greater under NTIT but moderate under CIT. The contemporaneous response of CPI inflation is greater under NTIT and ET but more muted under CIT. Since in the baseline calibration 80% of CPI inflation comes from non-traded inflation, the shape and profile of the former follows that of the latter. The low CPI inflation response under CIT rule can partly be explained by the presence of flexible exchange rates which dampen the direct effects of commodity terms of trade shocks on inflation. Another possible explanation is that the CIT rule is credible to the extent that inflation expectations are well anchored.

In all cases, central banks respond to the rise in inflation by increasing interest rates. Under the NTIT rule, the central bank responds to the shock more aggressively while under CIT, the response is moderate. The ET rule displays very small and less persistent interest rate responses. But under the NTIT rule, stabilising non-traded inflation requires a much sharper rise in interest rates than in other regimes. This result underlines the conventional wisdom that the interest rate channel dominates under the NTIT rule (Svensson, 2000). Under CIT, the moderate response can be explained by the presence of interest rate smoothing aimed at making monetary policy more predictable and credible. The weak interest rate responses under ET can possibly imply that ET central banks do not use interest rates, but instead use reserves as instruments of monetary policy (Benes et al., 2008).

Overall, the dynamic adjustment of most variables shows that CIT rule is superior to the NTIT and ET rules because it generally stabilises most variables. It is followed by ET and lastly NTIT. However, the stabilisation of these variables under CIT comes at the cost of increased real exchange rate fluctuations. The responses of most variables are generally consistent with the structural characteristics of the South African economy, for example its volatile exchange rates.

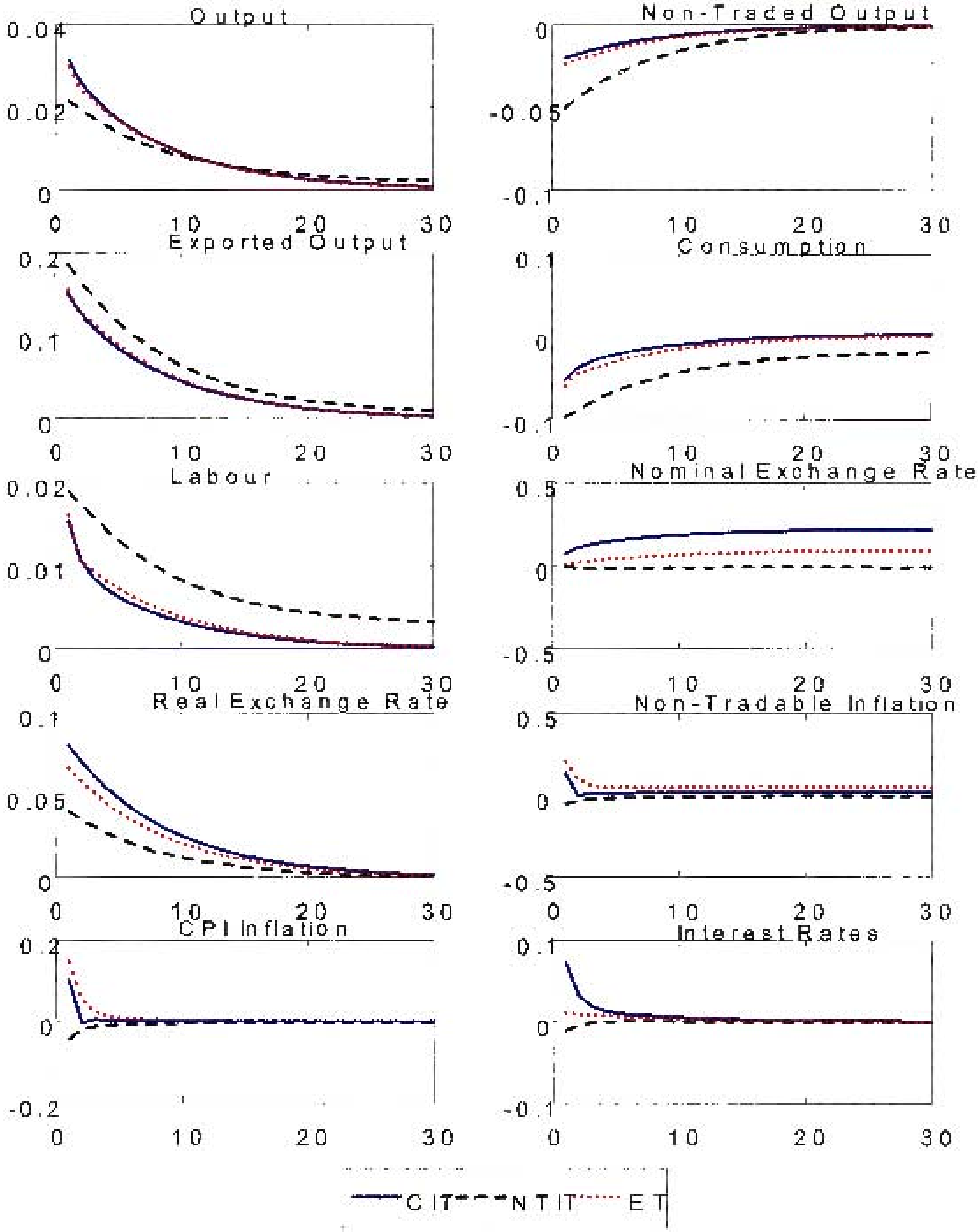
Export productivity shock

Although the aim of the chapter is to evaluate the responses to commodity terms of trade shocks, the introduction of the commodity sector in the model makes the analysis of responses to productivity shocks in the commodity export sector interesting. Since the total commodity is exported, the productivity shock in the commodity export sector is closely related to the commodity terms of trade shock. The evaluation of the monetary policy implications of a productivity shock in the commodity export sector also helps to examine the presence of the Balassa-Samuelson effect. Figure 3.3 presents impulse responses of variables to an export sector productivity shock.

The export sector productivity shock increases aggregate output and exported output while non-traded output decreases. In the presence of the two opposing effects on aggregate output, the expansionary effects of the former seem to be greater than the contractionary effects of the latter. The expanding export sector also generates nominal and real exchange rate appreciations. However, the real exchange rate may also appreciate due to an increase in interest rates. Because of labour mobility across sectors, wages are equalised, thus the increase in productivity in the traded sector raises wages also in the non-traded sector. This results in higher costs which push up prices of non-traded goods and increase inflation especially under ET and CIT rules. Central banks respond by raising interest rates. The dynamic responses of these variables suggest the presence of the Balassa-Samuelson effect where an increase in productivity in the traded sector appreciates the real exchange rate and increases prices of non-tradable goods through wage equalisations (Obstfeld and Rogoff, 1996).

The adjustment patterns of aggregate output are similar under ET and CIT rules. Non-traded output decreases in all regimes, but NTIT rule exhibits the largest fall. This suggests that non-traded output is very sensitive to productivity shocks in the export sector. The productivity shock also raises output in the export sector, with the strongest response being experienced under NTIT rule. Consumption decreases on impact following a productivity shock with the greatest decline being observed under NTIT rule and smallest responses under CIT and ET. The greater fall in consumption may be explained by the substitution effects between traded and non-traded goods which are stronger than the income effects. The largest fall in consumption under NTIT is not a surprise given that there is a large proportion of non-traded goods in the consumption basket. The commodity export sector productivity shock raises the marginal productivity of labour and wages in the traded sector, resulting in increase in labour supply to this sector. The response of labour is stronger and more persistent under NTIT than under CIT and ET, implying that a NTIT regime does not stabilise aggregate labour supply.

Figure 3.3: Impulse responses to an export sector productivity shock



The shock also induces more volatility of nominal and real exchange rates under CIT than in other regimes. They are lowest under NTIT and more muted under ET since the adjustment to the shock takes place through relative prices. This is in line with other studies, for example that of Obstfeld and Rogoff (2000) which shows that under productivity shocks, the optimal monetary policy involves some exchange rate fluctuations.

Under ET and CIT, the productivity shock immediately raises the non-traded goods prices which generate higher non-traded inflation and CPI inflation. The responses of both non-traded inflation and CPI inflation under NTIT are more muted, both on impact and along the transition. This implies that NTIT rule succeeds in stabilising both non-traded inflation and overall inflation. The volatility of non-traded and CPI inflation is quite high under ET rule, suggesting that the fixed exchange rate is a weak shock absorber. As in the case of commodity terms of trade shocks, the stabilisation of inflation by CIT following productivity shocks results in substantial movements in real and nominal exchange rates.

3.5.2 Volatility analysis

In order to compliment impulse response analysis, Table 3.5.1 presents standard deviations (volatilities) of selected macroeconomic variables under alternative monetary policy regimes. The results show that total output and non-traded output exhibit lowest volatility under CIT and highest under ET regimes. The intuition for higher volatility under ET is that in the presence of sticky prices at least in some sectors, the adjustment entails higher volatility in the real sector. Exported output and consumption are less volatile under CIT. This is consistent with Santacreu (2005) and Devereux et al. (2006) who also conclude that responding to CPI inflation generates less volatility in output and consumption. By design, ET delivers substantially lower volatility of both nominal exchange rate and real exchange rate, while CIT involve higher volatility of these variables. This result is a confirmation of earlier impulse responses where the exchange rates display larger responses under CIT. The possible reason is that the process of stabilising output and consumption by CIT rule involves substantial movements in the exchange rates. The volatility of labour supply is lowest under CIT but highest under NTIT.

However, responding to non-traded inflation generates lower volatility under NTIT rule since this regime focuses on non-traded inflation stabilisation. As expected, CIT delivers more stability in CPI inflation, but substantially higher instability in interest rates than occurs under NTIT and ET. Intuitively, CIT rule actively uses the interest rate to stabilise the economy.

Table 3.5.1: Volatality analysis

	CIT	NTIT	ET
Output	0.06	0.07	0.07
Non-traded output	0.02	0.02	0.03
Exported output	0.25	0.39	0.28
Labour	0.10	0.19	0.11
Consumption	0.09	0.41	0.33
Nominal exchange rate	0.33	0.24	0.01
Real exchange rate	0.22	0.11	0.10
Non-traded inflation	0.19	0.09	0.25
CPI inflation	0.52	1.10	2.36
Interest rates	1.44	0.04	0.03

CIT is CPI inflation targeting, NTIT is non-traded inflation targeting and ET is exchange rate targeting. The numerical values are standard deviations .

3.5.3 Welfare implications of alternative monetary policy regimes

Much of the literature on monetary policy and welfare assumes that the central bank minimises a loss function which translates the behavior of policy targets into some aggregate welfare measure (see e.g Clarida et al., 1999; Laxton and Pesenti, 2003).[14] Following this literature, this section assumes that the objective of the central bank is to minimise welfare losses from deviations of output, inflation, interest rates and exchange rates from their steady state values.[15]

[14]The alternative is to estimate welfare using utility function of the representative consumer.

[15]Woodford (2003) shows that under certain conditions, it is possible to motivate a quadratic loss function as a second order Taylor series approximation of the expected utility of the economy's representative household which is equal to the expected discounted sum of period losses for certain coefficients. He also shows that a linear approximation to the policy function is sufficient

Loss functions are appealing as ways of characterising welfare for several reasons. Firstly, they allow the incorporation of some aspects of interest-rate smoothing, consistent with the principle of optimal monetary policy since interest rate smoothing captures policy inertia often observed in the data (Clarida et al., 1999). Secondly as noted by Adolfson et al. (2011), loss functions can be formulated in terms of observable macroeconomic variables which help to provide simple and reasonable welfare analysis especially in economies which are characterised by massive economic fluctuations. Thirdly, Clarida et al. (1999) argue that loss functions capture the major cost of inflation that is uncertainty generated from inflation variability. The welfare loss function considered is :

$$L_t = \lambda_\pi \pi_t^2 + \lambda_{y_t}\, y_t^2 + \lambda_r {r_t}^2 + \lambda_e e_t^2 \tag{3.73}$$

Taking unconditional expectations, the loss function can be expressed as:

$$E(L_t) = \lambda_\pi Var(\pi_t) + \lambda_y\; Var(y_t) \;+ \lambda_r Var(r_t) + \lambda_e Var(e_t) \tag{3.74}$$

where π_t is a measure of inflation depending on the choice of inflation under consideration (CPI or non-traded inflation), y_t is output, e_t is nominal exchange rates, r_t is the interest rate. $Var(\pi_t)$, $Var(y_t)$, $Var(r_t)$ and $Var(e_t)$ are the unconditional variances of inflation, output, nominal exchange rates and interest rates. The loss function includes the stabilisation of the exchange rate since the model is that of an open economy. Kirsanova et al. (2006) show that there is a case for including exchange rate in the welfare function in small open economies. Interest rate variability term is included to capture the central bank's desire to avoid both extreme interest rate volatility and hitting the zero lower bound (Woodford, 2003). The coefficients in the policy rule are optimally chosen to minimise the loss function.[16] To avoid the arbitrary choice of weights in the loss function, the chapter follows

to accurately approximate welfare up to a second order if the second order approximation to the welfare function contains quadratic terms, where the welfare loss is proportional to the expected discounted sum of squared deviations of variables.

[16]The optimal parameters are computed using Dynare's optimal simple rule algorithm. In this computation, Dynare searches numerically the parameters of the policy function that minimise the weighted variance of variables and provides the value of the objective function (welfare loss).

Laxton and Pesenti (2003) and Alpanda et al. (2010) and sets alternative values of relative loss function weights from 0.5 to 2 in increments of 0.5. The relative weights on each variable in the loss function reflects central bank's preference in terms of stabilising those variables.

Table 3.5.2 reports the results of the welfare losses of different monetary policy rules. The results show that when the central bank places a weight of 1 on inflation variability and equal relative weight of 0.5 on output, interest rates and exchange rates in the loss function, CIT achieves the lowest welfare losses followed by NTIT and lastly ET. This implies that CIT rule is welfare enhancing possibly due to its broad based features. In fact, stabilising CPI inflation can help to remove market distortions caused by price stickiness, resulting in enhanced welfare, while NTIT rule generates significant welfare losses through higher relative price dispersions. Using utility based welfare measures, Devereux et al. (2006) rank NTIT first, followed by CPI targeting and lastly ET in a model with financial constraints and complete exchange rate pass-throughs. Similarly, Aoki (2001) finds that the optimal monetary policy is the one which targets sticky price inflation that is, non-traded inflation targeting. The intuition is that monetary policy try to prevent disequilibrium in the market for goods with stickiest price. Gali and Monacelli (2005) also find that domestic inflation targeting is the optimal monetary policy followed by CPI inflation targeting and lastly, exchange rate targeting.

When the relative weight on output is increased, while the weights on other variables are kept constant, NTIT rule delivers less welfare while large welfare loss are observed under ET with CIT being the intermediate case. However, the difference between welfare losses under NTIT and CIT is relatively small. The intuition for the less welfare loss under NTIT is that targeting non-traded inflation avoids excessive volatility in interest rates which subsequently reduces volatility in output. The result is consistent with Santacreu (2005) who concludes that the central bank which is concerned about output stabilisation should target non-traded inflation. When the central bank responds to overall CPI inflation, it attempts to offset the direct effects of exchange rate movements which are largely temporary. Thus, by responding to non-traded inflation, the central bank ignores the direct exchange rate impact on CPI, but focuses on the direct effect through the output gap. The finding that NTIT performs better when more weight is

Table 3.5.2: Welfare losses of alternative monetary policy regimes

Weights on loss function				Welfare losses		
λ_π	λ_y	λ_r	λ_e	CIT	NTIT	ET
1	0.5	0.5	0.5	0.04	0.05	0.28
1	1	0.5	0.5	0.01	0.09	0.18
1	1.5	0.5	0.5	0.03	0.02	0.11
1	2	0.5	0.5	0.04	0.03	0.33
1	0.5	1	0.5	0.27	1.54	1.57
1	0.5	1.5	0.5	0.52	1.84	1.72
1	0.5	2	0.5	0.62	2.12	2.93
1	0.5	0.5	1	0.05	0.06	0.05
1	0.5	0.5	1.5	0.33	0.63	0.52
1	0.5	0.5	2	0.34	0.98	0.58

CIT is consumer price index inflation targeting,
NTIT is non tradable inflation targeting and
ET is exchange rate targeting.

put on output suggests the presence of a trade-off between inflation and output stabilisation. Alpanda et al. (2010) also observe this trade-off in South Africa.

When more weight is put on interest rates, CIT rule is superior, followed by NTIT rule and lastly ET rule. The intuition is that higher interest rate stabilisation enhances credibility and reputation which helps to reduce welfare losses. The ET rule continues to perform poorly in terms of welfare because in the face of real shocks, it does not allow smooth adjustment of macroeconomic variables. As the central bank becomes more concerned about exchange rate stabilisation, CIT dominates other regimes because the reduction of exchange rate volatility quickly translates into output and inflation stabilisation which enhances welfare.

3.6 Sensitivity analysis

This section investigates the sensitivity of the reported results to changes in openness, price stickiness and the elasticity of substitution between traded goods and non-traded goods.

3.6.1 Sensitivity tests on impulse response functions

Firstly, the degree of openness is changed from 0.2 to 0.6. Figure B.1 presents the impulse response functions. The response patterns of non-traded output, exported output, non-traded inflation, real exchange rate and non-traded goods prices are generally similar to the benchmark calibration case. However, in terms of magnitude, the impulse responses of most variables are marginally greater under high openness than in the benchmark case, suggesting that increased openness magnifies the impact of commodity terms of trade shocks. This is expected since openness results in increases in demand for foreign goods and reduction in demand for domestic goods. Openness also increases the volatility and persistence of nominal and real exchange rates under CIT because of increased exposure to shocks. This confirms the results of Chia and Alba (2006) who observe that increasing openness doubles the volatility of real exchange rates under flexible exchange rates than under fixed exchange rates. Higher openness also propagates the impact of commodity terms of trade shocks on non-traded inflation and CPI inflation especially under CIT because of increased traded goods in the CPI basket.

Secondly, the degree of stickiness is changed to a special case where there is no stickiness of non-traded goods prices. This case is similar to the framework of Cashin et al. (2004). Figure B.2 shows the impulse responses when there is no stickiness. In this case, aggregate output, non-traded output, exported output consumption, labour and exchange rate responses are generally similar to the baseline calibration where stickiness is high. In terms of magnitude, the responses are larger when prices are flexible. This suggests that price stickiness dampens the effects of commodity terms of trade shocks on the economy. This indicates that price stickiness acts as a constraint to firms in the non-traded sector and when the constraint is removed, the variables become more volatile. The responses of nominal and real exchange rates are similar to the baseline case, consistent with the findings of Cashin et al. (2004). However, under NTIT, CPI inflation rises sharply and is more persistent, while under CIT rule, it is relatively stable, suggesting that CIT central banks pay more attention to the mechanism of price adjustment. If prices are flexible, central banks are more aggressive in ensuring that inflation expectations remain anchored.

Thirdly, the sensitivity test entails decreasing the elasticity of substitution between traded and non-traded goods from 1 to 0.4. Figure B.3 shows the impulse responses. Aggregate output increases and is more persistent following commodity terms of trade shocks because economic agents cannot easily substitute more expensive domestic goods for less expensive foreign goods. As a result, a higher income effect will generate greater demand for non-traded goods. The dynamic adjustment of exported output, nominal exchange rates, real exchange rates, non-traded good prices and interest rates are similar to the baseline calibration. Apart from this similarity, the responses in the new parameterisation framework (where the elasticity of substitution is low) are weaker than when the elasticity of substitution is high. This shows that low elasticity of substitution induces smaller responses of variables to international relative price movements and weaker feedback effects because of fewer substitution possibilities (Gali and Monacelli, 2005).

3.6.2 Sensitivity tests on volatility and welfare evaluations

The performance of alternative monetary policy rules with respect to volatility and welfare is also analysed when parameter values of openness, stickiness and elasticity of substitution of traded and non-traded goods are changed. Table B.5.2 in the Appendix presents the results. As in the baseline case, when the degree of openness is high, responding to non-traded inflation generates higher volatility in total output and non-traded output while responding to CIT results in greater nominal, real exchange rate and interest rate volatility. This shows that greater openness increases the sensitivity of output to shocks. On the other hand, labour supply, non-traded inflation, CPI inflation and consumption are more volatile under ET. Overall, CIT still performs better than NTIT and ET in terms of stabilising most macroeconomic variables.

When the value of the stickiness parameter is reduced, ET generates volatile aggregate output, exported output, consumption, non-traded prices and CPI inflation as in the benchmark calibration. The exchange rates and interest rates still display more volatility under CIT, suggesting that even when all sectoral prices are flexible, exchange rates continue to fluctuate more. Also, when the elasticity of substitution between traded and non-traded goods is reduced, volatility patterns of most variables remain broadly similar to the baseline case.

Table B.5.3 shows the effects of changing the degrees of openness, stickiness and elasticity of substitution on welfare. When the weight on all other variables are the same relative to inflation, greater openness results in less welfare losses under CIT. This suggests that CIT rule simultaneously makes use of the multiple channels of monetary policy transmission to reduce economic volatility. However, if more weight is put on output stabilisation, openness improves the welfare effects of NTIT rule followed by CIT rule and lastly ET rule. Also, when the central bank prefers to stabilise interest rates and exchange rates under high openness, CIT delivers less welfare loss as in the baseline case. This is consistent with the intuition that, as the economy becomes more open, the reduction in interest rate and exchange rate fluctuations tends to lower excess volatility in economic activity in the face of external shocks which in turn reduces welfare losses.

Under no stickiness, the CIT rule still performs better than other regimes especially when more weight is put on inflation, interest rate and exchange rate stabilisation. However, greater preference for output and exchange rate stabilisation generates less welfare losses under NTIT. Although the ranking of the regimes is broadly similar to the baseline case, the magnitude of welfare loss is greater under flexible prices than under price stickiness, suggesting that to some extent, welfare losses depend on the degree of nominal rigidity.

On the other hand, when the elasticity of substitution between traded goods and non-traded goods is low and the relative weight on inflation variability is greater than other variables, NTIT delivers less welfare losses. The NTIT rule also dominates when the central bank increases preference for output stabilisation. The possible reason for the better welfare performance of NTIT rule is that under low elasticity of substitution, consumers cannot easily substitute the more expensive non-traded goods for cheaper imports. Also, as in the baseline case, greater preference for interest rate and exchange rate stabilisation results in less welfare loss under CIT rule because low elasticity of substitution generates less volatility in exchange rates which enhances welfare.

3.7 Conclusion

This chapter develops a multi-sector New Keynesian DSGE model to examine the appropriate monetary policy responses to commodity shocks. Particularly, the study examines whether CPI inflation targeting performs better than NTIT and ET regimes. It also evaluates the optimal monetary policy implications of these shocks using the central bank loss function. The model features the commodity sector in a multi-sector setting and incorporates nominal price rigidities and monopolistic competition in the non-traded sector. It is calibrated to the South Africa economy.

The analysis shows that the dynamic effects of commodity terms of trade shocks and productivity shocks on the commodity export sector depends to a large extent on the monetary policy rule in place. The results show that CIT stabilises most variables such as output, consumption, CPI inflation and non-traded inflation. However, this stabilisation is at the cost of high real and nominal exchange rate volatility. The analysis of welfare shows that the central bank achieves less welfare loss under a CIT regime when CPI inflation has higher relative weight in the loss function. However, if the central bank cares more about output stabilisation, targeting non-traded inflation reduces welfare losses. Also, the stabilisation of interest rates and exchange rates is welfare enhancing under CIT. The results are generally robust to changes in some parameters such as openness, price stickiness and elasticity of substitution. Increasing openness tends to increase real exchange rate fluctuations under ET regimes. On the other hand, reducing price stickiness has the effect of propagating higher real exchange rate volatility under ET than in other regimes. Reducing the elasticity of substitution weakens the responses of variables because of weaker feedback effects generated by fewer substitution possibilities. The ranking of monetary policy rules however remains unchanged.

The results generally suggest that the central bank can reduce macroeconomic volatility by targeting CPI inflation. However, this stabilisation comes at the cost of higher exchange rate volatility. This implies that when the central bank responds to external shocks, it should consider the economy's greater vulnerability to exchange rate fluctuations. The evidence from welfare analysis suggests that a small open economy exposed to volatile commodity terms of trade shocks can reduce welfare losses by targeting CPI inflation. The implication of the analysis is that the consideration of the commodity sector in the model changes the conventional wisdom on monetary policy making that domestic inflation targeting is more optimal. For economies which are prone to commodity terms of trade shocks, the analysis shows that it pays to respond to CPI inflation rather than for non-traded inflation and exchange rates.

Chapter 4

Monetary policy and commodity terms of trade shocks in emerging market economies: An empirical analysis

4.1 Introduction

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

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

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

The chapter contributes to the literature in three ways. Firstly, it contributes to the practical debate on optimal policy responses to external shocks by empirically validating alternative monetary policy responses to external shocks. Since the failure of central banks to deal with the shocks of the 1970s, little consensus has emerged on the best monetary policy framework to deal with terms of trade shocks. However, recent advances in monetary policy making have given prominence to the adoption of inflation targeting as a way of stabilising economies. The proponents of this regime argue that the monetary policy framework that can effectively deal with external shocks is the one based on the trinity of flexible exchange rates, inflation targets and monetary policy rule (see e.g. Taylor, 2000). Contrary to this

[1] Resilience is the capacity to absorb shocks and recover quickly following such shocks.

view, the opponents of IT argue that it is more vulnerable to external shocks, and claim that other monetary policy regimes can stabilise economies better (see e.g. Kumhof, 2001; Stiglitz, 2008).

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

Thirdly, the chapter focuses specifically on EMEs. Most studies on external shocks and policy responses focus on developed countries and generalise the results to developing countries and EMEs (see e.g Edwards and Yeyati, 2005; Mishkin and Schmidt-Hebbel, 2007). But EMEs are different. These economies have a number of features that are important within the framework of monetary policy design in the presence of commodity terms of trade shocks. For instance, they are small in sizes, open and their exports are dominated by primary commodities. This makes them more vulnerable to commodity terms of trade shocks than advanced countries (Spatafora and Warner, 1995). In addition, many EMEs are unable to adopt optimal counter cyclical stabilisation policies because of less developed financial sector, sudden stops of capital flows, weak institutional frameworks (Calvo and Mishkin, 2003) and weak shock absorbers (Hoffmaister and Roldos, 2001). Also, their heterogeneous monetary policy frameworks provide a spectrum of experiences which allow clear comparison of different monetary policy responses to commodity terms of trade shocks. Therefore, the analytical focus on these countries helps to deepen our understanding of appropriate monetary policy responses to commodity terms of trade shocks, taking into account their structural and institutional realities.

The results show that there are differences in monetary policy responses to commodity terms of trade shocks, with inflation targeting having better outcomes. More precisely, commodity terms of trade shocks generate more muted responses of output gap, inflation and interest rates in inflation targeters than in monetary targeters and exchange rate targeters. Also, when the response of variables for inflation targeters before and after IT adoption are compared, the results show that the responses of output gap, inflation, exchange rates and interest rates are substantially larger for the period before IT adoption than after IT adoption. However, the responses of exchange rates to commodity terms of trade shocks are greater in IT countries than in ET countries. Through variance decompositions, the results show that commodity terms of trade shocks account for larger variability of output gap and inflation in non-IT countries than in IT countries. Overall, IT countries seem to exhibit less severe responses followed by exchange rate targeters and lastly monetary targeters. The results suggest that the adoption of inflation targeting can reduce the impact of commodity terms of trade shocks on the economy. However, policy makers also need to pay attention to exchange rate fluctuations induced by commodity terms of trade shocks. The results are generally robust to a battery of sensitivity tests.

The rest of the chapter is organised as follows: section 4.2 outlines the review of the literature, section 4.3 presents the theoretical framework. Section 4.4 outlines the empirical estimation method, identification and data. Section 4.5 presents the results while section 4.6 presents robustness tests. Finally, section 4.7 concludes the chapter.

4.2 Review of the literature

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

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

Subsequent empirical literature has tested the insulation hypothesis of exchange rates. For example, on a panel of 75 developing countries over the period 1973 to 1996, Broda (2004) finds that the short-run real GDP response to terms of trade shocks is smaller in countries with flexible exchange rates than those with fixed exchange rates. He concludes that flexible exchange rates buffer negative terms of trade shocks through smooth changes in the exchange rate. However, his study uses standard terms of trade indices in which the presence of nominal price rigidities may prevent adequate capturing of contemporaneous movements that induce immediate exchange rate responses (Chen and Rogoff, 2003).

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

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

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

In a calibrated model, Kumhof (2001) compares the performance of IT relative to other regimes in the face of many shocks. Under the negative tradable endowment shock and the real interest rate shock (exogenous shocks), IT performs worse than exchange rate targeting in terms of deviation of tradable consumption from its steady state value. In terms of welfare, monetary targeting outperforms exchange rate targeting and IT. He argues that IT imposes a very tight limit on exchange rate flexibility. Nevertheless, his study does not explicitly consider the optimal monetary policy responses to commodity terms of trade shocks.

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

4.3 Theoretical framework

Chapter 3 has provided the micro foundations of a canonical small open economy model. In order to motivate the empirical estimation in the next section, a simple theoretical framework which captures the interactions of key macroeconomic variables is postulated. The theoretical framework is a variant of a small open emerging market economy model which incorporates some features of the DSGE model in Chapter 3 and small open economy models of Ball (1998) and Cavoli et al. (2006). The core structure of the small open economy model includes an IS equation, a Phillips Curve, an uncovered interest parity (UIP) condition, monetary policy rule and the terms of trade equation.

In the model, each emerging market economy is assumed to produce exports, non-traded goods and have imports. Primary commodities are assumed to constitute a significant portion of exports such that the economy is a net exporter of mainly commodities. The terms of trade is defined as the ratio of the price of exports to the price of imports. In growth terms, the terms of trade is described by:

$$\Delta f_{it} = \pi_{Xit} - \pi_{Mit} \tag{4.1}$$

where Δf_{it} is the growth of terms of trade, π_{Xit} is the change in domestic price of exported goods and π_{Mit} the change in domestic price of imported goods of country i at time t. The law of one price is assumed to hold on both exports and imports. Taking this into account, and after some computations, the terms of trade can be written as:[2]

$$f_{it} = f_{it-1} + \pi^*_{Xt} - \pi^*_t. \tag{4.2}$$

Adding the constant and the shock for empirical estimation purposes, the following broad specification of the terms of trade equation is considered instead:

$$f_{it} = \alpha_{i0} + \alpha_1 f_{it-1} + \pi^*_{Xt} - \pi^*_t + \varepsilon_{fit}. \tag{4.3}$$

Equation (4.3) shows that the change in terms of trade is a result of the change in the price of exported goods and change in world price. Since primary commodities account for a significant portion of exports, the terms of trade index is generally considered as a commodity terms of trade index.[3]

The equation which links real exchange rate, nominal exchange rate and commodity terms of trade is given by: [4]

$$\Delta q_{it} = \Delta e_{it} + \pi_{it} - \pi^*_{Xt} + \Delta f_{it}, \tag{4.4}$$

where Δq_{it} is the growth rate of real exchange rate of country i at time t, Δe_{it} is the change in the nominal exchange rate of country i at time t, π_{it} is the inflation of country i at time t and π^*_{Xt} is the world inflation of exported goods at time t. To simplify the estimation, the following approximation is made:

$$q_{it-1} = \theta e_{it-1}, \tag{4.5}$$

where θ is a positive parameter. It follows that,

$$q_{it} = e_{it} + (\theta - 1)e_{it-1} + \pi_{it} - \pi^*_{Xt} + \Delta f_{it} \tag{4.6}$$

This implies that the real exchange rate is affected by the change in nominal exchange rate, domestic inflation, change in prices of exports and change in com-

[2]See Appendix C.1 for derivation.

[3]Going foward, the terms of trade is described as the commodity terms of trade.

[4]The derivation of this equation is in Appendix C.1

modity terms of trade.

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

$$e_{it} = e_{it-1} + \beta_2(r_{it} - r_t^*) + \varepsilon_{eit} \tag{4.7}$$

where β_2 is a parameter, r_{it} is the real interest rate of country i at time t, r_t^* is the rest of the world interest rate at time t and ε_{eit} is the disturbance term that captures other influences on the exchange rate and the noise in the foreign exchange and asset markets. The UIP condition relates the change in the exchange rate to domestic and foreign interest rate differentials and captures the idea that a rise in interest rates makes domestic financial assets to be more attractive leading to the appreciation of the exchange rate.

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

$$\pi_{it} = \gamma_1\pi_{it-1} + \gamma_2 y_{it} + \gamma_3 q_{it} + \gamma_4 y_{it-1} + \varepsilon_{\pi it} \tag{4.8}$$

where γ_1, γ_2, γ_3 and γ_4 are parameters, $\varepsilon_{\pi it}$ is the disturbance term components. In this specification, the lagged inflation term captures the inflation inertia, while the current and lagged output gap captures the contemporaneous as well as lags in the transmission of output shocks to inflation. The real exchange rate affects inflation through import prices. Substituting equation (4.6) in (4.8), the above Phillips curve can be written as:

$$\pi_{it} = \lambda_1\pi_{it-1} + \lambda_2 y_{it} + \lambda_3 e_{it} + \lambda_4 e_{it-1} - \lambda_3\pi^*_{Xt} + \lambda_3\left(f_{it} - f_{it-1}\right) + \lambda_5 y_{it-1} + \varepsilon_{\pi it} \tag{4.9}$$

where $\lambda_1, \lambda_2, \lambda_3$, λ_4 and λ_5 are the new parameters.

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

$$y_{it} = \delta_{i0} + \delta_1 y_{it-1} + \delta_2\left(r_{it} - \pi_{it}\right) + \delta_3 q_{it} + \delta_4 y_t^* + \varepsilon_{yit} \tag{4.10}$$

where δ_{i0}, δ_1, δ_2, δ_3 and δ_4 are parameters, y_{it} is the output gap in country i at time t, y_t^* is the foreign output at time t. ε_{yit} is an IS shock which captures other influences on output gap. The lagged output gap term captures the persistence effects of the output gap which may arise due to costly adjustment processes. The output gap is also affected by the interest rates, real exchange rate and foreign output. Substituting equation (4.6) into the above equation and rearranging yields:

$$y_{it} = \varphi_{i0}+\varphi_2 r_{it}-\varphi_3\pi_{it}+\varphi_4 e_{it}+\varphi_4 f_{it}+\varphi_1 y_{it-1}+\varphi_5 e_{it-1}-\varphi_4 f_{it-1}-\varphi_4\pi^*_{Xt}+\varphi_6 y^*_t+\varepsilon_{yit} \tag{4.11}$$

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

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

$$r_{it} = \omega_1 r_{it-1} + \omega_2 y_{it} + \omega_3\pi_{it} + \omega_4\Delta e_{it} + \varepsilon_{rit} \tag{4.12}$$

where ω_1, ω_2, ω_3 and ω_4 are parameters, ε_{rit} is the disturbance term. In this specification, the central bank responds to inflation, output gap and exchange rate while at the same time maintaining some degree of interest rate smoothing. The dynamic responses of variables are analysed under different monetary policy regimes. Under inflation targeting, the central bank adjusts interest rates to keep the inflation rate on target. Under monetary targeting, the central bank adjusts interest rates to keep the money growth rate constant while under exchange rate targeting, the monetary authorities act to keep the nominal exchange rate constant.

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

$$\begin{cases} f_{it} & = & \alpha_{i0} + \alpha_1 f_{it-1} + \pi^*_{Xt} - \pi^*_t + \varepsilon_{fit} \\ e_{it} & = & e_{it-1} + \beta_2(r_{it} - r^*_t) + \varepsilon_{eit} \\ \pi_{it} & = & \lambda_1 \pi_{it-1} + \lambda_2 y_{it} + \lambda_3 e_{it} + \lambda_4 e_{it-1} - \lambda_3 \pi^*_{Xt} + \lambda_3 (f_{it} - f_{it-1}) + \lambda_5 y_{it-1} + \varepsilon_{\pi it} \\ y_{it} & = & \varphi_{i0} + \varphi_2 r_{it} - \varphi_3 \pi_{it} + \varphi_4 e_{it} + \varphi_4 f_t + \varphi_1 y_{it-1} + \varphi_5 e_{it-1} - \varphi_4 f_{it-1} - \varphi_4 \pi^*_{Xt} + \varphi_6 y^*_t + \varepsilon_{yit} \\ r_{it} & = & \omega_1 r_{it-1} + \omega_2 y_{it} + \omega_3 \pi_{it} + \omega_4 \Delta e_{it} + \varepsilon_{rit} \end{cases}$$

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

$$AY_{it} = X_i + BY_{it-1} + CX^*_t + \varepsilon_{it} \tag{4.13}$$

where,

$$A = \begin{pmatrix} 1 & 0 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 & -\beta_2 \\ -\lambda_3 & -\lambda_3 & 1 & -\lambda_2 & 0 \\ -\varphi_4 & -\varphi_4 & \varphi_3 & 1 & -\varphi_2 \\ 0 & -\omega_4 & -\omega_3 & -\varphi_4 & 1 \end{pmatrix},$$

$$B = \begin{pmatrix} \alpha_1 & 0 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 & 0 \\ -\lambda_3 & \lambda_4 & \lambda_1 & \lambda_5 & 0 \\ -\varphi_4 & \varphi_5 & 0 & \varphi_1 & 0 \\ 0 & \omega_4 & 0 & 0 & \omega_1 \end{pmatrix}, \quad C = \begin{pmatrix} 0 & 1 & -1 & 0 \\ -\beta_2 & 0 & 0 & 0 \\ 0 & \lambda_3 & 0 & 0 \\ 0 & -\lambda_4 & 0 & \varphi_6 \\ 0 & 0 & 0 & 0 \end{pmatrix},$$

$$Y_{it} = \begin{pmatrix} f_{it} \\ e_{it} \\ \pi_{it} \\ y_{it} \\ r_{it} \end{pmatrix}, Y_{it-1} = \begin{pmatrix} f_{it-1} \\ e_{it-1} \\ \pi_{it-1} \\ y_{it-1} \\ r_{it-1} \end{pmatrix}, X_i = \begin{pmatrix} \alpha_{i0} \\ 0 \\ 0 \\ \varphi_{i0} \\ 0 \end{pmatrix}, X_t^* = \begin{pmatrix} r_t^* \\ \pi_{Xt}^* \\ \pi_t^* \\ y_t^* \end{pmatrix} \text{ and } \varepsilon_{it} = \begin{pmatrix} \varepsilon_{fit} \\ \varepsilon_{eit} \\ \varepsilon_{\pi it} \\ \varepsilon_{rit} \\ \varepsilon_{yit} \end{pmatrix}$$

Y_{it} is the vector of endogenous variables, A the matrix of structural coefficients and contemporaneous interactions, B is the matrix of lagged interactions, C is the matrix of external time interactions, X_i is the vector of constants for each country, X_t^* is the vector of exogenous variables from the rest of the world at time t and ε_{it} is the vector of structural disturbances which are normally distributed with mean zero, constant variance and serially uncorrelated.[5]

The structural equations (4.13) cannot be estimated directly because of the correlation between the variables and the error terms. Therefore, the structural equations are transformed into reduced form equations which can actually be estimated. This is achieved by pre-multiplying equation (4.13) by A^{-1} to obtain the following reduced form equation:

$$Y_{it} = F_i + \Gamma Y_{it-1} + T_t + u_{it} \tag{4.14}$$

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

4.4 Empirical estimation, identification and data

4.4.1 Empirical estimation method

The chapter considers the reduced form panel VAR framework in the spirit of equation (4.14). However, in order to improve the econometric properties of the model in the estimation, the chapter follows Love and Zicchino (2006) and applies

[5]However, this paper will not consider the rest of the world variables explicitly, it will approximate them by time variables.

the following broad specification instead: [6]

$$Y_{it} = \Gamma_0 + \Gamma(L)Y_{it} + F_i + T_t + u_{it} \tag{4.15}$$

where: $Y_{it} = (CTOT_{it},\ YGAP_{it},\ INFL_{it},\ ER_{it},\ RTS_{it})$ is a vector of all variables. $CTOT_{it}$ is the commodity terms of trade, $YGAP_{it}$ is the output gap, $INFL_{it}$ is the inflation rate, ER_{it} is the exchange rate variable and RTS_{it} is the interest rate. Γ_0 is a matrix of constants, F_i is the vector of country specific fixed effects and T_t is a vector of time fixed effects which accommodates aggregate shocks to Y_{it} that are common across countries. u_{it} is the reduced form residual vector and $\Gamma(L)$ is the matrix of polynomial lags that capture the relationships between variables and their lags. i and t are country and time indices respectively. As Love and Zicchino (2006) note, the application of VARs in panel data requires the assumption that the underlying structure be the same for each cross-sectional unit.[7]

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

[6] The stata codes developed by Love and Zicchino (2006) are used to run the Panel VAR model

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

4.4.2 Identification

The challenge in estimating model (4.15) is the presence of country-specific unobserved characteristics. Therefore, fixed effects are introduced to take into account individual country heterogeneity. However, fixed effects are correlated with regressors because of the lags of the dependent variables in the system. The mean-differencing procedure commonly used to eliminate fixed effects tends to create biased coefficients. Following Arellano and Bover (1995) and Love and Zicchino (2006), forward mean differencing (Helmert procedure) is used to remove all future values for each country-year. This procedure involves removing fixed effects of all variables by transforming them into deviations from the average future observations. The transformation ensures that the variance is standardized by weighting each observation and errors that are not correlated. The procedure preserves the orthogonality between the transformed variables and the lagged regressors. The coefficients are then estimated by GMM where lagged regressors are used as instruments. This transformation also preserves homoskedasticity while reducing serial correlation (Arellano and Bover, 1995).

The impulse response functions of variables to commodity terms of trade shocks are then estimated. The key identifying assumption is the exogeneity of commodity terms of trade shocks which rests on the small open economy argument (Ahmed, 2003; Edwards and Yeyati, 2005). In the estimations, reduced-form errors may be correlated, making impulse response functions unreliable. Following Sims (1980), the standard Choleski decomposition of the variance-covariance matrix of residuals is used to identify the innovations in the system.[8] This decomposition induces a recursive orthogonal structure on the shocks where the variance-covariance matrix of the residuals is diagonal and lower triangular. The procedure relies on recursive causal ordering of variables where the variables listed earlier in the VAR impact the other variables contemporaneously, while disturbances in the variables listed later have lagged effects on the preceding ones.[9] The variables are ordered according to the degree of exogeneity, with earlier variables considered to be more exogenous than later variables (Mishkin and Schmidt-Hebbel, 2007).

[8] Note that matrix A is made lower triangular by assuming that $-\beta_2 = -\lambda_2 = -\varphi_2 = 0$

[9] This identifiaction scheme has been frequently used in monetary policy transmission studies (see e.g Christiano et al.,1999).

In the present study, the variables in the panel VAR are ordered as follows: commodity terms of trade, output gap, inflation, exchange rate and interest rate. Terms of trade is ordered first, implying that it does not react to contemporaneous changes in other variables. It is believed that this is the most exogenous variable because of the small open economy argument. Output gap is ordered second consistent with the assumption that commodity terms of trade shocks affect output gap contemporaneously and with a lag while there is likely to be no feedback effects. Inflation and exchange rate are ordered after output gap, because economic theory suggests that contemporaneous causation goes from output gap dynamics to movements in domestic prices and exchange rates. The exchange rate is ordered after inflation because of the argument that the effect of inflation on exchange rate is likely to be contemporaneous and if there is any feedback effect, it is likely to happen with a lag. However as noticed by Ahmed (2003), the reverse can be true since changes in the exchange rate can be a source of instability for domestically driven shocks. Finally, interest rate is ordered last, because being a policy variable, it reacts contemporaneously to the dynamics of the earlier macroeconomic variables, although the feedback effects are expected to operate with a lag. This is in line with several studies in monetary transmission processes (see e.g. Bernanke and Mihov, 1998; Christiano et al., 1999). This analysis adopts an ordering similar to Mishkin and Schmidt-Hebbel (2007).

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

4.4.3 Data

This chapter uses quarterly panel data for 35 emerging market economies from 1980-2008. The countries are listed in Table 4.4.1. The sample is divided into 15 inflation targeters and 20 non-inflation targeters (control group). The sample of inflation targeters is further divided with respect to time, that is before inflation targeting and after inflation targeting. This constitutes an unbalanced panel because of the differences in the adoption dates of inflation targeting.[10] Non-inflation targeters are divided into monetary targeters and exchange rate targeters to allow for heterogeneity in the setting of monetary policies.[11] The sample of non-inflation targeters consists of 11 monetary targeters and 9 exchange rate targeters. Non-inflation targeters are further divided in terms of time, where 1995 is the dividing year. This allows for dynamic comparison between two time horizons, that is, before and after 1995. This period is chosen because it is consistent with the inflation targeters' average adoption dates in the 1990s.

The main variable in this chapter is the commodity terms of trade index which was originally developed by Deaton and Miller (1996). The index used in this chapter was modified and updated by Spatafora and Tytell (2009). The commodity terms of trade index is a weighted average of the main commodity export prices divided by the weighted average of the main commodity import prices.[12] This index is related to the standard terms of trade index but conceptually different in that it focuses on commodities and reflects their importance in the overall economy.

Commodity terms of trade is calculated as follows :

$$CTOT_{it} = \frac{\prod_j (P_{jt}/MUV_t)^{X_{ji}}}{\prod_j (P_{jt}/MUV_t)^{M_{ji}}} \tag{4.16}$$

[10] The adoption dates for inflation targeting are indicated in Table A.1.2.

[11] The classification of non-inflation targeters follows Mishkin and Schmidt-Hebbel (2007), Batini et al. (2006), IMF (2008) and central bank websites.

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

where P_{jt} is the individual commodity prices, MUV_t is the manufacturing unit value index defined as the trade-weighted index of the five major developed countries' exports of manufactured commodities to developing countries.[13] MUV is used as a deflator in order to get real commodity export and import prices (see e.g. Cashin and McDermott, 2002). X_{ji} is the share of exports of commodity j in country i's GDP and M_{ji} is the share of imports of commodity j in country i's GDP. In order to allow the effect of commodity export or import prices to be larger for countries with higher commodity exports or imports and for cross country differences to be taken into account, the deflated index is weighted by the share of commodity exports or imports in a country's GDP (Spatafora and Tytell, 2009). The weights for both imports and exports are fixed and averaged over time and applied to world prices of the same commodity to form a country specific geometrically weighted index of prices. This allows supply responses to be excluded so that commodity terms of trade indices are exogenous to the behavior of individual countries. Since the nature and composition of each country's exports and imports are different, the commodity terms of trade indices move differently for each country even though the underlying world prices are the same. In the estimations, the growth of commodity terms of trade is used.

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

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

For the exchange rate variable, the percentage change in the bilateral nominal exchange rate for each country is used. This reflects the depreciation or apprecia-

[13]The developed countries considered here are France, Germany, Japan, United Kingdom and United States of America

tion of the bilateral nominal exchange rate. The bilateral nominal exchange rate also allows the evaluation of the direct effects of commodity terms of trade shocks on the exchange rate. Also, exchange rate targeters normally target the bilateral nominal exchange rate rather than the real exchange rate. Several studies use bilateral nominal exchange rates in the panel VAR to capture the transmission of external shocks to EMEs (see e.g Mishkin and Schmidt-Hebbel, 2007; Coulibaly and Kempf, 2010).

The interest rate variable used is the policy interest rate of central banks. Whenever the policy interest rate is not available, the three month treasury bill rate is used. Policy rates are interest rates at which the central bank provides short term loans to banks. Several studies on the monetary transmission mechanism based on VARs use this variable as an indicator of the stance of monetary policy since it is the operating target of the central bank (see eg. Christiano et al., 1999; Bernanke and Blinder, 1992).[14] As shown in the theoretical framework, the short term policy interest rate is depicted by the Taylor rule. In this case, central banks follow a monetary policy rule in their responses to economic disturbances. Variable descriptions and data sources are presented in Table C.1.2 in the Appendix.[15]

4.4.4 Descriptive analysis

This section provides descriptive statistics to uncover some key stylised facts on the data. Figure 4.1 shows the profile of commodity terms of trade indices which have been detrended by the Hodrick Prescott filter for different monetary policy regimes.[16] Commodity terms of trade have fluctuated significantly over the years. The booms and busts in commodity terms of trade shocks seem to follow major global economic disturbances such as the debt crisis in 1982, the Mexican crisis in 1998, Asian crisis in 1997, oil shocks in the 1990s, commodity boom in the 2000s

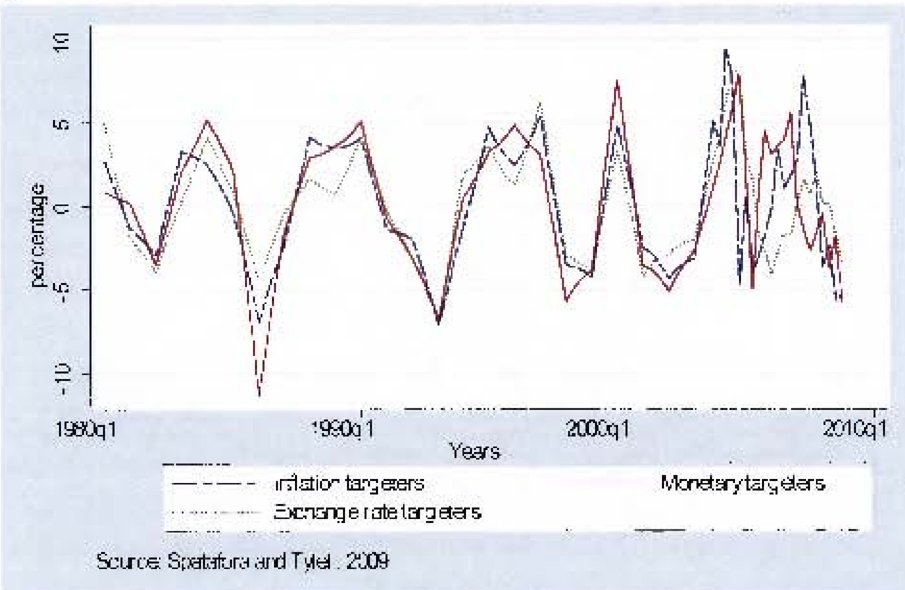
[14]This study did not include money supply growth, although it is an intermediate variable for monetary targeters. It is believed that the inclusion of interest rates effectively reduce the effectiveness and predictive power of money supply since short term interest rates are better measures of monetary policy stance than money supply (Sims 1980). Also, in a standard ISLM model, money supply requires an increase in the interest rates to restore money market equilibrium. The ommision of this variable is in line with most literature on monetary policy.

[15]All the variables are expressed as growth rates except output gap.

[16]The commodity terms of trade indices in the figure are HP filtered so that they are interpreted as deviations from a trend which represents shocks.

and the global financial crises from 2007. The rise in commodity prices from 2003 which peaked in 2008 is also reflected by the high volatility in commodity terms of trade around 2007. The busts seem to be larger, sharp and relatively shorter and are intercepted by booms. The general picture is that different regimes were exposed to relatively similar patterns of commodity terms of trade shocks.

Figure 4.1: Commodity terms of trade shocks under different monetary policy regimes



In Table 4.4.1, countries are grouped according to their monetary policy regimes. The table shows that for inflation targeters, Mexico, Thailand and Chile have large volatility of commodity terms of trade, while Hungary and Poland have less volatility. The high volatility can be explained by the concentration of few commodity exports whose prices are very volatile on the world markets. Chile relies on copper which accounts for over 40% of its total exports, while Thailand and Mexico depend on rice and oil respectively. However, the levels and volatilities of other macroeconomic variables seem to be high in Brazil and Peru, possibly reflecting their historical experiences with hyper-inflation and exchange rate volatility in the 1980s. For monetary targeters, terms of trade volatility is considerable high in Nigeria, Algeria and Argentina reflecting the nature of their exports. Nigeria and

Algeria are oil exporters while Argentina is a wheat exporter. This also corresponds to the large volatility of exchange rates and output gap which may indicate that much of these fluctuations originated externally. The extreme volatility of inflation and exchange rates especially in Argentina and Croatia may reflect previous high exchange rate pass-throughs and less credibility of monetary policies. Among exchange rate targeters, Table 4.4.1 shows that Ukraine, El Salvador, Venezuela and Malaysia exhibit great volatility in commodity terms of trade of 9.23%, 8.76%, 7.85% and 7.82% respectively. Ukraine and Venezuela are oil exporters, hence the volatility of their exchange rates may reflect oil price fluctuations. The table also shows that Malaysia and El Salvador have highly volatile commodity terms of trade and output gap which can be explained by fluctuations in international prices of rubber and coffee, which are their key exports respectively.

Table C.1.3 compares summary statistics of inflation targeters before and after IT adoption. It shows that commodity terms of trade variability is higher before IT adoption than after IT adoption. Moreover, the volatility of output gap, inflation and interest rates is also greater before inflation targeting than after inflation targeting possibly reflecting the process of disinflation (Batini et al., 2006).

In Table C.1.4, summary statistics for inflation targeters, monetary targeters and exchange rate targeters after 1995 are compared. On average, exchange rate targeters have greater commodity terms of trade variability than inflation targeters and monetary targeters. Inflation targeters have an average inflation rate of 5.44 while monetary targeters and exchange rate targeters have rates of 10.65 and 12.40 respectively. Inflation volatility is considerably less in IT countries, while it is six times and four times greater in monetary targeters and exchange rate targeters respectively. Possibly this could reflect IT's credibility and the power to anchor inflation expectations. Output gap exhibits greater volatility in exchange rate targeters than in other regimes. The exchange rate is more stable in inflation targeters than in exchange rate targeters which is generally unexpected considering the sluggishness in the adjustment of the exchange rates in the latter. Overall, the descriptive statistics show that inflation targeters exhibit less volatility than other regimes and the observed standard deviations are substantially greater before IT

Table 4.4.1: Summary statistics for the sample of inflation targeters, monetary targeters and exchange rate targeters

	CTOT		Output gap		Inflation		Exchange Rates		Interest rates	
	Mean	S.dev	Mean	S.dev	Mean	S.dev	Mean	S.dev	Mean	S.dev
Inflation Targeters										
Brazil	1.02	6.75	0.49	1.93	396.10	53.32	30.83	86.01	123.02	61.39
Chile	0.94	8.7	-0.84	2.02	12.40	8.86	2.32	3.57	18.68	18.16
Colombia	1.05	5.01	0.27	1.15	17.75	8.64	3.5	3.8	25.64	12.60
Czech Republic	-0.03	0.25	0.24	15.37	5.11	2.97	0.50	7.68	5.64	3.39
Hungary	1.05	0.15	0.41	1.75	12.97	8.70	1.65	4.86	13.05	7.19
Indonesia	-0.109	7.51	0.83	2.25	11.87	9.95	3.23	14.87	14.98	11.02
Israel	-0.06	0.96	0.34	1.27	48.03	85.76	7.10	14.56	69.23	16.95
Mexico	1.18	11.56	0.78	1.78	32.50	34.16	6.15	11.52	31.55	26.36
Peru	1.41	3.55	4.74	3.77	432.0	133.26	26.71	115.28	156.19	149.36
Philippines	0.99	4.12	-2.31	2.29	9.89	8.09	1.75	4.99	10.04	2.57
Poland	1.50	0.17	0.92	39.63	48.33	97.09	7.56	27.37	43.53	99.14
South Africa	0.25	6.59	0.95	1.16	10.32	4.62	2.39	7.13	13.12	3.81
South Korea	0.92	2.70	0.75	1.66	5.59	4.95	0.94	5.92	6.01	3.26
Thailand	0.59	10.44	-1.48	2.25	3.83	3.23	0.56	4.64	8.08	4.23
Turkey	0.88	2.61	0.95	2.19	50.77	27.38	9.81	11.16	45.11	15.16
Monetary Targeters										
Algeria	-1.10	6.72	1.53	1.16	10.47	8.93	2.95	7.60	6.80	4.04
Argentina	-0.91	6.09	-0.55	13.07	283.85	63.50	28.32	89.11	47.06	49.39
Croatia	-0.03	0.31	-0.23	18.93	139.00	48.77	19.13	50.35	85.04	31.9
Dominican Republic	0.12	5.63	1.92	2.17	16.91	14.47	4.71	23.54	4.16	7.43
Egypt	0.21	5.87	0.99	0.92	11.88	6.35	2.52	11.78	12.72	2.68
India	0.041	1.84	2.59	1.1	7.97	3.23	1.58	3.85	9.10	2.12
Nigeria	1.58	8.39	2.37	7.81	21.69	17.62	6.86	31.73	13.59	4.45
Pakistan	-0.20	3.82	0.59	0.99	8.40	4.42	1.85	2.79	11.25	3.02
Russia	0.12	1.14	3.56	2.16	117.64	65.64	22.97	15.31	92.93	85.01
Tunisia	0.91	6.01	2.31	1.15	5.61	2.74	1.15	4.23	7.96	2.19
Uruguay	0.04	3.01	-1.66	3.21	37.13	31.41	7.87	15.74	74.23	37.83
Exchange Rate Targeters										
China	0.13	0.04	-0.01	20.46	5.88	6.94	1.17	4.23	6.01	2.47
Cote D' Ivoire	0.96	6.75	0.46	1.76	5.34	4.67	0.47	6.79	7.62	2.69
Eduador	1.51	4.12	0.71	66.39	31.16	21.35	5.17	9.17	27.24	17.60
Lebanon	-0.14	1.21	-2.78	7.19	43.72	23.53	4.25	11.98	19.25	6.73
Malaysia	0.42	7.82	-0.17	22.39	3.18	2.00	0.37	3.20	4.72	1.74
Morocco	-0.86	2.16	-2.27	21.56	4.72	3.27	0.62	3.85	6.12	1.93
El Salvador	0.98	8.76	-0.03	1.41	11.12	7.86	0.84	5.69	12.51	5.81
Ukraine	1.63	9.23	-0.02	2.72	158.98	97.90	7.44	18.61	82.55	46.81
Venezuela	1.04	7.85	0.172	3.31	30.92	20.55	4.75	8.74	32.43	18.61

CTOT is the commodity terms of trade growth, S.dev is the standard deviation. Inflation targeters set numerical targets of inflation and make a commitment to achieve these targets. Inflation forecast is the intermediate target of monetary policy. Monetary targeters uses instruments to achieve a target growth rate of a monetary aggregate, such as reserve money, M1, or M2. The targeted aggregate is the nominal anchor or intermediate target of monetary policy. Exchange rate targeters have monetary authorities who are ready to buy or sell foreign exchange to maintain the predetermined exchange rate at its announced level or range e.g. currency board, regimes with no separate legal tender, fixed pegs, crawling pegs with and without bands. Sources: Authors' calculations based on the sources in Table C.1.2

adoption than after IT adoption.[17]

4.4.5 Panel data tests

To estimate the empirical model correctly, the variables should be stationary and the model should be estimated with correct lag length. Stationarity tests are conducted using the Fisher Type of test as suggested by Maddala and Wu (1999). This test combines the p-values from individual unit root tests and asymptotically follows a chi-square distribution with 2N degrees of freedom. It can also handle unbalanced panels. The null hypothesis is that the variables are not stationary. Table C.1.5 shows the results. Based on this test, the null hypothesis is rejected showing that the variables are stationary. Therefore the panel VAR is estimated in levels since overdifferencing may remove important information (Kireyev, 2000; Francis and Ramey, 2009). The estimation of panel VARs in levels is also common in recent studies of developing countries (see e.g. Raddatz, 2007; Loayza and Raddatz, 2007). However, the estimation is also done in first differences in the robustness tests.

VARs are generally sensitive to lag length. As pointed out by Kireyev (2000), few lags do not adequately capture the dynamics of the system and lead to omitted variable bias while too many lags lead to loss of too much information. In our estimation, the selection of the optimum lag length is guided by the Akaike information criteria, Bayesian information criteria and the Hannan- Quinn Criteria. Based on these criteria, the optimal lag length is four, which is also consistent with most estimations using quarterly data.

4.5 Results analysis

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

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

for IT countries before and after IT adoption. Inflation targeters after IT adoption are also compared with monetary targeters and exchange rate targeters after 1995. Monetary targeters and exchange rate targeters are also compared for the period before and after 1995.

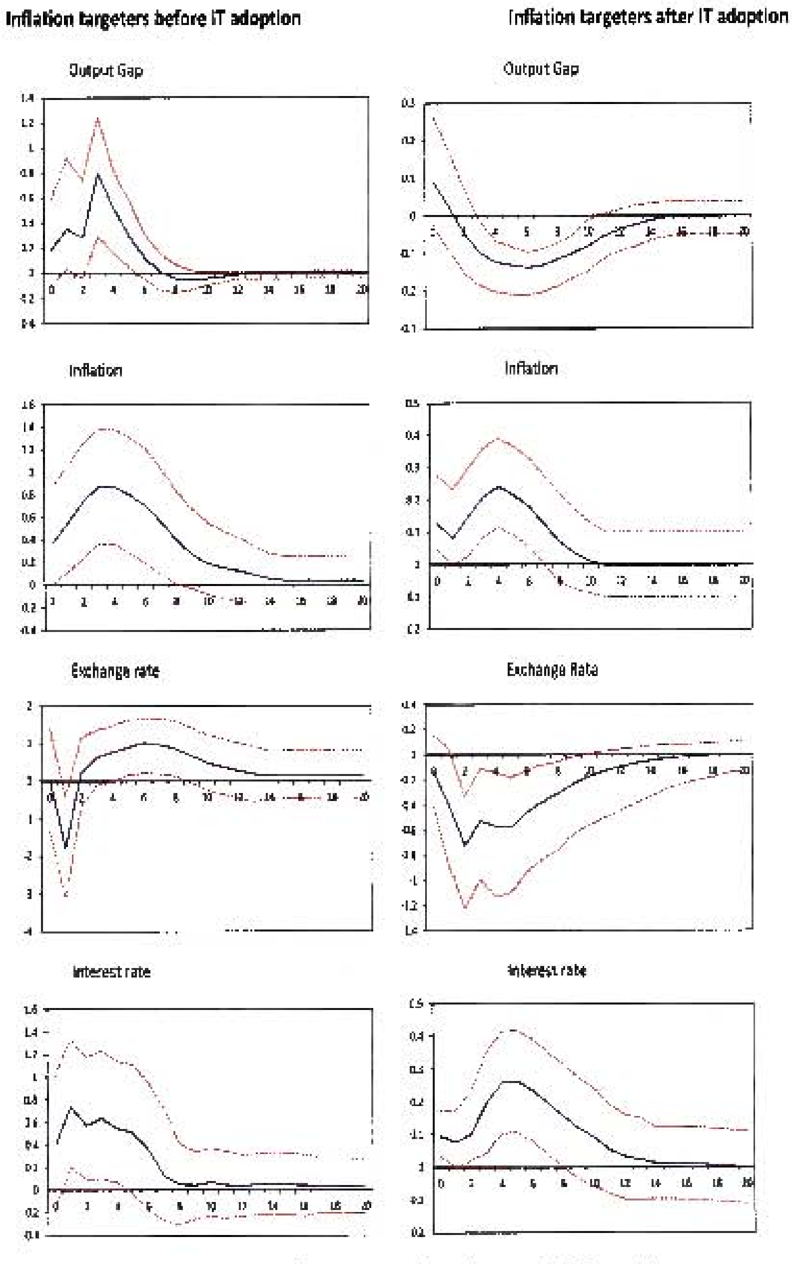
4.5.1 Impulse responses to commodity terms of trade shocks

The impulse responses to one positive standard deviation shock in commodity terms of trade are discussed. Figure 4.2 shows the impulse responses of variables to commodity terms of trade shocks for inflation targeters before and after IT adoption. The central solid lines show the point estimates of the impulse response functions and the outer dashed lines show confidence intervals of the impulse response functions.

Broadly, the propagation mechanism follows interesting dynamics. The commodity terms of trade shock induces an exchange rate appreciation. As the exchange rate appreciates, the booming commodity sector generates a wealth effect which result in strong increase in domestic demand especially for non-traded goods by either government or private sector. The rising domestic demand raises the output gap as the economy overheats, resulting in increase in domestic prices especially those of non-traded goods. Consequently inflation will rise, prompting central banks to respond by raising interest rates.

The dynamic responses of macroeconomic variables differ for the period before the adoption of inflation targeting and the period after the adoption of inflation targeting. For the period before IT adoption, the shock contemporaneously raises output gap, which peaks at 0.8% in the third quarter. However for the period after IT adoption, the rise in output gap is weak on impact, but drops slowly over time. The response of output gap is stronger, sustained and more cyclical before IT adoption than after IT adoption while it is weaker for the period after IT adoption. The weaker response of output gap for the period after IT adoption may reflect the fact that IT regimes take into account output fluctuations in their policy rules. As such, they move interest rates to offset aggregate response following the shock. This is consistent with the finding of Mishkin and Schmidt-Hebbel (2007) which show that the response of output gap to oil price shocks has been less volatile after

Figure 4.2: Impulse responses of variables to commodity terms of trade shocks: Inflation targeters before and after inflation targeting



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

IT adoption than before IT adoption.

Reflecting rising domestic demand and prices, inflation increases both before IT adoption and after IT adoption. Inflation exhibits high volatility for the period before IT adoption than for the period after IT adoption. Specifically for the period before IT adoption, the inflation rise peaks at about 0.85% in the third quarter while for the period after IT adoption, inflation rises and peaks at about 0.24% in the fourth quarter. This suggests that inflation responds more to commodity terms of trade shocks in the pre-IT period than in the post-IT period. The lower and less persistent inflation response for the post inflation targeting period possibly reflects the stabilising role of inflation targeting which reduces inflation volatility by improving the credibility of monetary policy and anchoring inflation expectations (Goncalves and Salles, 2008; Levin et al., 2004)

For the pre-IT period, the positive innovation of commodity terms of trade generates a 1.5% appreciation of the exchange rate in the first quarter before depreciating gradually over time.[18] The shock also appreciates the exchange rate for the period after IT adoption, but the trough does not occur until the second quarter. The effect is significant until the 11th quarter. The exchange rate appreciation is much stronger before IT adoption than after IT adoption. Although the opposite is expected due to flexible exchange rates after IT adoption, this result may reflect the fact that IT central banks respond to exchange rates in order to smooth out their high volatility (Sgherri, 2008). This result however is not uncommon in the literature, for example Edwards (2006) and Petursson (2009) find no evidence that the adoption of IT increases exchange rate volatility compared to their pre-IT adoption period.

In response to rising inflationary pressures, the central banks respond by raising interest rates as shown on the fourth row of Figure 4.2. For the period before IT adoption, interest rates rise by about 0.42% on impact and peaks 0.78% in the first quarter followed by a protracted adjustment to steady state levels. However, for the period after IT adoption, commodity terms of trade shocks induce a contemporaneous interest rate rise of only 0.1% which peaks at 0.25% in the fifth quarter. Clearly, interest rate responses are stronger and more volatile before IT adoption than after IT adoption, suggesting that central banks responded to shocks more

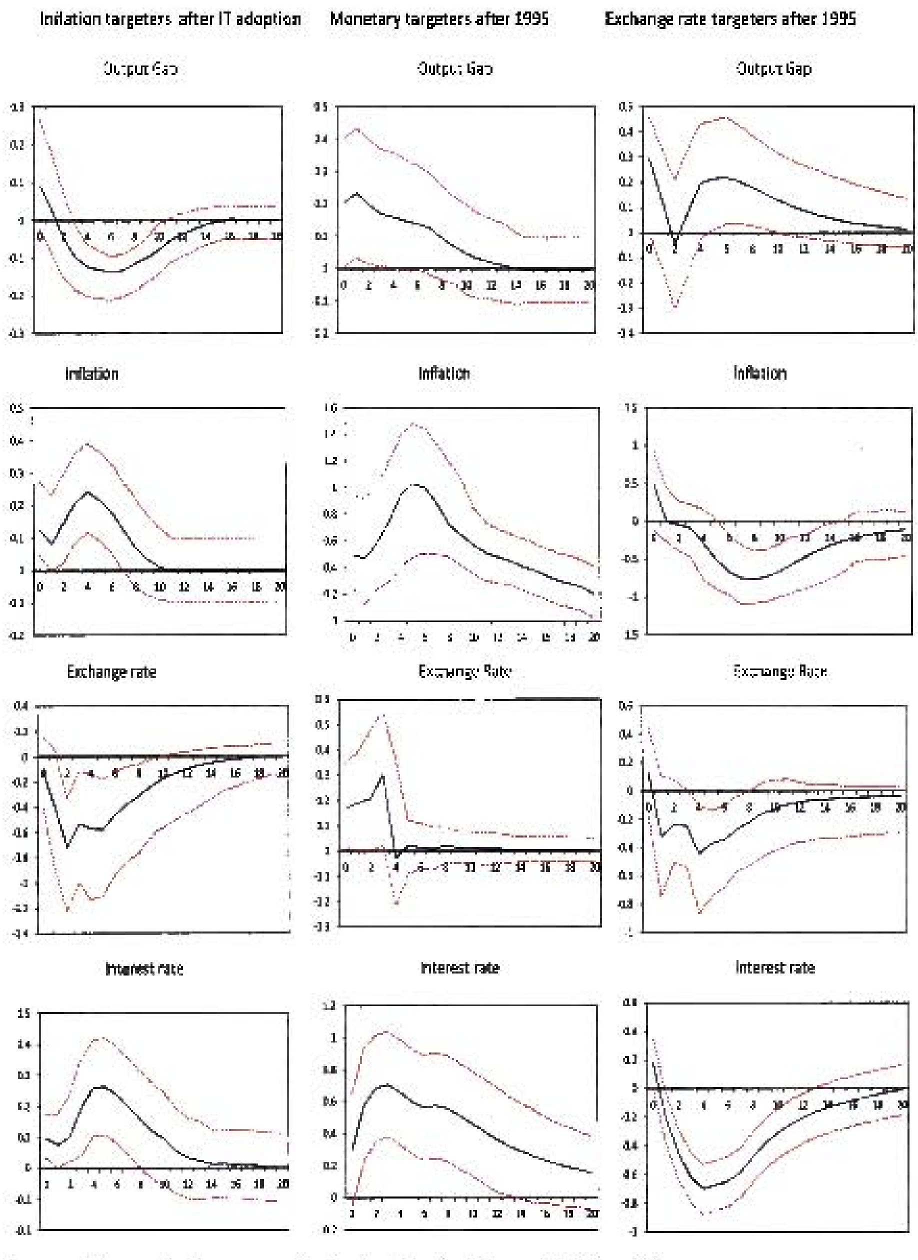
[18]The nominal exchange rate here is indirectly quoted.

aggressively in the pre-IT period than in the post-IT period. In fact, after IT adoption, central banks seem to respond to shocks more gradually as they try to smooth interest rates to reduce their volatility and improve the predictability of monetary policy (Svensson, 2000). The impulse responses of the interest rate after IT adoption are less hump shaped than the pattern observed in most theoretical DSGE models, thus further supporting the interest rate smoothing explanation (see e.g. Medina and Soto, 2005; Batini and Tereanu, 2010).

The analysis of results proceeds by comparing impulse responses of variables for IT countries and non-IT countries. To take into account the heterogeneity of non-inflation targeters in terms of monetary policy frameworks, non-inflation targeters are subdivided into monetary targeters and exchange rate targeters. To allow reasonable comparison with inflation targeters after IT adoption, the subsamples of monetary targeters and exchange rate targeters are considered after 1995, consistent with the inflation targeters's average adoption period in the 1990s. The impulse responses for inflation targeters after IT adoption and non-inflation targeters (monetary targeters and exchange rate targeters) after 1995 are shown in Figure 4.3.

The commodity terms of trade shock results in initial rise in output gap in all regimes, reflecting rising domestic demand due to overheating of the economies. There is less variability and slower adjustment of output gap in inflation targeters than monetary targeters and exchange rate targeters, reflecting the forward looking nature of IT regime which considers changes in the output gap as a signal to rising inflationary pressures (Svensson, 1997; Ball, 1998). Smaller output gap response under IT may also reflect deteriorating trade balance following the appreciation of the exchange rate. Monetary targeting give rise to large output gap fluctuations indicating that its credibility is not well established to deal with large commodity terms of trade shocks. Exchange rate targeters exhibit significantly greater output gap volatility and the response is more persistent compared to the first two regimes, reflecting the greater cyclicality of the output gap that is also observed in the descriptive analysis in Table C.1.4. This suggests that exchange rate targeters are greatly constrained by the fixed exchange rate in adjusting to parity, resulting in greater output gap volatility. Exchange rate targeters are more vulnerable to commodity terms of trade shocks than IT countries where flexible exchange

Figure 4.3: Impulse responses of variables to commodity terms of trade shocks: Inflation targeters, monetary targeters and exchange rate targeters



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

rates partially offset the output gap fluctuations. The result accords with the findings of Broda (2004) and Edwards and Yeyati (2005) who observe that terms of trade shocks are amplified in countries that have more rigid exchange rates, while countries with flexible exchange rates buffer shocks and reduce output volatility.

In all the three regimes, inflation rises on impact, following the surge in domestic demand especially for non-traded goods emanating from the wealth effect generated by a commodity terms of trade shock. Under monetary targeting, the effect is sharp and persistent, while it is modest under exchange rate targeting and more muted under IT. Precisely, the monetary targeting regime generates inflation response which is four times higher than in IT regime. The initial response under exchange rate targeting is double that of IT, reflecting restrained exchange rate adjustment. This puts pressure on domestic prices and inflation to rise. Consistent with other studies, the muted response of inflation in IT countries compared to monetary targeters and exchange rate targeters could possibly point to the anchoring of inflation expectations due to its credibility and flexibility in dealing with shocks. For instance, Batini and Tereanu (2010) find that IT forward looking rules exhibit less response than other rules following oil price shocks because of the forward looking and flexible nature of IT which reduces the propagation power of inflation. Similarly, Mishkin and Schmidt-Hebbel (2007) find that inflation responses are significantly less for inflation targeters than non-inflation targeters following oil price shocks because IT weakens the reaction of inflation to oil price shocks. The flexible exchange rate in IT also helps in dampening the response of inflation to shocks.

As expected, positive innovations in commodity terms of trade induce some appreciation of the nominal exchange rate during the period contemporaneous to the shock especially in IT countries. In this case, the strongest reaction occurs after two quarters, followed by the adjustment in the medium term. For monetary targeters the exchange rate depreciates on impact followed by a rather faster appreciation in the medium term as flexible exchange rate allows this adjustment to take place. This strong appreciation also acts to dampen domestic output under IT, resulting in low response of output gap. Under exchange rate targeting, the shock induces an initial depreciation which is followed by an immediate appreciation in the first quarter. Inflation targeters exhibit greater volatility of the exchange rate than other regimes, possibly due to the presence of the flexible exchange rate which act as an adjustment mechanism in the face of shocks. The lower response of exchange rate in exchange rate targeters is attributed to the fixed exchange rate, in line with theoretical expectations. This is supported by Gerlach and Gerlach-Kristen (2006) who point out that in exchange rate targeters, there is sluggish adjustments of the exchange rate which may imply no direct responses to terms of trade shocks.

In response to the rise in inflation, the central banks under all regimes respond by raising interest rates. On impact, IT central banks raise interest rates by 0.1%, followed by another 0.25% increase and then a gradual downward adjustment over time in tandem with inflation developments. For monetary targeters, the initial response is to raise interest rates by more basis points (0.3 %) and further to 0.7% in the third quarter, while the initial positive response for exchange rate targeters (0.2%) is short-lived. Therefore, interest rate responses are considerably more pronounced for monetary targeters than for inflation targeters and exchange rate targeters. As Calvo and Reinhart (2002) suggest, this may indicate lack of credibility in non-IT regimes, which calls for stronger policy action to counter inflationary pressures. For inflation targeters, the result may imply that there is interest rate smoothing which is implemented to avoid volatility in real activity (see e.g. Sack and Wieland, 2000). Since inflation and output gap are relatively stable under IT, this shows that central banks adjust interest rates to stabilise inflation by ensuring a more gradual and smoother return of output to its trend.

It is also important to analyse if there are any systematic differences of dynamic responses for non-inflation targeters before and after 1995. This helps to see if there might be a time effect on the response to shocks in different periods. Figure C.1 and C.2 presents the impulse responses for monetary targeters and exchange rate targeters for the period before and after 1995 respectively. In both cases, output gap responds less to commodity terms of trade shocks before 1995 than after 1995.[19] For monetary targeters, the responses are significant in the fourth and fifth quarters, while for exchange rate targeters the responses are significant in the second to eight quarters. The reaction of inflation is greater before 1995 than after 1995 in exchange rate targeters but the opposite reaction is observed

[19] See first rows of Figure C.1 and Figure C.2

for monetary targeters. Mishkin and Schmidt-Hebbel (2007) find larger inflation response to oil price shocks in non-inflation targeters after 1997 than before 1997.

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

4.5.2 Variance decompositions

This section assesses variance decompositions that is the variation of variables attributed to commodity terms of trade shocks. Table 4.5.1 presents the results.[20]

The results show that about 10.51% and 9.21% of variability in output gap in the short-run and longrun is explained by commodity terms of trade shocks before IT adoption. However, for the period after IT adoption, commodity terms of trade shocks account for less variability of output gap in the short run (7.13%) and in the long-run (5.03%), suggesting that the adoption of IT reduces output gap sensitivity to commodity terms of trade shocks. A similar pattern is also observed in the case of inflation, where commodity terms of trade shocks account for greater variability before IT adoption than after IT adoption. This suggests that inflation expectations have become anchored as credibility of monetary policy improves after IT adoption such that the effects of external shocks are not completely passed through to output and prices. One interesting result from this analysis is that both inflation and output gap are stabilised under inflation targeting, reflecting a reduction in the inflation-output volatility trade-off often observed in literature (see e.g. Erceg et al., 2000; Woodford, 2003). This suggests that IT provides a precommitment mechanism that helps that helps to reduce the inflation-output

[20]Although variance decompositions to shocks in other variables are computed, they are not reported because they are not relevant for the postulated hypothesis. This study is interested in the variation of the variables explained by commodity terms of trade shocks only.

Table 4.5.1: Variance decompositions

	Output gap		Inflation		Exchange rate		Interest rates	
	10	20	10	20	10	20	10	20
Inflation Targeters								
IT Before IT adoption	10.51	9.21	13.40	12.30	16.18	14.25	11.28	11.31
IT After IT adoption	7.13	5.03	7.58	4.73	15.53	13.68	12.03	12.31
Monetary Targeters								
MT before 1995	12.46	12.47	19.80	21.27	13.39	12.56	11.37	11.36
MT after 1995	12.25	11.25	19.47	16.49	13.09	13.09	12.02	12.93
Exchange rate targeters								
ET Before 1995	13.93	13.82	11.12	10.11	9.94	8.89	10.18	10.22
ET After 1995	25.66	18.81	12.08	11.96	8.86	8.87	13.65	13.48
IT, MT and ET								
IT after adoption	7.13	5.03	7.58	4.73	15.53	13.68	12.03	12.31
MT after 1995	12.25	11.25	17.47	16.49	13.09	13.09	12.02	12.93
ET after 1995	25.66	18.81	12.08	11.96	4.86	8.87	13.65	13.48

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

IT= inflation targeters, MT= Monetary targeters, ET = Exchange rate targeters gap volatility trade-off. However, in the case of interest rate variations, commodity terms of trade shocks account for greater variations after IT adoption than before IT adoption. This is in contrast to the earlier finding from impulse response function where interest rates were more responsive to shocks before IT adoption than after IT adoption.

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

Commodity terms of trade shock accounts for 17.47% and 16.49 % of inflation variation in 10 and 20 quarters under monetary targeting while contributing 12.08% and 11.96% in 10 and 20 quarters under exchange rate targeting. But the fluctuations of inflation accounted for by commodity terms of trade shocks are far less under inflation targeting, being 7.58% and 4.73% in 10 and 20 quarters respectively. This evidence reinforces earlier findings from impulse response analysis in this study, where inflation responses were more muted in IT countries than non-IT countries.

The variance decomposition of the exchange rate indicates that commodity terms of trade shocks explain about 13.09% and 8.86% in monetary targeters after 1995 and exchange rate targeters after 1995 respectively, compared to 15.53% in inflation targeters in the short-run. This shows that exchange rates are more volatile in IT countries than in non-IT countries, possibly due to the presence of flexible exchange rates. Other papers have reached a similar conclusion that terms of trade shocks account for larger variation of exchange rates in flexible exchange rate regimes than in pegs (see e.g. Bleaney and Fielding, 2002; Broda, 2004). Furthermore, commodity terms of trade shocks account for about 12.31% of the interest rate variation in 20 quarters for inflation targeters. This is less than in monetary targeters and exchange rate targeters with the variances of 12.93% and 13.48% respectively. This may suggest that when monetary policy is credible and predictable as presumed in IT countries, it can avoid costly responses to external shocks. The preceding analysis shows that IT outperforms monetary targeters and exchange rate targeters in stabilising macroeconomic variables following commodity terms of trade shocks.

4.6 Robustness analysis

This section provides robustness checks. Firstly, the results are tested to see their sensitivity to the ordering of variables in the panel VAR. The motivation for this test is that the Choleski decomposition is sensitive to the way variables are ordered in the panel VAR. Also, the test helps to overcome the criticism of arbitrary ordering of variables normally leveled on Choleski decomposition (Pesaran and Shin, 1998). The model is therefore reestimated with alternative ordering of variables where exchange rates are now ordered before inflation. The results are shown in Figure C.3 and Figure C.4. Generally, the shapes of impulse response functions of the output gap before and after IT adoption are similar to the baseline case. As in the baseline case, inflation responds strongly before inflation targeting while it responds with a delay after IT adoption. Similar impulse response patterns to the baseline are also observed for exchange rates, inflation and interest rates, where responses are large before IT adoption than after IT adoption. The comparison of different monetary policy regimes in Figure C.4 reveals that the profiles and shapes of impulse response functions are also similar to the baseline identification scheme and the conclusion is also consistent.[21] Thus the results are robust to alternative ordering of variables in the panel VAR.

[21] We also tried several alternative ordering arrangements for example inflation was ordered before output gap and exchange rate was ordered before output gap but the results did not change significantly.

Secondly, the panel VAR model is reestimated in first differences. This is motivated by the recent controversies about the need to difference data that has a time series component (see e.g. Enders, 2004). Also, there are several studies that have estimated panel VARs in first differences, which makes this alternative specification to be comparable with existing results (see e.g. Broda, 2004; Loayza and Raddatz, 2007). Figure C.5 reports the results before and after IT adoption while Figure C.6 reports the results under alternative monetary policy regimes. The responses of output gap, exchange rates and interest rates are broadly similar to the baseline case. The exception is the profile and shape of inflation response which is different since the adjustment is more immediate in the robustness model than in the baseline model. However, the significance of the impulse response functions deteriorate in the model with differenced variable compared with the baseline. Also, the impulse response functions from first differenced variables exhibit more cyclicality and unsmooth pattern than in the benchmark case. The possible explanation is that the data should be in levels and not in differences. This is supported by Francis and Ramey (2009) who note that overdifferencing can lead to imprecise and biased estimates in VARs. Nonetheless, the conclusion that the adoption of IT has stabilised most variables still hold.

Thirdly, the key identifying assumption in this chapter is the exogeneity of commodity terms of trade shocks. However, in the sample there are some relatively large economies which may control the market for particular commodities. Thus the chapter investigates the sensitivity of the results to the exclusion of these large economies in the estimations. Following Edwards and Yeyati (2005), large economies are defined as countries with aggregate real GDP in USD in the top quintile of the global real GDP distribution. The IMF's World Economic Outlook, 2008 is used to make this classification. The countries excluded from the estimations are Brazil, Russia, India and China (BRIC). Figure C.7 and Figure C.8 report the results for the period before and after IT adoption and across regimes respectively. In both cases, the magnitudes and dynamics of the responses are generally similar to those in the original specification. In fact, for the responses across regimes (Figure C.8), the output gap exhibits less volatility in IT countries than monetary targeters and exchange rate targeters. This is in line with Bleaney and Fielding (2002) who find higher output fluctuations in pegged exchange rate regimes than in flexible exchange rate regimes. Inflation exhibits less inertial effects in IT countries than in monetary targeters and exchange rate targeters. Also, as the original results show, exchange rate response is more muted in exchange rate targeters than in monetary targeters while it is highly volatile in inflation targeters. The muted response under ET is not a surprise considering the sluggish adjustment of the nominal exchange rate (Broda, 2004). Therefore the exclusion of big economies does not qualitatively change the results.

To ascertain the exogeneity of commodity terms of trade, the chapter conducts the Granger causality and block exogeneity test. The test investigates the statistical significance of the variables of the system based on the Wald test. The results are shown on Table C.1.6. Based on the overall p-value of the Chi-square, the null hypothesis of no Granger causality or no endogeneity of the dependent variable is accepted. This shows that commodity terms of trade is indeed exogenous, affirming the ordering of commodity terms of trade first in the panel VAR.

Fourthly, some studies claim that oil exporting countries may respond differently to shocks (see e.g Spatafora and Warner, 1995). To determine if the inclusion of oil exporters drives the results, the panel VAR model is reestimated with a sample that excludes major oil exporters. Table C.1.7 presents a list of major oil exporting countries which were excluded. Figure C.9 reports the impulse responses before and after IT adoption, while Figure C.10 reports the impulses for different monetary policy regimes. The results for the comparison of dynamic responses before and after IT adoption demonstrate some similarities with those in the benchmark specification. This is intuitive considering that the original sample of inflation targeters included only three oil exporters (Mexico, Indonesia and Colombia). Also for different regimes, it is observed that inflation responses tend to follow the dynamic pattern of output gap. However, interest rate responses are less persistent when oil exporters are excluded than in the benchmark case. A possible explanation is that oil exporting central banks do not respond aggressively to commodity terms of trade shocks compared to oil importers. Overall, the exclusion of oil exporters does not have a significant effect on the results.

Fifthly, in the baseline specification, 1995 was considered as the dividing year for non-inflation targeters based on the average period for the adoption of inflation targeting in the 1990s. However, in terms of distribution, with the exception of

Chile and Israel which adopted inflation targeting much earlier in the 1990s, most of the countries adopted inflation targeting in the late 1990s and early 2000s. Hence, an important question is how robust the results are to the average starting period of inflation targeting. To this effect, year 2000 is alternatively considered as the average starting period for inflation targeting and thus the dividing year for non-inflation targeters when the early IT adopters are not considered. The results are presented in Figure C.11. The results show that most of the variables display similar response patterns to the baseline case. The only exception is the response of inflation under exchange rate targeters which rises on impact and peaks at 0.43% in the first quarter before falling over time. However, when the responses are compared across monetary policy regimes in terms of volatility, conclusions similar to the baseline case are reached.

4.7 Conclusion

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

The empirical results show that in general, countries which have adopted inflation targeting respond better to commodity terms of trade shocks than countries which have not adopted this regime. However, commodity terms of trade shocks seem to propagate higher exchange rate volatility in inflation targeting countries than exchange rate targeting countries. Also, when the responses of variables to commodity terms of trade shocks before and after IT adoption are compared, the results show that the responses of output gap, inflation, nominal exchange rates and interest rates are substantially greater before than after IT adoption. This may suggest that inflation targeting helps countries to reduce macroeconomic response to commodity terms of trade shocks relative to their own pre-targeting experience. There is also evidence of interest rate smoothing in IT countries implying less aggressive responses to commodity terms of trade shocks.

The chapter also finds considerable evidence that commodity terms of trade disturbances account for greater variation in most variables in non-inflation targeting countries than in inflation targeting countries. They also explain greater variation in most variables before IT adoption than after IT adoption, both in the short-run and the long-run, reflecting smaller and less persistent response to commodity terms of trade shocks. This indicates that inflation targeting performs better than monetary targeting and exchange rate targeting in stabilising most macroeconomic variables. However, variance decomposition of exchange rates indicates that commodity terms of trade shocks explain greater variation in IT than non-IT countries.

The findings suggest that the adoption of IT makes a difference in the way macroeconomic variables respond to commodity terms of trade shocks. The more muted responses of output gap and inflation in IT countries than non-IT countries suggest that increasing the flexibility of exchange rates may provide further insulation against shocks. However, the increased flexibility of exchange rates in IT countries is associated with higher exchange rate volatility. This suggests that IT emerging market economies need to pay attention to the effects of exchange rate movements generated by commodity terms of trade shocks. Although commodity terms of trade shocks have undesirable effects on macroeconomic variables, this analysis shows that the adoption of inflation targeting can make the effects manageable

Chapter 5

Conclusion

5.1 Summary of findings

This thesis focuses on the interaction of two characteristics of emerging market economies (institutional weaknesses and vulnerability to terms of trade shocks) and their interactions with monetary policy and macroeconomic dynamics. These are discussed in three essays, where each essay constitutes a chapter. The first essay presented in Chapter 2 analyses the role of institutional structures in the achievement of inflation targets in emerging market economies. In this essay, the thesis contributes to the literature by taking stock of the intrinsic role played by institutional structures in the achievement of inflation targets since the adoption of IT in EMEs. The essay applies the panel ordered logit model, thereby also contributing methodologically to the literature.

In this first essay, the thesis has shown that improvement in central bank independence, fiscal discipline and financial sector development help in the achievement of inflation targets in EMEs. It has confirmed the view that monetary, fiscal and financial institutional structures matter for inflation targeting in EMEs. Higher CBI reduces inflation target deviations by shaping central bank incentives and increasing the credibility of commitments to price stability. Fiscal discipline promotes price stability by reducing the government's appetite for financing the budget deficit through seigniorage revenue. Similarly, deep financial systems also help to reduce fiscal dominance since budget deficits can be financed from capital markets. The results provide evidence that improvement in institutional structures enhance the effectiveness of monetary policy. Although institutional structures matter for the achievement of inflation targets in EMEs, the thesis has shown that other macroeconomic and structural factors such as output gap, exchange rate gap, openness and inflation target horizon also matter for inflation targeting.

In the second essay presented in Chapter 3, the thesis evaluates the alternative monetary policy responses to commodity terms of trade shocks using a DSGE model calibrated to the South African economy. In this essay, the thesis contributes to the literature by incorporating the commodity sector and focusing on the commodity terms of trade shock in a multi-sector DSGE model. The chapter has shown that in the face of commodity terms of trade shocks, CPI inflation targeting regime stabilises most variables better than non-traded inflation targeting and exchange rate targeting regime. However, in responding to commodity shocks, the CPI inflation targeting central bank encounters higher exchange rate volatility. This result highlights the policy maker's dilemma of how much exchange rate flexibility to tolerate while stabilising the macroeconomy. Also, in terms of welfare, the CIT regime performs better than NTIT regimes and ET regimes when the central bank is more concerned about inflation, interest rate and exchange rate stabilisation. However, when the central bank puts more weight on output stabilisation, it can benefit from targeting non-traded inflation. The analysis has shown that the when the commodity sector is incorporated in the model and commodity terms of trade are considered, CPI inflation targeting emerges as superior to domestic non-traded inflation targeting and exchange rate targeting in stabilising the economy and enhancing welfare. This finding is in contrast to most previous theoretical studies which have concluded that domestic inflation targeting is the optimal monetary policy.

Finally, the third essay presented in Chapter 4 has empirically analysed how different monetary policy regimes practised in emerging market economies respond to commodity terms of trade shocks in order to determine if inflation targeting makes a difference. The essay contributes empirically to the debate on the choice of monetary policy anchors for macroeconomic stabilisation in the face of commodity terms of trade shocks in EMEs.

Using a panel VAR technique, the analysis has shown that inflation targeting respond better than other regimes. The variables exhibit less volatility for the period before the adoption of inflation targeting than for the period after the adoption of inflation targeting. Exchange rate flexibility has important implications for the overall impact of shocks under alternative monetary policy regimes. In this case, flexible exchange rates dampen the impact of the shock on most variables, thus acting as a shock absorber. However, the use of flexible exchange rates under inflation targeting results in its greater volatility. The results also show that inflation targeting is associated with interest rate smoothing, which helps to make monetary policy credible and predictable. Commodity terms of trade shocks also explain substantial amount of variability of variables under monetary targeting regimes and exchange rate targeting regimes than under inflation targeting regimes. For inflation targeting countries, the contribution of commodity terms of trade to the variability of the variables is greater for the period before inflation targeting than for the period after inflation targeting. However, commodity terms of trade explain greater variation of exchange rates in inflation targeting countries than non-inflation targeting countries. The empirical analysis generally provides similar conclusions with those from the DSGE model that positive commodity terms of trade shocks generate exchange rate appreciations and that CIT regime induces higher exchange rate volatility than other regimes. However, the DSGE framework extends to the analysis of welfare implications and reach the same conclusion that CIT outperforms other monetary policy regimes. On the other hand, the empirical analysis extends to the analysis of variance decompositions and still concludes that inflation targeting is better than monetary targeting and exchange rate targeting.

5.2 Implications of the findings for policy

The thesis findings in Chapter 2 suggest that emerging market economies should continue to reform their monetary, fiscal and financial institutional structures in order to keep inflation under control. Since the strong effects of institutions are achieved when all institutions are improved, this implies that there should be coordination of monetary, fiscal and financial institutional structures in order to achieve sustainable price stability. The development of institutional structures to support price stability should be complemented by sound macroeconomic policies, since macroeconomic variables also explain inflation target deviations. The findings of the thesis also suggest that policy makers should pay attention to both domestic and external factors in their formulation of monetary policies.

The results of the investigation of alternative monetary policy responses to commodity terms of trade shocks presented in Chapter 3 generally suggest that the central bank can reduce macroeconomic volatility by targeting CPI inflation. However, this stabilisation comes at the cost of greater exchange rate volatility. This implies that when the central bank responds to external shocks, it should consider the economy's greater vulnerability to exchange rate fluctuations. The evidence from welfare analysis suggests that a small open economy exposed to the volatile commodity terms of trade shocks can reduce welfare losses by targeting CPI inflation.

On the empirical evaluation of the responses of commodity terms of trade shocks presented in Chapter 4, the findings imply that the adoption of inflation targeting makes it easier to manage the macroeconomic impacts of commodity terms of trade shocks. Increasing the flexibility of exchange rates is also necessary because it enhances the resilience of inflation targeting by providing further insulation against shocks. However, the increased flexibility of exchange rates in IT countries comes at the cost of higher exchange rate flexibility. This implies that IT emerging market economies need to pay attention to exchange rate fluctuations induced by commodity terms of trade shocks.

5.3 Suggestions for future research

The analysis of the role of institutions in inflation targeting has found that central bank independence, fiscal discipline and financial sector development matter for the achievement of inflation targets in emerging market economies. Future research can investigate the degree to which institutional structures help in anchoring inflation expectations. In this case, the focus will be on the deviation of actual inflation from the inflation forecast. Another fruitful research extension is the evaluation of whether the effects of institutions differ according to the monetary policy in place.

The thesis has also found that CPI inflation targeting frameworks perform better than other regimes in terms of reducing macroeconomic volatility and enhancing welfare. It would be useful to consider in future research, whether this result holds when commodity export prices are sticky in the currency of the producers. Also, an interesting extension would be the incorporation of uncertainty of the commodity terms of trade shocks in the model. Uncertainty about the size and duration of the commodity terms of trade shock may affect the results since monetary policy responses may depend on whether the shock is temporary or permanent. This consideration helps to avoid policy mistakes arising from a permanent shock mistakenly believed to be a temporary shock. The model can also be enriched by considering the role of fiscal policy, where its stabilisation effects are compared with those of monetary policy. In this case, the analysis can focus on the optimal monetary policy responses as well as possible benefits of monetary and fiscal policy coordination in dealing with commodity terms of trade shocks.

The empirical analysis has confirmed that inflation targeting stabilises the economy better than monetary targeting and exchange rate targeting. Further research can explore whether institutional quality enhances the robustness of monetary policy responses to commodity terms of trade shocks. The empirical analysis can also be extended to evaluate whether the level of financial sector development affects the degree to which countries respond to commodity terms of trade shocks. This is based on the presumption that more developed financial markets make it easier for monetary policy to dampen the impact of commodity terms of trade shocks on the economy.

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Appendix A

Appendix for Chapter 2

A.1 Marginal effects of the ordered logit model

This part illustrates the steps in estimating marginal effects. The first step consists of estimating the discrete choice panel model and obtain the estimated parameter $\widehat{\beta}$. The second step involves computing the predicted probabilities for each outcome using $\widehat{\beta}$; that is:

$$\widehat{p}_{jit} = prob(Y_{it} = j), \; j = 0, 1, 2. \tag{A.1}$$

These probabilities are given by:

$$\begin{aligned} \widehat{p}_{0it} &= F(L_{it} - X_{it}\widehat{\beta}), \\ \widehat{p}_{1it} &= F(U_{it} - X_{it}\widehat{\beta}) - F(L_{it} - X_{it}\widehat{\beta}), \\ \widehat{p}_{2it} &= 1 - F(U_{it} - X_{it}\widehat{\beta}). \end{aligned} \tag{A.2}$$

The third step consists of computing the marginal effects of each outcome by regressing $\Delta\widehat{p}_{jit}$, the first difference of $\widehat{p}_{jit}$ on ΔX_{it}, the first difference of X_{it} as follows :

$$\begin{aligned} \Delta\widehat{p}_{jit} &= \Delta X_{it}\theta_j + \eta_{jit}, \text{ for } j = 0, 1, 2. \\ \eta_{jit/\Delta X_{it}} &\sim N(0, \sigma^2) \end{aligned} \tag{A.3}$$

where θ_j is the vector of parameter values in regression j and η_{jit} the panel error term for regression j. The marginal effect is then given by

$$\widehat{\theta}_j = \left[(\Delta X)'(\Delta X)\right]^{-1}(\Delta X)'(\Delta\widehat{p}_j), \tag{A.4}$$

which is the estimated value θ_j using the fixed effect standard panel regression.

The estimation is done in GLLAMM module of Stata developed by Rabe-Hesketh et al. (2004). In this programme, the procedure involves the following three steps:

Step1: Run the *gllamm* command in Stata, making sure that *f(binom)* and *adapt* are set as options.

Step2: Compute the predicted probabilities for each outcome; the *gllapred* command can help to achieve this.

Step 3: Compute the marginal effects of each outcome, using *xtreg* to regress the first difference of the predicted probability of each outcome on the first difference of all the previous explanatory variables.

Table A.1.1: Summary of literature for Chapter 2

Author	Method	Findings
Buchanan and Wagner (1977)	Public choice theory	CBI increases the credibility of commitments to price stability
Kydland and Prescott (1977)	Dynamic inconsistency theory	CBI constrains money creation capacity of the government
Cukierman et al. (1992)	Panel data	CBI reduces inflation
Alesina and Summers (1993)	Panel data	CBI negatively affect inflation
Gosselin (2008)	Pooled panel data	Institutional factors reduce inflation target deviations
Sargent and Wallace (1981)	Fiscal dominance theory	Higher budget deficit increases inflation
De Haan and Zelhorst (1990)	Panel Data	Inflation and budget deficits are positively related
Fischer et al. (2002)	Panel data	Inflation and budget deficits are negatively related
Bernanke and Gertler (1995)	Credit channel MTM	Financial development increases monetary impulses
Neyapti (2003)	GMM	Developed financial markets help to reduce fiscal deficits
Cottarelli and Kourelis (1994)	Two stage least squares	Financial development enhances the effectiveness of monetary policy

Table A.1.2: Inflation targeting emerging market economies

Country	Adoption date	Target range*	Previous anchor	Target measure	Target horizon	Policy rate
Brazil	1999Q1	2-7	ER	CPIA	Ann/Multi Year	Celic rate
Chile	1991Q1	2-4	ER	CPI	Ann/Multi Year	Policy rate
Colombia	2000Q1	4.5-5.5	ER	CPI	Ann/Long term	Intervention rate
Czech Republic	1998Q1	2-4	ER & MS	CPI	Ann/Multi Year	Repo rate
Hungary	2001Q1	2.5-4.5	ER	CPI	Ann/Long term	Base rate
Indonesia	2005Q1	5-7	MS	CPI	Ann	Bank rate
Israel	1992Q1	1-3	ER	CPI	Ann/Indef	Bank rate
Mexico	1999Q1	2-4	ER	CPI	Ann/Long term	Overnight rate
Peru	1994Q1	1.5-3.5	MS	CPI	Indef	Reference rate
Philippines	2002Q1	5-6	ER & MS	CPI	Annual	Repo rate
Poland	1999Q1	1.5-3.5	ER	CPI	Ann/Med/Indef	Policy rate
South Africa	2000Q1	3-6	MS	CPIX	Ann/Med term	Repo rate
South Korea	1998Q1	2.5-3.5	MS	CPI	Ann/Med term	Base rate
Thailand	2000Q2	0-3.5	MS	Core CPI	Ann/Indef	Repo rate
Turkey	2006Q1	2-6	ER	CPI	Annual	Overnight rate

Key : ER= Exchange Rate, MS= Money supply , CPI= Consumer Price Index
Ann = Annual. Indef =Indefinate, Med term= medium term
*Inflation target ranges are for the end of 2008
Sources: Mishkin and Schmidt Hebbel (2007) and various central bank websites.

Table A.1.3: Variables description and sources

Variables	Description	Sources
infldc	Inflation deviations from the target bands. It is the ordinal discrete dependent variable.	IFS, Datastream and central bank websites.
lcbi	Logarithm of central bank independence index. The index is measured by legal cbi index. It is computed from sixteen different legal characteristics found in central bank laws.	Cukierman et al (1992), Crowe and Meade (2008), Polillo and Guillen (2005) and Authors' updates
lpcgdp	Logarithm of private credit to GDP ratio. The ratio measures the financial sector development. Credit that financial intermediaries issue to the private sector as a share of GDP.	World Development Indicators and IFS
bdgdp	Primary fiscal balance to GDP ratio measuring fiscal discipline. It reflects budget deficit or surplus.	IFS and Datastream
lygp	Output gap is the difference between the log of actual and trend GDP. Hodrick Prescott filter with a smoothing parameter of $\lambda = 1600$ is used in the estimation	Data obtained from IFS Output gap computed from HP filter
lexrg	The nominal exchange rate gap. It controls for exchange rate-inflation pass-through effects often observed in EMEs	Data obtained from IFS, but exchange rate gap computed from HP filter.
ltot	Logarithm of terms of trade index. The index is calculated as the ratio of export prices index over import prices index.	IFS and Datastream
lopen	logarithm of openness. The openness is measured by the ratio of exports plus imports over GDP. It measures the intensity of the economy's interaction into the world trade.	IFS
rts	Policy rates capture central bank interest rate policy decisions.	Central bank websites
inflg	Lagged value of inflation is measured as inflation from the past period.	IFS and Datastream
lhorzn	Logarithm of inflation target horizon is the number of periods it takes for inflation to return to target bands after a shock. It controls for structural features of inflation targeting.	Roger and Stone (2005)
lllgdp	Logarithm of liquid liabilities to GDP ratio as an alternative proxy for financial sector development. Are composed of currency plus demand and interest bearing liabilities of banks and non banks	IFS and World Development Indicators
dbtgdp	Government domestic debt as a percentage of GDP.	Global Insight and World Development Indicators
ltor	Logarithm of turnover rate of central bank governors. It is de facto measure of CBI.	Crowe and Meade (2008) and central bank websites

Table A.1.4: Correlation matrix of variables

	infdv	bdgdp	lexrg	ltot	rts	lcbi	lygp	lopen	lhorzn	lpcgdp	ltor	dbtgdp	lllgdp	inflg
infdc	1													
bdgdp	0.04	1												
lexrg	-0.16	0.01	1											
ltot	-0.02	-0.04	-0.17	1										
rts	-0.27	-0.3	0.01	-0.56	1									
lcbi	-0.04	-0.24	0.07	-0.19	0.15	1								
lygp	0.01	-0.05	-0.11	0.02	0.04	-0.01	1							
lopen	-0.01	0.12	-0.06	0.1	-0.5	0.08	-0.16	1						
lhorzn	0.04	-0.15	0.14	-0.04	0.31	-0.00	-0.02	-0.4	1					
lpcgdp	-0.08	0.32	0.01	0.33	-0.43	-0.05	0.04	0.42	-0.47	1				
ltor	0.15	-0.51	0.10	0.25	-0.03	-0.11	-0.02	-0.33	-0.08	0.03	1			
dbtgdp	0.08	0.45	0.13	0.08	0.35	0.36	-0.01	-0.38	0.42	-0.67	-0.06	1		
lllgdp	-0.03	0.02	-0.02	0.24	-0.30	-0.26	0.01	0.21	-0.23	0.78	0.03	-0.60	1	
inflg	0.46	0.04	0.05	-0.03	0.47	-0.09	-0.04	-0.16	-0.36	0.14	-0.03	0.14	0.33	1

Table A.1.5: Panel unit root tests based on the Fisher type test

Variables	lcbi	bdgdp	lpcgdp	ltot	lexrg	rts	lopen	lygp	ltor	dbtgdp	lllgdp	inflg	lhorzn
χ^2	477.4	265.8	77.1	456.2	70.1	85.0	41.8	413.6	62.2	56.8	100.7	55.2	64.4
P Value	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.01

H_0: Panel series not stationary

Table A.1.6: Panel cointegration tests using the Persyn and Westerlund technique

Statistic	Value	Z-value	P-value	Robust P-value
Gt	-2.98	-3.022	0.15	0.60
Ga	-16.44	0.65	0.75	0.94
Pt	10.51	-2.71	0.003	0.04
Pa	-16.81	-5.09	0.17	0.57

H_0: No cointegration

Dependent variable: infdv, independent variable: lcbi

Ga and Gt are group mean test statistics

Pt and Pa are pooled test statistics

Figure A.1: Institutional developments and inflation target outcomes in EMEs

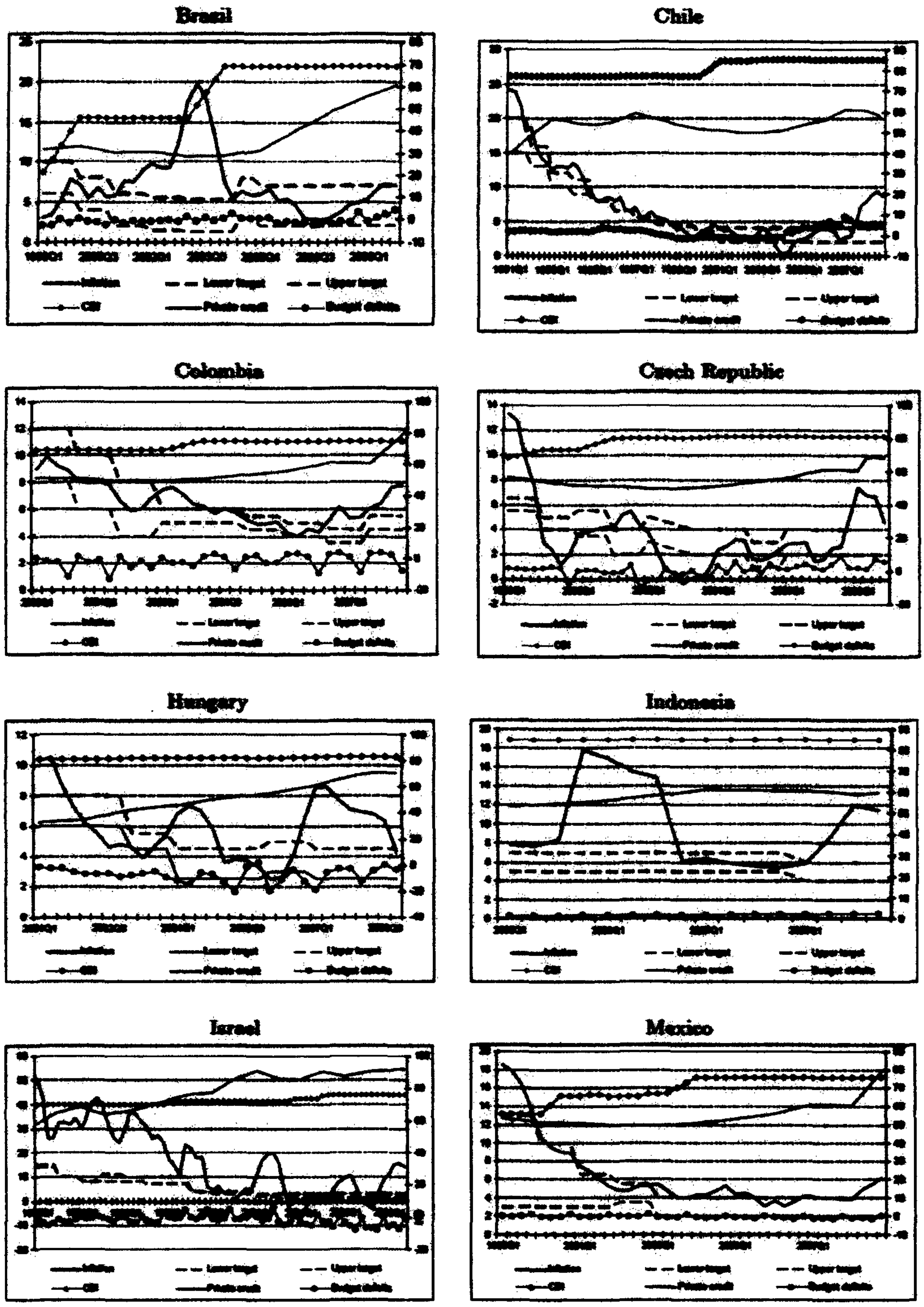
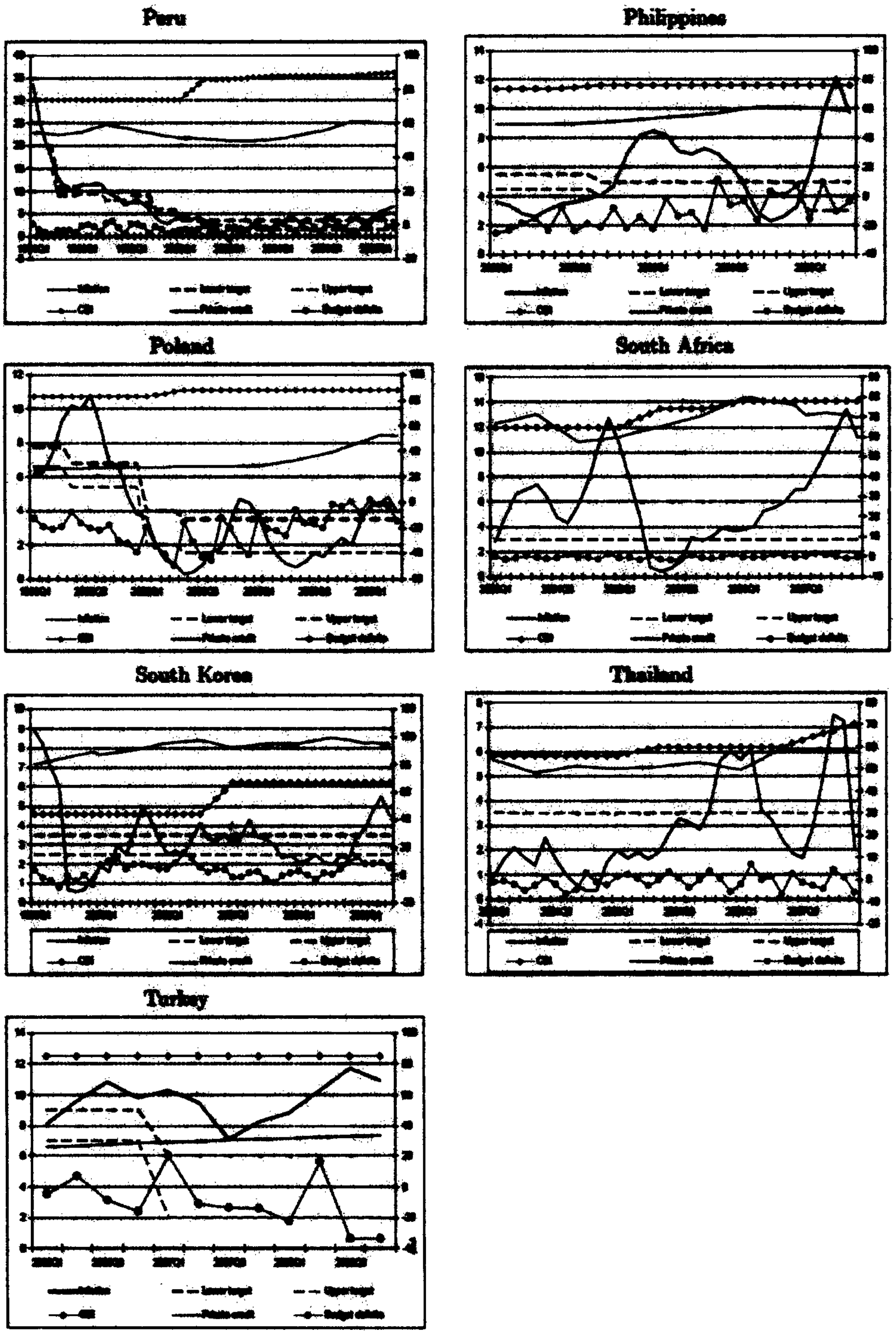


Figure A.1 continued: Institutional developments and inflation target outcomes in EMEs



Sources: Cukierman et al. (1992), Crowe and Meade (2008), Polillo and Guillen(2005), Mishkin and Schmidt Hebbel (2007), IFS, WDI, various central bank websites and author's computations.

Table A.1.7: Ordered probit results

	Model 6			Model 6'		
Variables	mfx_0	mfx_1	mfx_2	mfx_0	mfx_1	mfx_2
lygp	-0.348***	-0.0617**	0.348***	-0.228***	-0.0797	0.307***
	(0.0589)	(0.0288)	(0.0589)	(0.0629)	(0.0656)	(0.0606)
lexrg	-0.707***	-0.0582***	0.707***	-0.449***	-0.300***	0.750***
	(0.0639)	(0.0165)	(0.0639)	(0.0584)	(0.0718)	(0.0638)
ltot	-0.0916*	0.0293	0.0916*	-0.0486	-0.000989	0.0495
	(0.0470)	(0.0198)	(0.0470)	(0.0387)	(0.0477)	(0.0464)
lopen	-0.197***	-0.0178	0.197***	-0.159***	-0.0544	0.214***
	(0.0572)	(0.0146)	(0.0572)	(0.0511)	(0.0571)	(0.0581)
lhorzn	-0.120***	0.0572	0.120***	-0.143***	0.0367	0.106***
	(0.0411)	(0.0429)	(0.0411)	(0.0300)	(0.0444)	(0.0354)
rts	-0.0120**	0.0014**	0.0120**	-0.00955**	-0.00115	0.0107*
	(0.00576)	(0.000840)	(0.00576)	(0.00447)	(0.00352)	(0.00612)
inflg	-0.0258***	0.00119***	0.0258***	-0.0125***	-0.0142***	0.0267***
	(0.00611)	(0.000453)	(0.00611)	(0.00385)	(0.00327)	(0.00655)
lcbi	0.110***	0.00145*	-0.110***			
	(0.0338)	(0.00895)	(0.0338)			
bdgdp	-0.000271**	-0.00778***	0.000271***			
	(0.000408)	(0.000445)	(0.000408)			
lpcgdp	0.0613*	0.00178*	-0.0613*			
	(0.0522)	(0.00874)	(0.0522)			
ltor				0.00811	0.0170	-0.0251*
				(0.0103)	(0.0132)	(0.0142)
lllgdp				-0.100	-0.00403	0.104
				(0.0928)	(0.111)	(0.107)
dbtgdp				-0.00262***	-0.00355***	0.00618***
				(0.000357)	(0.000398)	(0.000340)
Constant	-0.00403	-6.09e-05	0.00403	-0.000974	-0.00212	0.00310
	(0.00309)	(0.000777)	(0.00309)	(0.00278)	(0.00289)	(0.00321)
Observations	586	586	586	586	586	586
R^2	0.487	0.334	0.487	0.384	0.330	0.601
Number of countries	15	15	15	15	15	15

Robust standard errors in parentheses, *** p<0.01, ** p<0.05, * p<0.1
Model 6 is the ordered probit model including initial institutional variables *lcbi*, *bdgdp* and *lpcgdp*
Model 6' is the ordered probit model including alternative institutional variables *ltor*, *dbtgdp* and *lllgdp*
mfx_0, mfx_1 and mfx_2 are marginal effects of having inflation below the band, within the band and above the band respectively.

Table A.1.8: Ordered logit results for the sample period 1991-1999

	Model 7			Model 7'		
Variables	mfx_0	mfx_1	mfx_2	mfx_0	mfx_1	mfx_2
lygp	-0.141**	-0.154*	0.295***	-0.121**	-0.192*	0.313***
	(0.433)	(0.286)	(0.266)	(0.447)	(0.335)	(0.216)
lexrg	-0.332*	-0.0200*	1.352*	-1.407**	-0.0942**	1.501**
	(0.577)	(0.398)	(0.594)	(0.528)	(0.353)	(0.555)
ltot	0.167**	0.187*	-0.354***	0.322***	0.164	-0.486***
	(0.0688)	(0.0872)	(0.0707)	(0.0764)	(0.0923)	(0.0557)
lopen	-0.0392	-0.204	0.243	-0.125	-0.180	0.305*
	(0.249)	(0.268)	(0.184)	(0.223)	(0.255)	(0.159)
lhorzn	-0.0354	0.0177	0.0177	0.0289	0.0493	-0.0782
	(0.0328)	(0.0460)	(0.0188)	(0.0483)	(0.0270)	(0.0705)
rts	-0.0171	-0.00734	0.0244	-0.00441	-0.00676	0.0112
	(0.0153)	(0.0121)	(0.0210)	(0.0107)	(0.0114)	(0.0184)
inflg	-0.00749*	-0.00812**	0.0156*	-0.0107***	-0.00791**	0.0186***
	(0.00418)	(0.00275)	(0.00683)	(0.00251)	(0.00306)	(0.00521)
lcbi	0.796*	0.491*	-0.305*			
	(0.042)	(0.024)	(0.340)			
bdgdp	-0.00394**	-0.000154**	0.00379**			
	(0.00453)	(0.00459)	(0.00424)			
lpcgdp	0.205	0.277	-0.482			
	(0.170)	(0.351)	(0.462)			
ltor				-0.0706	-0.0319	0.102
				(0.0589)	(0.0420)	(0.0982)
lllgdp				0.0998	0.342	-0.442
				(0.668)	(0.457)	(0.964)
dbtgdp				-0.0201**	-0.00764**	0.0124**
				(0.00381)	(0.00233)	(0.00177)
Constant	0.00893*	-0.000728	-0.00821	0.0147**	-0.00959*	-0.00511
	(0.00385)	(0.00548)	(0.00621)	(0.00590)	(0.00470)	(0.0101)
Observations	111	111	111	111	111	111
R^2	0.461	0.297	0.547	0.579	0.289	0.635
Number of countries	8	8	8	8	8	8

Robust standard errors in parentheses, *** p<0.01, ** p<0.05, * p<0.1

Model 7 is the ordered logit model for the period 1991- 1999 when baseline institutional variables (*lcbi,bdgdp and lpcgdp*) are included. Model 7' is the ordered logit model for the period 1991-1999 when alternative institutional variables (*ltor, dbtgdp,and lllgdp*) are included.

mfx_0, mfx_1 and mfx_2 are marginal effects of having inflation below the band, within the band and above the band respectively.

Table A.1.9: Ordered logit results for the period 2000-2008

	Model 8			Model 8'		
Variables	mfx0	mfx1	mfx2	mfx0	mfx1	mfx2
lygp	-0.0176**	-0.230**	0.248**	-0.0303**	-0.0909**	0.121**
	(0.113)	(0.139)	(0.0638)	(0.0818)	(0.0656)	(0.0606)
lexrg	-0.280***	-0.333**	0.612***	-0.279***	-0.255*	0.534***
	(0.0645)	(0.120)	(0.0953)	(0.0728)	(0.143)	(0.103)
ltot	0.0516	-0.131*	0.0794	-0.00689	-0.129	0.136**
	(0.0581)	(0.0639)	(0.0521)	(0.0617)	(0.0761)	(0.0482)
lopen	-0.0914*	-0.141*	0.233**	-0.125*	-0.0388*	0.164**
	(0.0578)	(0.0698)	(0.0578)	(0.0644)	(0.0547)	(0.0570)
lhorzn	-0.187*	0.0864	0.101	-0.201*	0.0380	0.163**
	(0.0770)	(0.171)	(0.0977)	(0.0857)	(0.131)	(0.0571)
rts	-0.00137	-0.00123	0.00260	-0.00122	0.000649	0.000571
	(0.00636)	(0.00795)	(0.00487)	(0.00607)	(0.00570)	(0.00574)
inflg	-0.0428***	-0.0324***	0.0753***	-0.0441***	-0.0327***	0.0768***
	(0.00622)	(0.00856)	(0.00885)	(0.00677)	(0.00843)	(0.00947)
lcbi	0.130	0.436	-0.306*			
	(0.262)	(0.316)	(0.0940)			
bdgdp	-0.00439***	-0.00113***	0.00552***			
	(0.000899)	(0.00141)	(0.000588)			
lpcgdp	0.170***	0.0301***	-0.140***			
	(0.0273)	(0.0526)	(0.0364)			
ltor				-0.0113*	-0.0320*	0.0433*
				(0.0146)	(0.0173)	(0.0132)
lllgdp				-0.0414	-0.252	0.293*
				(0.193)	(0.199)	(0.0972)
dbtgdp				-0.000107**	-0.00150**	0.00161**
				(0.000269)	(0.000238)	(0.000160)
Constant	0.00147	-0.000386	-0.00109	0.00226*	-0.000524	-0.00174
	(0.00112)	(0.00191)	(0.00131)	(0.00110)	(0.00174)	(0.00114)
Observations	466	466	466	466	466	466
R^2	0.502	0.225	0.732	0.475	0.225	0.718
Number of countries	15	15	15	15	15	15

Robust standard errors in parentheses, *** p<0.01, ** p<0.05, * p<0.1

Model 8 is the ordered logit model for the period 2000-2008 when baseline institutional variables (*lcbi,bdgdp and lpcgdp*) are included. Model 8' is the ordered logit model for the period 2000-2008 when alternative institutional variables (*ltor, dbtgdp and lllgdp*) are included.

mfx_0, mfx_1 and mfx_2 are marginal effects of having inflation below the band, within the band and above the band respectively.

Table A.1.10: Ordered logit results for the sample which excludes 2007-2008

	Model 9			Model 9'		
Variables	mfx_0	mfx_1	mfx_2	mfx_0	mfx_1	mfx_2
lygp	-0.139***	-0.374***	0.513***	-0.180***	-0.112***	0.292***
	(0.0495)	(0.0857)	(0.0639)	(0.0564)	(0.0495)	(0.0374)
lexrg	-0.781***	-0.403***	1.184***	-0.859***	-0.311**	1.169***
	(0.0997)	(0.126)	(0.107)	(0.116)	(0.117)	(0.102)
ltot	0.0467	-0.118	0.0718	-0.0106	-0.00572	0.0164
	(0.0394)	(0.0840)	(0.0522)	(0.0291)	(0.0410)	(0.0306)
lopen	0.00773**	-0.128**	0.121**	-0.00541**	-0.0837**	0.0891**
	(0.0626)	(0.0712)	(0.0509)	(0.0677)	(0.0669)	(0.0383)
lhorzn	-0.120***	0.135*	-0.0152	-0.0941***	0.0650	0.0291
	(0.0386)	(0.0721)	(0.0524)	(0.0276)	(0.0527)	(0.0579)
rts	-0.00703*	-0.00122	0.00825	-0.00700*	-0.00110	0.00811
	(0.00337)	(0.00341)	(0.00502)	(0.00391)	(0.00326)	(0.00554)
inflg	-0.0100***	-0.0118***	0.0218***	-0.0108***	-0.0126***	0.0233***
	(0.00282)	(0.00326)	(0.00527)	(0.00344)	(0.00387)	(0.00673)
lcbi	0.000813*	0.0776*	-0.0784*			
	(0.0675)	(0.0644)	(0.0108)			
bdgdp	-0.00662***	-0.000512***	0.00714***			
	(0.000734)	(0.00158)	(0.000975)			
lpcgdp	0.0350*	0.297*	-0.261*			
	(0.0727)	(0.152)	(0.130)			
ltor				0.00562*	0.0466*	-0.0522*
				(0.0126)	(0.0229)	(0.0188)
lllgdp				0.214**	0.444***	-0.230**
				(0.148)	(0.141)	(0.124)
dbtgdp				-0.000854**	-0.00326***	0.00411***
				(0.000349)	(0.000369)	(0.000480)
Constant	-0.000753	0.00112	-0.000366	-0.000378	0.00120	-0.000826
	(0.00116)	(0.00175)	(0.00172)	(0.000364)	(0.000946)	(0.00106)
Observations	466	466	466	466	466	466
R^2	0.467	0.262	0.647	0.375	0.252	0.606
Number of countries	15	15	15	15	15	15

Robust standard errors in parentheses, *** $p<0.01$, ** $p<0.05$, * $p<0.1$
Model 9 is the ordered logit model including all institutional variables the for period excluding 2007-8
Model 9' is the ordered logit model including all alternative institutional variables for period excluding 2007-8
mfx_0, mfx_1 and mfx_2 are marginal effects of having inflation below the band, within the band and above the band respectively.

Appendix B

Appendix for Chapter 3

B.1 Household optimisation

$$Max\ U = E_0 \sum_{t=0}^{\infty} \beta^t \left(\frac{C_t^{1-\sigma}}{1-\sigma} - \eta \frac{L_t^{1+\psi}}{1+\psi} \right)\ s.t\ P_t C_t = W_t L_t + \Pi_t + D_t - E_t(Q_{t+1} D_{t+1}) \tag{B.1}$$

First order conditions:

$$\frac{d\mathcal{L}}{dC_t} = C_t^{-\sigma} = -\lambda_t P_t \tag{B.2}$$

$$C_{t+1}^{-\sigma} = -\lambda_{t+1} P_{t+1} \tag{B.3}$$

Dividing equation (B.3) by (B.2) gives:

$$\left(\frac{C_t+_1}{C_t} \right)^{-\sigma} = \frac{-\lambda_{t+1} P_{t+1}}{-\lambda_t Pt} \tag{B.4}$$

$$\frac{d\mathcal{L}}{dL_t} = \frac{-\eta L_t^{\psi}}{W_t} = \lambda_t \tag{B.5}$$

Substituting equation (B.2) into (B.5):

$$C_t^{\sigma} \eta L_t^{\psi} = \frac{W_t}{P_t} \tag{B.6}$$

$$\frac{d\mathcal{L}}{dD_t} = \frac{E_t\left(Q_{t+1}\right)}{\beta} = \frac{\lambda_{t+1}}{\lambda_t} \tag{B.7}$$

Combining (B.7) and (B.4) gives:

$$\beta\left(\frac{C_{t+1}}{C_t}\right)^{-\sigma}\left(\frac{P_t}{P_{t+1}}\right) = E_t\left(Q_{t+1}\right) \tag{B.8}$$

Using $E_t\left(Q_{t+1}\right) = R_t^{-1}$ and substituting in equation (B.8) gives:

$$\beta R_t E_t\left(\left(\frac{C_{t+1}}{C_t}\right)^{-\sigma}\left(\frac{P_t}{P_{t+1}}\right)\right) = 1 \tag{B.9}$$

B.2 Real exchange rate and commodity terms of trade

Real exchange rate is given by:

$$\mathbb{Q}_t = \frac{\varepsilon_t P_t}{P_t^*} \tag{B.10}$$

The law of one price is assumed to hold for both imports and exports such that:

$$P_{Xt} = \frac{P_{Xt}^*}{\varepsilon_t} \tag{B.11}$$

$$P_{Tt} = \frac{P_{Tt}^*}{\varepsilon_t} \tag{B.12}$$

Substituting P_t and P_t^* from equations (3.4) and (3.31) into (B.10) gives:

$$\mathbb{Q}_t = \frac{\varepsilon_t P_{Nt}^{\alpha} P_{Tt}^{1-\alpha}}{P_{Nt}^{*\alpha^*} P_{Tt}^{*1-\alpha^*}} \tag{B.13}$$

Substituting P_{Nt}, P_{Tt} and P^*_{Nt} from equations (3.24), (3.29) and (3.34) into gives:

$$\mathbb{Q}_t = \frac{\left(\frac{A_{Xt}}{A_{Nt}}\varepsilon_t P_{Xt}\right)^{\alpha} (P^*_{Tt})^{1-\alpha^*} \left(\frac{1}{MC^R_{Nt}}\right)^{\alpha}}{\left(\frac{A^*_{It}}{A^*_{Nt}} P^*_{It}\right)^{\alpha^*} (P^*_{Tt})^{1-\alpha^*}} \tag{B.14}$$

Substituting $\varepsilon_t P_{Xt} = P^*_{Xt}$, into equation (B.14) and assuming that $\alpha = \alpha^*$, gives:

$$\mathbb{Q}_t = \left(\frac{A_{Xt}}{A^*_{It}}\frac{A^*_{Nt}}{A_{Nt}}\frac{P^*_{Xt}}{P^*_{It}}\right)^{\alpha} \left(\frac{1}{MC^R_{Nt}}\right)^{\alpha} \tag{B.15}$$

B.3 International risk sharing and uncovered interest parity

$$\beta E_t \left(\frac{C_{t+1}}{C_t}\right)^{-\sigma} \left(\frac{P_t}{P_{t+1}}\right) = E_t\left(Q_{t+1}\right) \tag{B.16}$$

Since $E_t\left(Q_{t+1}\right) = \frac{1}{Rt}$, equation (B.16) can be written as:

$$\beta E_t \left(\frac{C_{t+1}}{C_t}\right)^{-\sigma} \left(\frac{P_t}{P_{t+1}}\right) = \frac{1}{Rt} \tag{B.17}$$

International risk sharing implies that:

$$\beta E_t \left(\frac{C^*_{t+1}}{C^*_t}\right)^{-\sigma} \left(\frac{\varepsilon_t P^*_t}{\varepsilon_{t+1} P^*_{t+1}}\right) = \frac{1}{Rt} \tag{B.18}$$

Equating domestic and foreign consumption and solving gives:

$$C_t^{-\sigma} = \left[\frac{C_{t+1}C^*_t}{C^*_{t+1}}\right]^{-\sigma} \left(\frac{P_t}{P_{t+1}}\right) \left(\frac{\varepsilon_{t+1}P^*_{t+1}}{\varepsilon_t P^*_t}\right) \tag{B.19}$$

But $\mathbb{Q}_t = \frac{\varepsilon_t P_t}{P^*_t}$; and $\mathbb{Q}_{t+1} = \frac{\varepsilon_{t+1}P_{t+1}}{P^*_{t+1}}$, substituting into (B.19):

$$C_t = \left(\frac{C_{t+1}}{C^*_{t+1}}\right) \frac{1}{\mathbb{Q}_{t+1}^{\frac{1}{\sigma}}} \mathbb{Q}_t^{\frac{1}{\sigma}} C^*_t \tag{B.20}$$

As shown in Gali and Monacelli (2005), iterating equation (B.20) results in:

$$C_t = \Omega Q_t^{\frac{1}{\sigma}} C_t^* \tag{B.21}$$

where Ω is a constant that represents initial asset positions.

Under complete markets, the uncovered interest parity condition can be derived as follows:

$$\beta E_t \left(\frac{C_{t+1}}{C_t}\right)^{-\sigma} \left(\frac{P_t}{P_{t+1}}\right) = E_t Q_{t+1} = \frac{1}{R_t} = \beta E_t \left(\frac{C^*_{t+1}}{C^*_t}\right)^{-\sigma} \left(\frac{\varepsilon_t P^*_t}{\varepsilon_{t+1} P^*_{t+1}}\right) \tag{B.22}$$

Also,

$$\beta E_t \left(\frac{C^*_{t+1}}{C^*_t}\right)^{-\sigma} \left(\frac{P^*_t}{P^*_{t+1}}\right) = \frac{1}{R^*_t} \tag{B.23}$$

Substituting (B.22) and $\frac{1}{R_t}$ for $E_t Q_{t+1}$ into (B.23) gives:

$$E_t Q_{t+1} = \frac{1}{R^*_t} \frac{\varepsilon_t}{E_t \varepsilon_{t+1}} \tag{B.24}$$

(B.24) can be written as:

$$E_t Q_{t+1} R^*_t \frac{\varepsilon_{t+1}}{\varepsilon_t} = 1 \tag{B.25}$$

Subtracting $E_t Q_{t+1} R_t = 1$ from B.25 leads to:

$$E_t Q_{t+1} (R_t - R^*_t \frac{\varepsilon_{t+1}}{\varepsilon_t}) = 0 \tag{B.26}$$

Log-linearising around the steady state:

$$r_t - r^*_t = E_t \Delta e_{t+1} \tag{B.27}$$

Combining equation (B.27) with the log-linearised version of (B.10) gives:

$$E_t \Delta q_{t+1} = (r_t + E_t \pi_{t+1}) - (r^*_t + E_t \pi^*_{t+1}) \tag{B.28}$$

B.4 Domestic price setting

Optimisation problem for optimising firms in the non-traded sector is:

$$Max \sum_{t=0}^{\infty} (\theta_N)^k E_t \left\{Q_{t+k} Y_{t+k} \left(P_{Nt}^{new} - MC_{Nt+k}^{n}\right)\right\}$$

$$s.t\ Y_{t+k} \leq \left(\frac{P_{Nt}^{new}}{P_{Nt+k}}\right)^{-\varepsilon} \left(C_{Nt+k} + C_{Nt+k}^{new}\right) \tag{B.29}$$

where MC_{Nt+k}^{n} is the nominal marginal cost and $\theta_N^k E_t Q_{t+k}$ is the effective stochastic discount factor. Substituting Y_{t+k} and expanding:

$$\mathcal{L} = \sum_{t=0}^{\infty} (\theta_N)^k E_t \left\{ Q_{t+k} \left(\frac{P_{Nt}^{new^{1-\varepsilon}}}{P_{Nt+k}^{-\varepsilon}} \right) \left(C_{Nt+k} + C_{Nt+k}^{new}\right) - \left(\frac{P_{Nt}^{new}}{P_{Nt+k}}\right)^{-\varepsilon} \left(C_{Nt+k} + C_{Nt+k}^{new}\right) MC_{Nt+k}^{n} \right\} \tag{B.30}$$

$$\frac{d\mathcal{L}}{dP_{Nt}^{new}} = \sum_{t=0}^{\infty} (\theta_N)^k E_t \left\{ \begin{array}{c} Q_{t+k}(1-\varepsilon) \left(\frac{P_{Nt}^{new}}{P_{Nt+k}}\right)^{-\varepsilon} \left(C_{Nt+k} + C_{Nt+k}^{new}\right) + \\ \varepsilon \left(\frac{P_{Nt}^{new^{-\varepsilon-1}}}{P_{Nt+k}^{-\varepsilon}} \right) \left(C_{Nt+k} + C_{Nt+k}^{new}\right) MC_{t+k}^{n} \end{array} \right\} = 0 \tag{B.31}$$

Substituting the value of Y_{t+k}, and factorising gives the first order condition:

$$\sum_{t=0}^{\infty} (\theta_N)^k E_t \left\{ Q_{t+k} Y_{t+k} \left(P_{Nt}^{new} - \frac{\varepsilon}{\varepsilon - 1} MC_{Nt+k}^{n} \right) \right\} = 0 \tag{B.32}$$

Using the fact that $E_t(Q_{t+1}) = \beta \left(\frac{C_{t+1}}{C_t}\right)^{-\sigma} \left(\frac{P_t}{P_{t+1}}\right)$ which implies that $(Q_{t+k}) = \beta^k E_t \left(\frac{P_t}{P_{t+k}}\right) \left(\frac{C_{Nt+k}}{C_{Nt}}\right)^{-\sigma}$ and applying to (B.32) results in:

$$\sum_{t=0}^{\infty} (\beta\theta_N)^k E_t \left\{ P_{Nt} C_{Nt}^{-\sigma} P_{t+k}^{-1} C_{Nt+k}^{-\sigma} Y_{t+k} \left(P_{Nt}^{new} - \frac{\varepsilon}{\varepsilon - 1} MC_{Nt+k}^{n} \right) \right\} = 0 \tag{B.33}$$

Since $P_{Nt} C_t^{-\sigma}$ are known at time t, they can be taken off. Thus (B.33) becomes:

$$\sum_{t=0}^{\infty} (\beta\theta_N)^k E_t \left\{ P_{Nt+k}^{-1} C_{Nt+k}^{-\sigma} Y_{t+k} \left(P_{Nt}^{new} - \frac{\varepsilon}{\varepsilon - 1} MC_{Nt+k}^{n} \right) \right\} = 0 \tag{B.34}$$

Using the definition of real marginal costs $MC^R_{t+k} = \frac{MC^n_{Nt+k}}{P_{Nt+k}}$ and substituting into equation (B.34), dividing by $\frac{P_{Nt-1}}{P_{Nt-1}}$ and factorising P_{Nt-1} gives:

$$\sum_{t=0}^{\infty} (\beta\theta_N)^k E_t \left\{ C^{-\sigma}_{t+k} Y_{t+k} \frac{P_{Nt-1}}{P_{Nt+k}} \left(\frac{P^{new}_{Nt}}{P_{Nt-1}} - \frac{\varepsilon}{\varepsilon - 1} MC^R_{Nt+k} \left(\frac{P_{Nt+k}}{P_{Nt-1}} \right) \right) \right\} = 0 \tag{B.35}$$

where $\frac{\varepsilon}{\varepsilon-1}$ is the markup. Using the geometric sum formula $\sum_{t=0}^{\infty} (\beta\theta_N)^k = \frac{1}{1-\theta_N\beta}$ and log-linearising, gives:

$$p^{new}_{Nt} = p_{Nt-1} + \sum_{t=0}^{\infty} (\beta\theta_N)^k \left\{ E_t \pi_{Nt+k} + (1 - \beta\theta_N) E_t mc^R_{Nt+k} \right\} \tag{B.36}$$

Rewriting equation (B.36) after splitting the equation into two parts t and $t+1$ to ∞:

$$p^{new}_{Nt} = p_{Nt-1} + \pi_{Nt} + (1-\beta\theta_N) mc^R_t + (\theta_N\beta) \sum_{t=0}^{\infty} (\theta_N\beta)^k \left\{ E_t \pi_{Nt+k} + (1 - \beta\theta_N) E_t mc^R_{Nt+k} \right\} \tag{B.37}$$

Using equation (B.36) to substitute the last term of equation (B.37) and rearranging:

$$p^{new}_{Nt} - p_{Nt-1} = (\theta_N\beta) \left\{ E_t \pi_{Nt+1} - p^{new}_{Nt+1} \right\} + \pi_{Nt} + (1 - \beta\theta_N) mc^R_{Nt} \tag{B.38}$$

Substituting $p^{new}_{Nt} - p_{Nt-1}$ of equation (B.37) into equation (B.38) and solving for π_{Nt}:

$$\pi_{Nt} = \beta E_t \pi_{Nt+1} + \lambda_{Nt} mc^R_{Nt} \tag{B.39}$$

where $\lambda_{Nt} = \frac{(1-\beta\theta_N)(1-\theta_N)}{\theta_N}$ and θ_N is the stickiness parameter.

B.5 Equations characterising the model

$$c_t = E_t c_{t+1} - \frac{1}{\sigma}(r_t - E_t \pi_{t+1}) \tag{B.40}$$

$$\pi_t = \alpha\pi_{N_t} + (1 - \alpha)\pi_{Tt} \tag{B.41}$$

$$p_{Nt} = a_{Xt} - a_{Nt} + p^*_{Xt} - e_t \tag{B.42}$$

$$\pi_{Nt} = \beta E_t \pi_{Nt+1} + \lambda_{Nt} mc^R_{Nt} \tag{B.43}$$

$$\pi_{Tt} = \nu \pi^*_{I_t} + (1-\nu)\pi^*_{X_t} - e_t \tag{B.44}$$

$$y_{Nt} = -\rho(1-\alpha)\left[p_{Nt} + e_t - p^*_{Tt}\right] + c_t \tag{B.45}$$

$$y_{X_t} = y^*_{Tt} + \nu(p^*_{Xt} - p^*_{It}) \tag{B.46}$$

$$y_t = y_{Nt}\left(\frac{\overline{Y}_N}{\overline{Y}}\right) + y_{X_t}\left(\frac{\overline{Y}_X}{\overline{Y}}\right) \tag{B.47}$$

$$l_t = \frac{L_X}{L}(y_{Xt} - a_{Xt}) + \frac{L_N}{L}(y_{Nt} - a_{N_t}) \tag{B.48}$$

$$q_t = \alpha(a_{Xt} - a^*_{It} + a^*_{Nt} - a_{Nt} + f_t - mc^R_{Nt}) \tag{B.49}$$

$$e_t = q_t - \alpha p_{Nt} - (1-\alpha)(p^*_{Tt} - e_t) + \alpha^* p^*_{Nt} + (1-\alpha^*)p^*_{Tt} \tag{B.50}$$

$$f_t = f_{t-1} + \pi^*_{X_t} - \pi^*_{It} + \epsilon_{ft} \tag{B.51}$$

$$r_t = \rho_r r_{t-1} + (1-\rho_r)(\omega_1 y_t + \omega_2 \pi_t + \omega_3 \pi_{Nt} + \omega_4 \Delta e_t) + \epsilon_{r,t} \tag{B.52}$$

$$mc^R_X = \sigma c_t + \psi l_t + (1-\alpha)(p^*_{Tt} - e_t) + \alpha p_{Nt} - p^*_{Xt} + e_t - a_{Xt} \tag{B.53}$$

$$mc^R_{Nt} = \sigma c_t + \psi l_t + \alpha p_{N_t} + (1-\alpha)(p^*_{Tt} - e_t) - p_{Nt} - a_{Nt} \tag{B.54}$$

$$a_{Xt} = \rho_X a_{Xt-1} + \epsilon_{X_t} \tag{B.55}$$

$$a_{Nt} = \rho_N a_{Nt-1} + \epsilon_{Nt} \tag{B.56}$$

$$a_{N^*_t} = \rho_{N^*} a_{N^*_{t-1}} + \epsilon_{N^*_t} \tag{B.57}$$

$$a_{I^*_t} = \rho_{I^*} a_{I^*_{t-1}} + \epsilon_{I^*_t} \tag{B.58}$$

$$p^*_{Nt} = a^*_{It} - a^*_{Nt} + p^*_{It} \tag{B.59}$$

$$y^*_{Tt} = \nu(y^*_{It}) + (1-\nu)y^*_{Xt} \tag{B.60}$$

$$p^*_{Tt} = \nu(p^*_{It}) + (1-\nu)p^*_{Xt} \tag{B.61}$$

$$\pi^*_{Tt} = \nu \pi^*_{I_t} + (1-\nu)\pi^*_{X_t} \tag{B.62}$$

$$r_t - r^*_t = E_t \Delta e_{t+1} \tag{B.63}$$

$$r_t^* = \rho_{r^*} r_{t-1}^* + \epsilon_{r^*,t} \tag{B.64}$$

$$y_t^* = \alpha^* y_{Nt}^* + (1-\alpha^*) y_{Tt}^* \tag{B.65}$$

$$p_{It}^* = \rho_{p_I^*} p_{It-1}^* + \epsilon_{p_{I_t}^*} \tag{B.66}$$

$$\pi_{It}^* = \rho_{p_I^*} \pi_{It-1}^* + \epsilon_{\pi_{I_t}^*} \tag{B.67}$$

$$p_{Xt}^* = \rho_{p_X^*} p_{X_{t-1}}^* + \epsilon_{p_{X_t}^*} \tag{B.68}$$

$$\pi_{Xt}^* = \rho_{\pi_X^*} \pi_{X_{t-1}}^* + \epsilon_{\pi_{X_t}^*} \tag{B.69}$$

$$y_{Xt}^* = y_{I_t}^* + (p_{Xt}^* - p_{It}^*) \tag{B.70}$$

$$y_{Nt}^* = -\rho^* p_{Nt}^* + \rho^*(\alpha^* p_{Nt}^* + (1-\alpha^*) p_{Tt}^*) + y_t^* \tag{B.71}$$

Table B.5.1: Summary of the literature for Chapter 3

Author	Method	Findings
Aoki (2001)	Two sector model	Sticky price inflation targeting is optimal
Laxton and Pesenti (2003)	Small open economy model	Inflation forecast based rules perform better than conventional Taylor rules
Parrado (2004)	DSGE model	DIT performs better than CIT and ET
Gali and Monaceli (2005)	Small open economy DSGE model	DIT is better than CIT and ET
Santacreu (2005)	Bayesian DSGE model	CIT performs better than NTIT
Devereaux et al. (2006)	Small open economy DSGE model	CIT generally performs better than NTIT and ET
Alpanda et al. 2010	Small open economy DSGE model	Optimal policy places a big weight on output and inflation than estimated Taylor rule

Table B.5.2: Sensitivity tests on volatility

	High openness			No price stickiness			Low elasticity of substitution		
	CIT	NTIT	ET	CIT	NTIT	ET	CIT	NTIT	ET
Output	0.11	0.35	0.22	0.06	0.05	0.10	0.07	0.08	0.09
Non-traded output	0.13	0.32	0.15	0.04	0.11	0.05	0.02	0.04	0.02
Exported output	0.51	0.19	0.61	0.30	0.31	0.32	0.27	0.16	0.25
Labour	0.13	0.23	0.30	0.03	0.05	0.02	0.04	0.17	0.07
Consumption	0.25	0.43	0.45	0.17	0.18	0.25	0.25	0.32	0.38
Nominal exchange rate	0.20	0.18	0.03	0.21	0.03	0.02	0.21	0.21	0.03
Real exchange rate	0.14	0.09	0.07	0.22	0.11	0.17	0.21	0.11	0.18
Non-traded inflation	0.32	0.04	0.34	0.38	0.37	0.49	0.33	0.33	0.38
CPI inflation	0.19	0.25	2.34	0.15	0.27	2.31	0.58	0.03	2.3
Interest rates	2.67	0.02	0.09	1.28	0.09	0.04	1.46	0.01	0.04

CIT is CPI inflation targeting, NTIT is non-traded inflation targeting and ET is exchange rate targeting

Figure B.1: Impulse responses to commodity terms of trade shocks: high openness

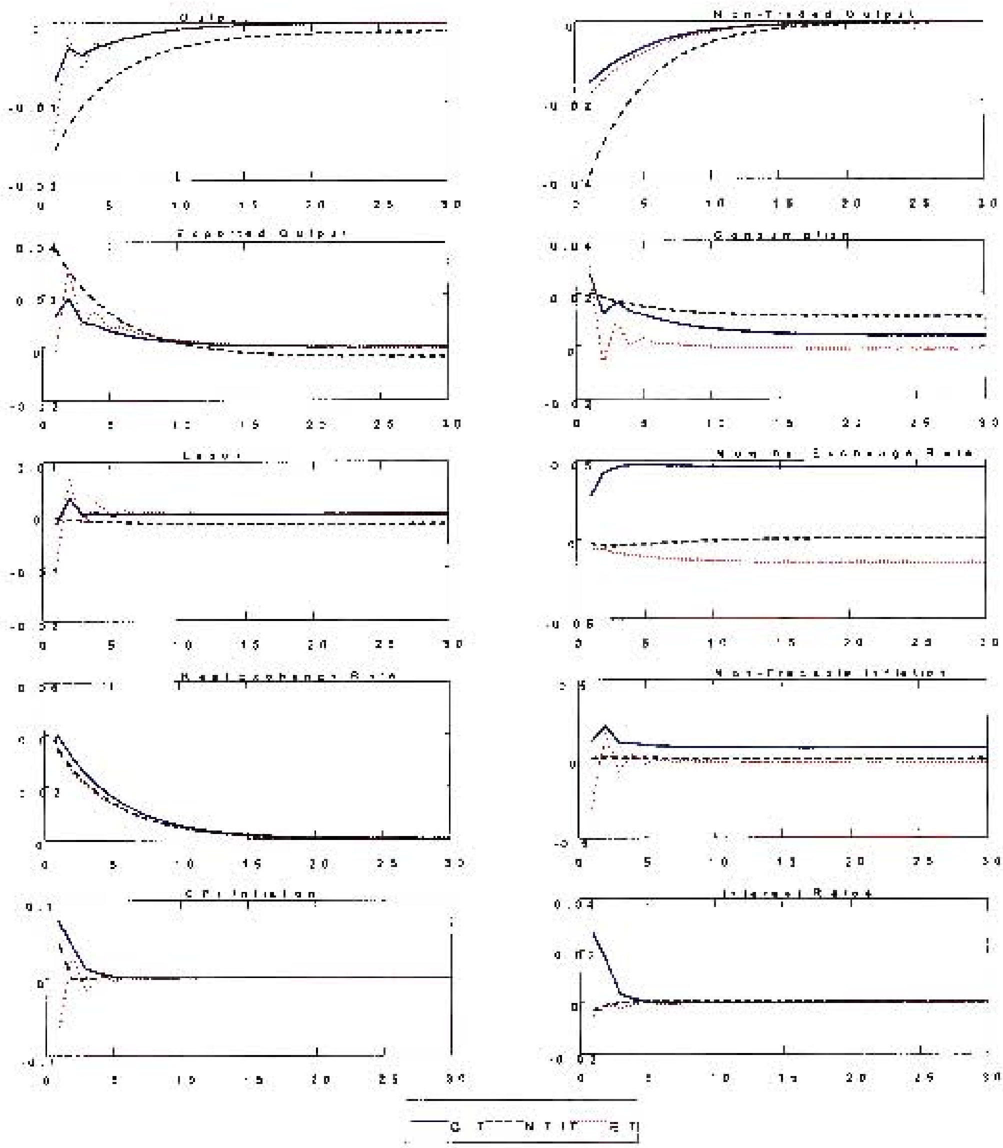


Figure B.2: Impulse responses to commodity terms of trade shock: no price stickiness

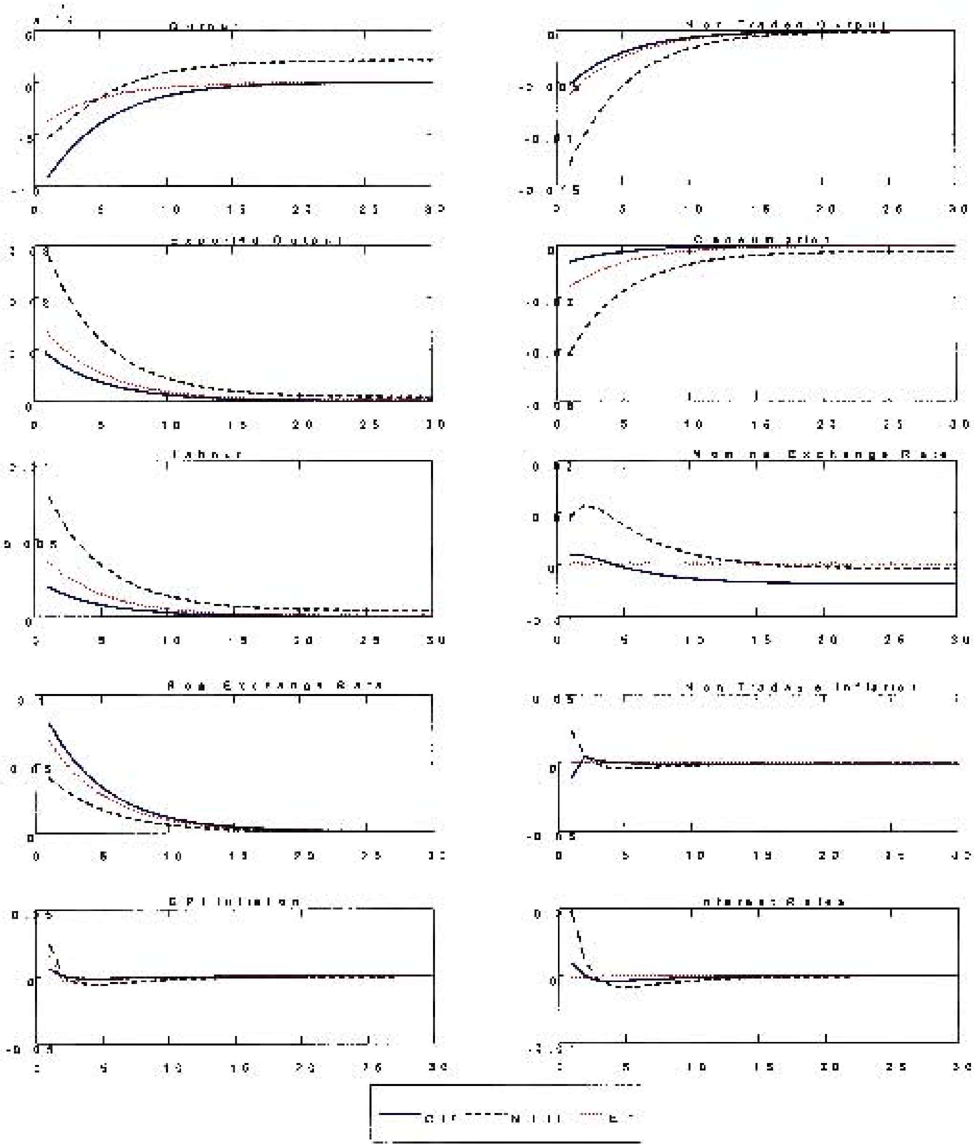


Figure B.3: Impulse responses to commodity terms of trade shock: low elasticity of substitution between traded and non traded goods

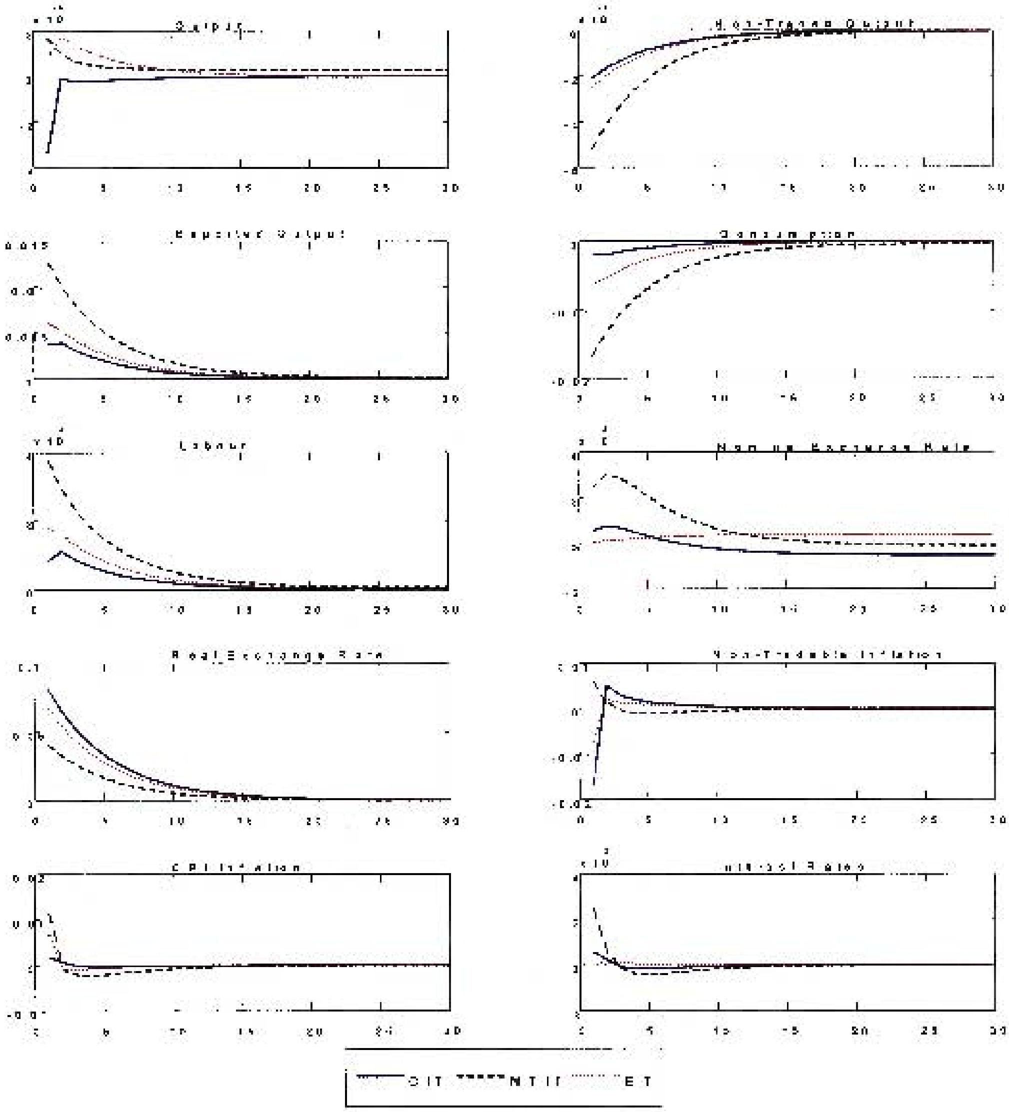


Table B.5.3: Sensitivity tests on welfare evaluations

Weights on central bank loss function				Welfare losses								
				High openness			No stickiness			Low elasticity of substitution		
λ_π	λ_y	λ_r	λ_e	CIT	NTIT	ET	CIT	NTIT	ET	CIT	NTIT	ET
1	0.5	0.5	0.5	0.07	0.13	1.32	0.06	0.48	0.68	0.08	0.04	0.26
1	1	0.5	0.5	0.03	0.14	0.72	0.02	0.02	0.69	0.13	0.13	0.27
1	1.5	0.5	0.5	0.15	0.14	0.60	0.04	0.05	0.72	0.13	0.22	0.30
1	2	0.5	0.5	0.62	0.15	0.44	0.03	0.02	0.69	0.15	0.15	0.45
1	0.5	1	0.5	0.01	0.01	1.00	0.15	0.20	0.65	0.11	0.17	0.27
1	0.5	1.5	0.5	0.15	0.64	1.44	0.22	0.24	1.02	0.12	0.13	0.44
1	0.5	2	0.5	0.17	0.64	1.03	0.98	0.99	0.68	0.10	0.03	0.29
1	0.5	0.5	1	0.02	0.03	0.07	0.07	1.42	1.62	0.17	0.32	0.27
1	0.5	0.5	1.5	0.03	0.04	0.04	0.18	0.44	1.68	0.21	0.23	0.28
1	0.5	0.5	2	0.03	0.04	0.09	0.24	0.90	1.79	0.24	0.29	0.26

CIT is consumer price index inflation targeting, NTIT is non-traded inflation targeting and ET is exchange rate targeting

Appendix C

Appendix for Chapter 4

C.1 Terms of trade and real exchange rate

Terms of trade is given by:

$$f_{it} = p_{Xit} - p_{Mit} \tag{C.1}$$

where p_{Xit} is the price of exports and p_{Mit} is the price of imports

$$\Delta f_{it} = \pi_{Xit} - \pi_{Mit} \tag{C.2}$$

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

$$\pi_{Xit} = \pi^*_{Xt} - \Delta e_{it} \tag{C.3}$$

$$\pi_{Mit} = \pi^*_{Mt} - \Delta e_{it} \tag{C.4}$$

where π_{Xit} is exported inflation (change in price of exports), π^*_{Xt} is the change in the world price of exports which is assumed to be exogenous. Δe_{it} is the change in the nominal exchange rate, π_{Mit} is imported inflation (change in domestic price of imports) and π^*_{Mt} is the change in the world prices of imports. Substituting equation (C.3) and equation (C.4) into equation (C.2) yields :

$$\Delta f_{it} = \pi^*_{Xt} - \Delta e_{it} - (\pi^*_{Mt} - \Delta e_{it}) \tag{C.5}$$

$$\Delta f_{it} = \pi^*_{Xt} - \pi^*_{Mt} \tag{C.6}$$

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

$$\pi^*_{Mt} = \pi^*_t \tag{C.7}$$

where π^*_{Mt} is imported inflation and π^*_t is the world inflation. Using this assumption, equation (C.6) becomes:

$$\Delta f_{it} = \pi^*_{Xt} - \pi^*_t \tag{C.8}$$

which implies that:

$$\pi^*_t = \pi^*_{Xt} - \Delta f_{it} \tag{C.9}$$

Recalling that the real exchange rate (q_{it}) is define by:

$$q_{it} = e_{it} + p_{it} - p^*_t \tag{C.10}$$

Expressed in terms of change, real exchange rate is:

$$\Delta q_{it} = \Delta e_{it} + \pi_{it} - \pi^*_t \tag{C.11}$$

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

$$\Delta q_{it} = \Delta e_{it} + \pi_{it} - \pi^*_{Xt} + \Delta f_{it} \tag{C.12}$$

Table C.1.1: Summary of literature for Chapter 4

Author	Method	Findings
Friedman (1953)	Theoretical	Flexible exchange rates are shock absorbers in small open economies
Broda (2004)	Panel VAR	Flexible exchange rates buffer terms of trade shocks
Edwards and Yeyati (2005)	Panel SUR model	Flexible exchange rates perform better than fixed exchange rates
Svensson (2000)	Small open economy model	CIT performs better than DIT
Kumhof (2001)	Small open economy model	IT is worse than MT and ET
Mishkin and Schmidt Hebbel (2007)	Panel VAR	IT reduces the impact of oil price shocks on inflation and reduces the passthrough effects

Table C.1.2: Variables description and data sources

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

Table C.1.3: Summary statistics of inflation targeters before and after inflation targeting adoption

	Inflation Targeters before inflation targeting adoption					Inflation Targeters after inflation targeting adoption				
Variables	Obs	Ave	S.dev	Min	Max	Obs	Ave	S.dev	Min	Max
CTOT	1136	0.92	17.47	-44.86	31.83	604	0.13	4.26	-43.15	15.31
INFL	1136	109.1	528.93	-0.59	7481.64	604	5.44	3.85	-3.2	23.85
YGAP	1136	0.16	13.70	-9.874	9.3	604	0.04	1.21	-6.8	4.49
ER	1136	10.54	8.37	-100	181.21	604	0.35	9.13	-1.18	40.37
RTS	1136	168.4	140.2	2.4	6184	604	8.5	5.3	1.25	41.95

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

Sources: Authors' computations based on the sources in Table C.1.2

Table C.1.4: Summary statistics of inflation targeters, monetary targeters and exchange rate targeters after 1995

	Inflation targeters after inflation targeting adoption				Monetary targeters after 1995				Exchange rate targeters after 1995			
Variables	Ave	S.dev	Min	Max	Ave	S.dev	Min	Max	Ave	S.dev	Min	Max
CTOT	0.13	4.26	-43.2	15.3	0.20	5.01	-44.0	13.97	0.11	5.98	-31.5	71.8
INFL	5.44	3.85	-3.2	23.85	10.7	19.6	-1.16	222.5	12.4	13.6	-0.81	367.7
YGAP	0.04	1.21	-6.8	4.49	-0.16	1.51	-5.52	9.08	0.98	12.8	-70.1	77.6
ER	0.35	9.13	-1.18	40.37	2.23	15.02	-30.8	292.6	4.36	12.0	-19.3	91.8
RTS	8.5	5.3	1.25	41.95	14.83	16.25	1.07	118.4	33.17	16.3	2.17	135

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

Observations under IT=604, observations under MT=616 and observations under ET=540

Sources: Authors' computations based on the sources in Table C.1.2

Table C.1.5: Panel unit root tests based on the Fisher Type Test

Variable	CTOT	Output gap	Inflation	Exchange rates	Interest rates
$\chi 2$	97.81	179.60	208.12	1397.19	318.58
P.Value	0.016	0.000	0.000	0.000	0.000

H_0: Panel series are not stationary

Table C.1.6: VAR Granger causality and Block exogeneity Wald Test

Dependent variable: Commodity terms of trade		
Variables	Chi -square (χ^2)	P-values
Output gap	0.409	0.981
Inflation	2.491	0.646
Exchange rate	1.082	0.897
Interest Rates	0.290	0.991
All	4.75	0.997

H_0 : No Granger causality or no endogeneity.

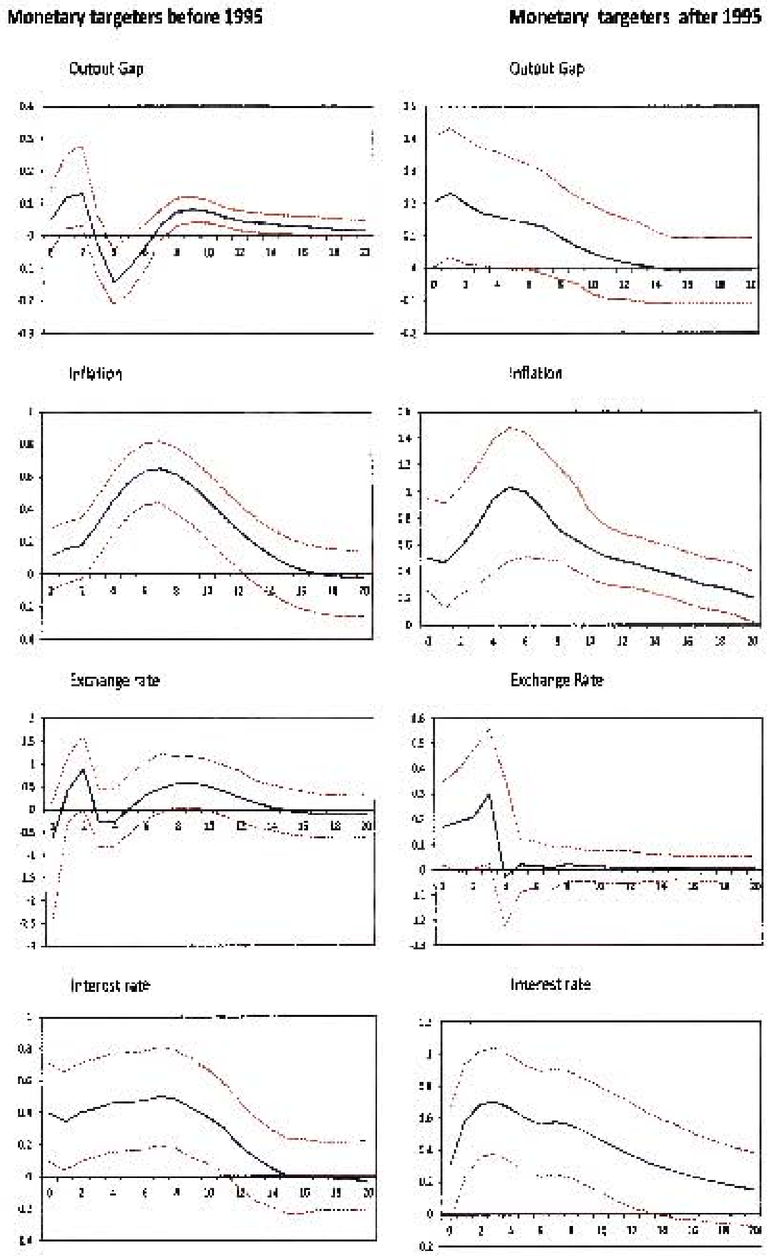
All captures the p-values based on the block exogeneity test

Table C.1.7: List of oil exporting countries in each monetary policy regime

Inflation targeters	Monetary targeters	Exchange Rate Targeters
Colombia	Algeria	Ecuador
Indonesia	Nigeria	Ukraine
Mexico	Russia	Venezuela

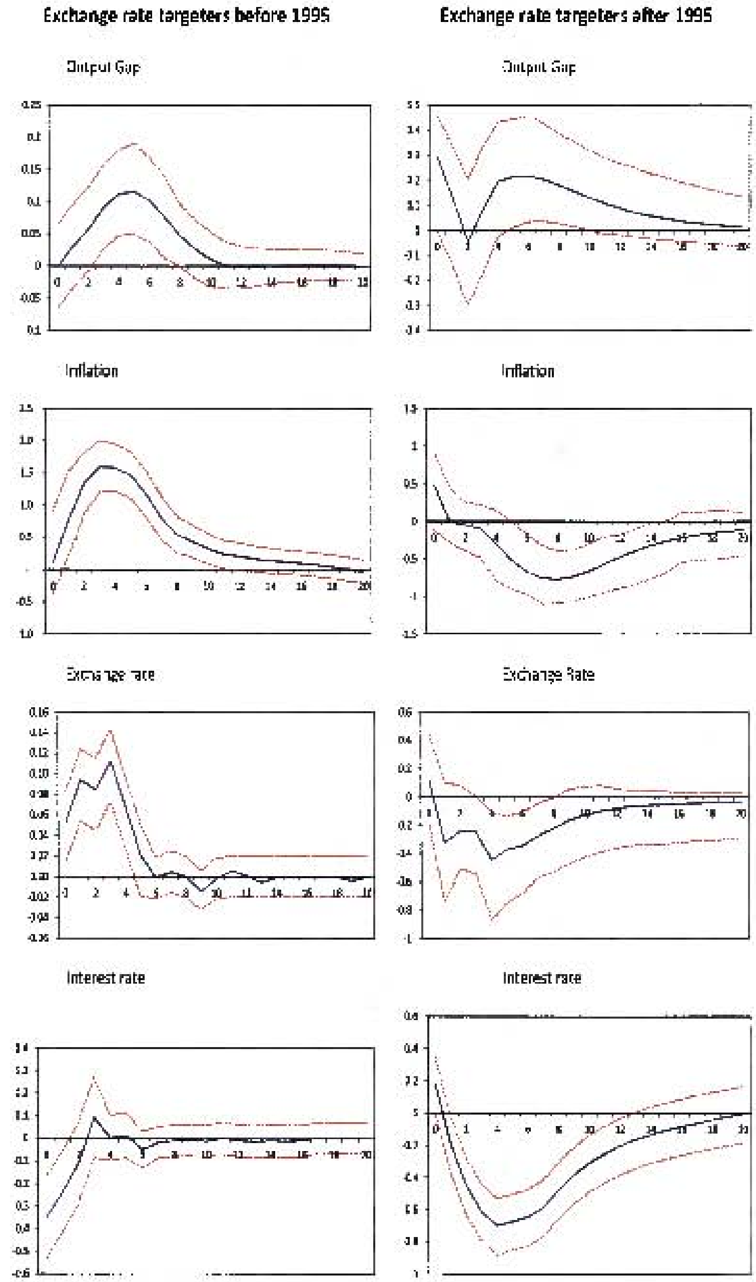
Source: UNCTAD Handbook of Statistics, 2008

Figure C.1: Impulse responses of variables to CTOT shocks: Monetary targeters before and after 1995



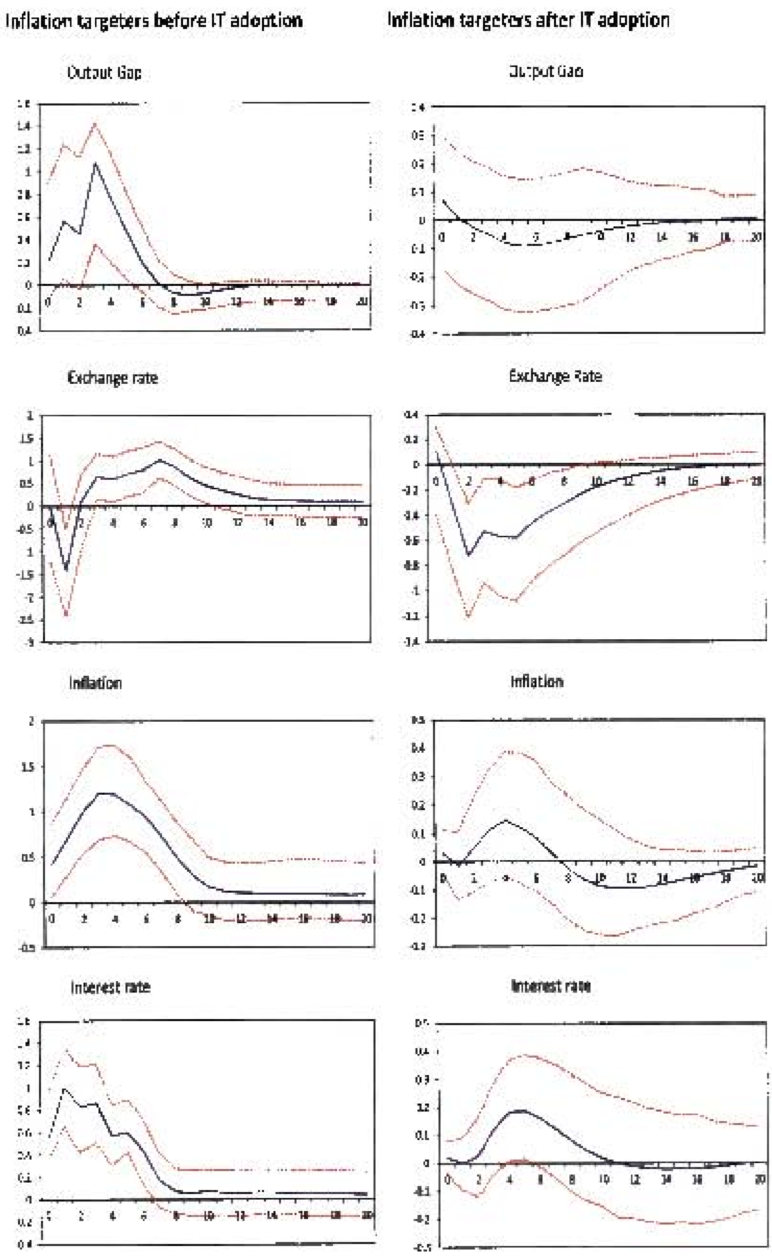
Errors are 5% on each side generated by Monte- Carlo simulations with 500 repetitions

Figure C.2: Impulse responses of variables to CTOT shocks: Exchange rate targeters before and after 1995



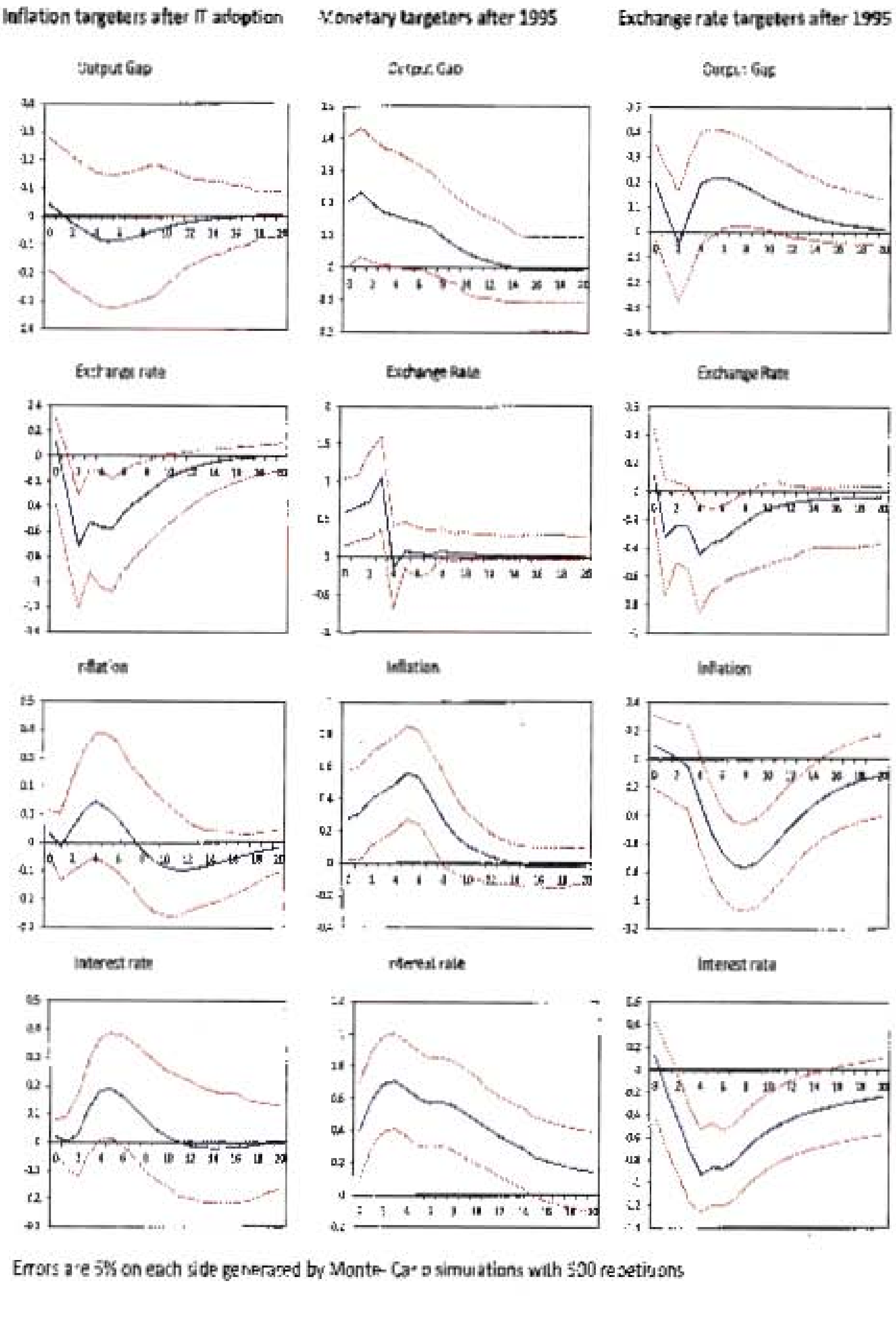
Errors are 5% on each side generated by Monte- Carlo simulations with 500 repetitions

Figure C.3: Impulse responses of variables to CTOT shocks with alternative ordering of variables: Inflation targeters before and after IT adoption



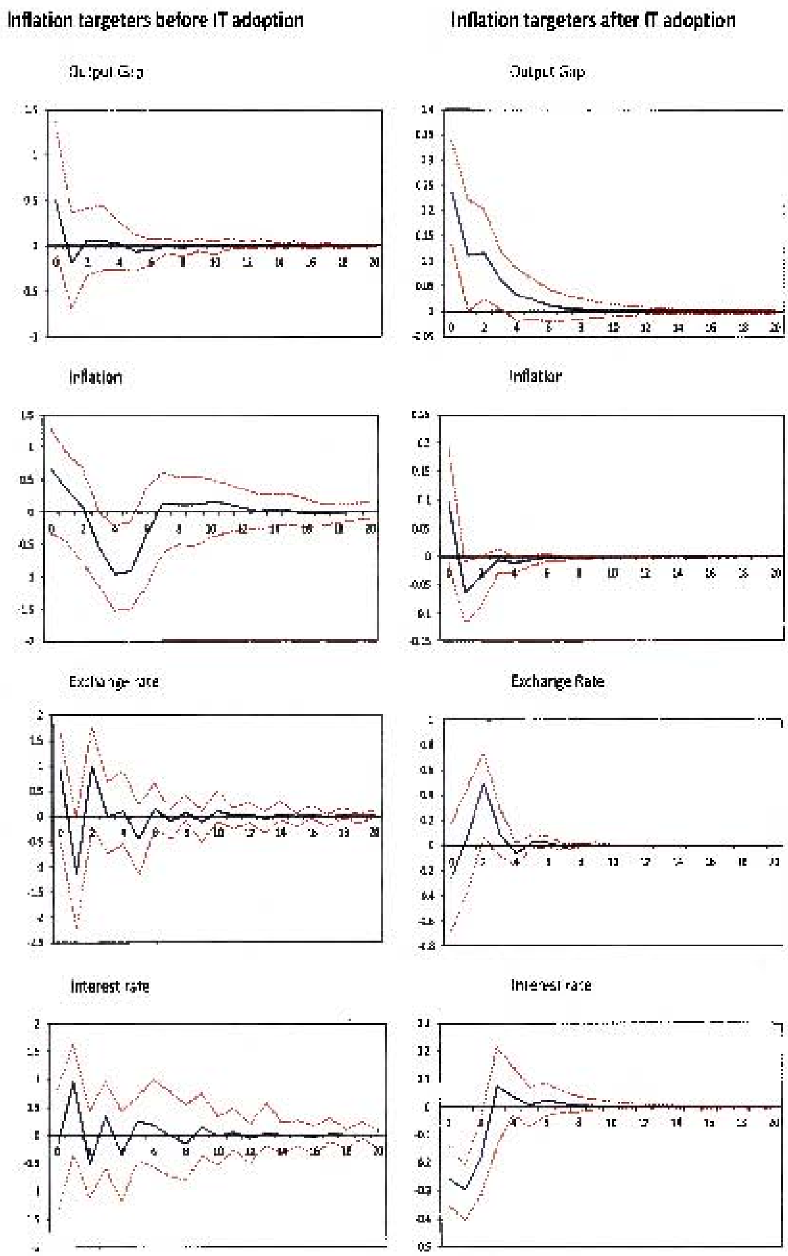
Errors are 5% on each side generated by Monte- Carlo simulations with 500 repetitions

Figure C.4: Impulse responses of variables to CTOT shocks with alternative ordering of variables: Inflation targeters, monetary targeters and exchange rate targeters



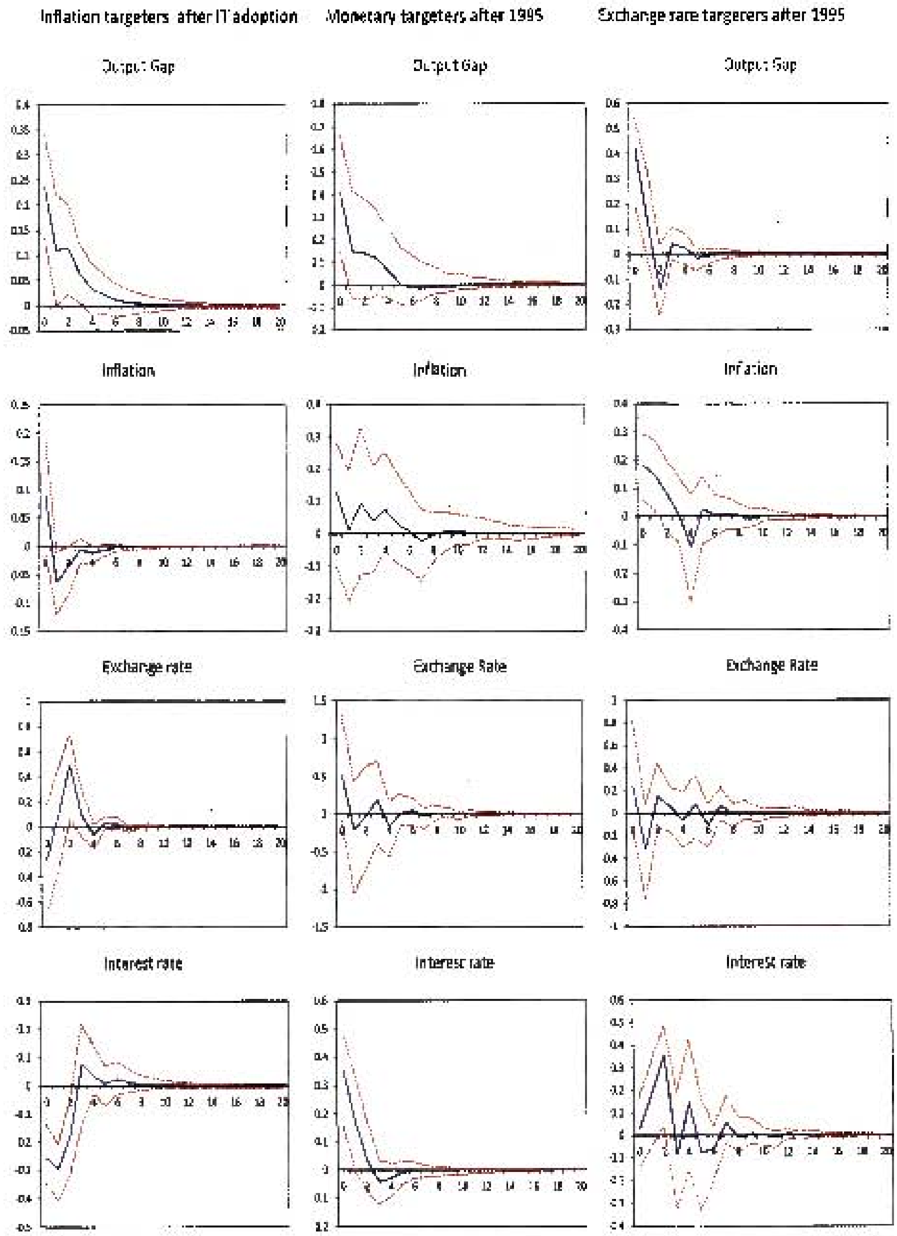
Errors are 5% on each side generated by Monte-Carlo simulations with 500 repetitions

Figure C.5: Impulse responses of variables to CTOT shocks in first differences: Inflation targeters before and after IT adoption.



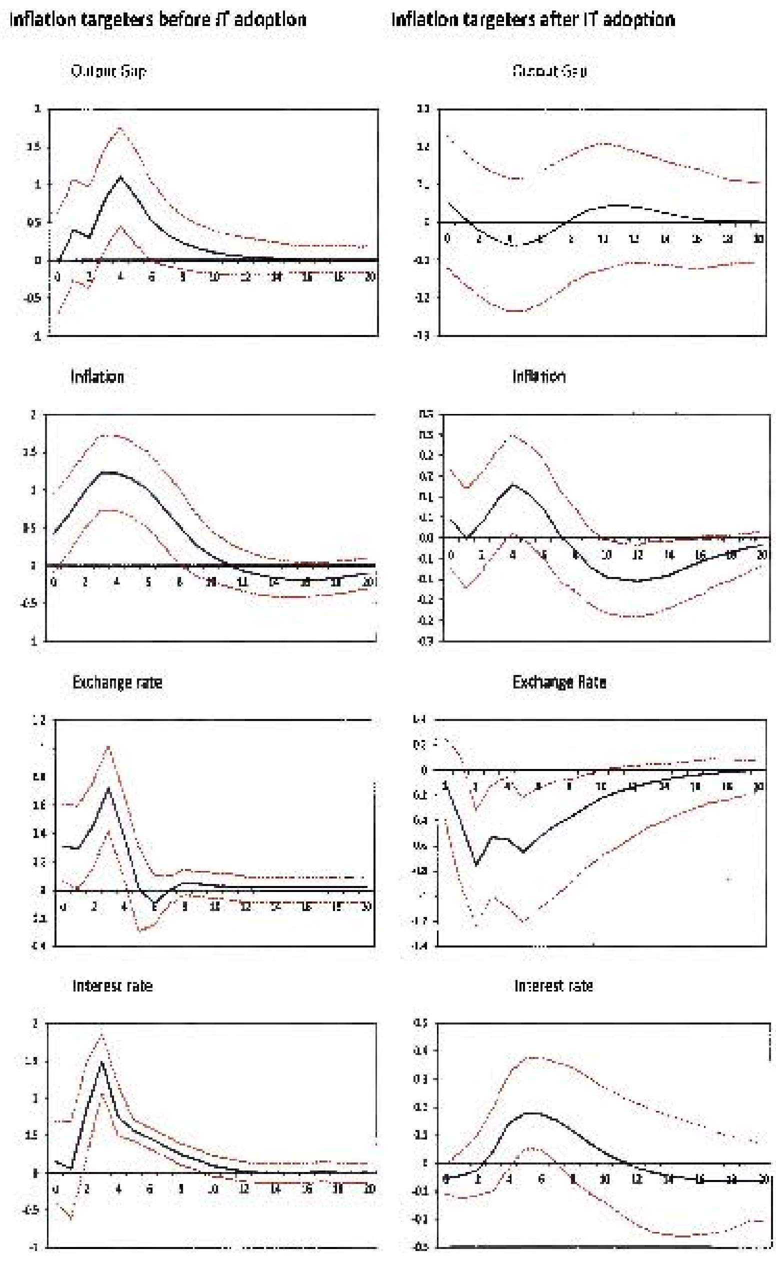
Errors are 5% on each side generated by Monte- Carlo simulations with 500 repetitions

Figure C.6: Impulse responses of variables to CTOT shocks in first differences: Inflation targeters, monetary targeters and exchange rate targeters.



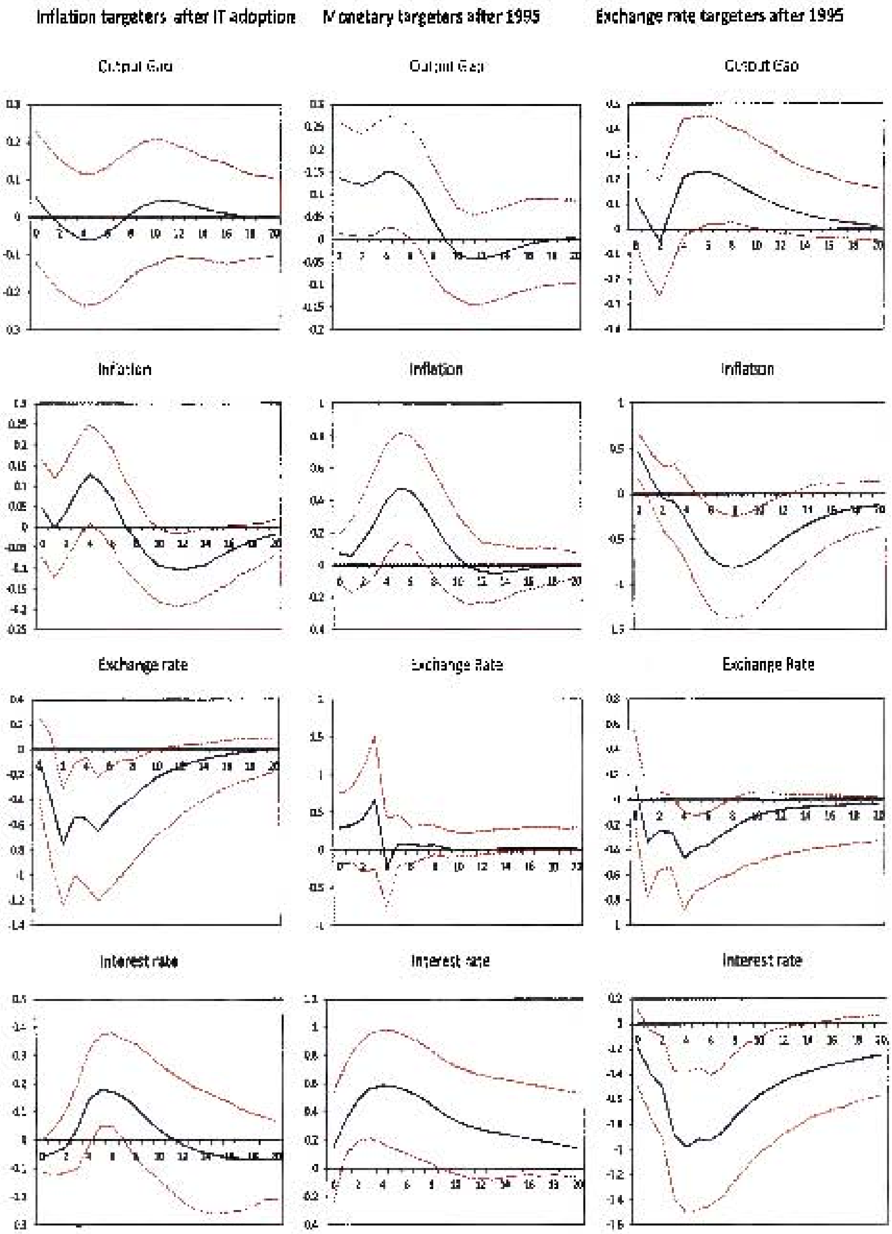
Errors are 5% on each side generated by Monte-Carlo simulations with 500 repetitions

Figure C.7: Impulse responses of variables to CTOT shocks: Inflation targeters before and after IT adoption excluding big economies.



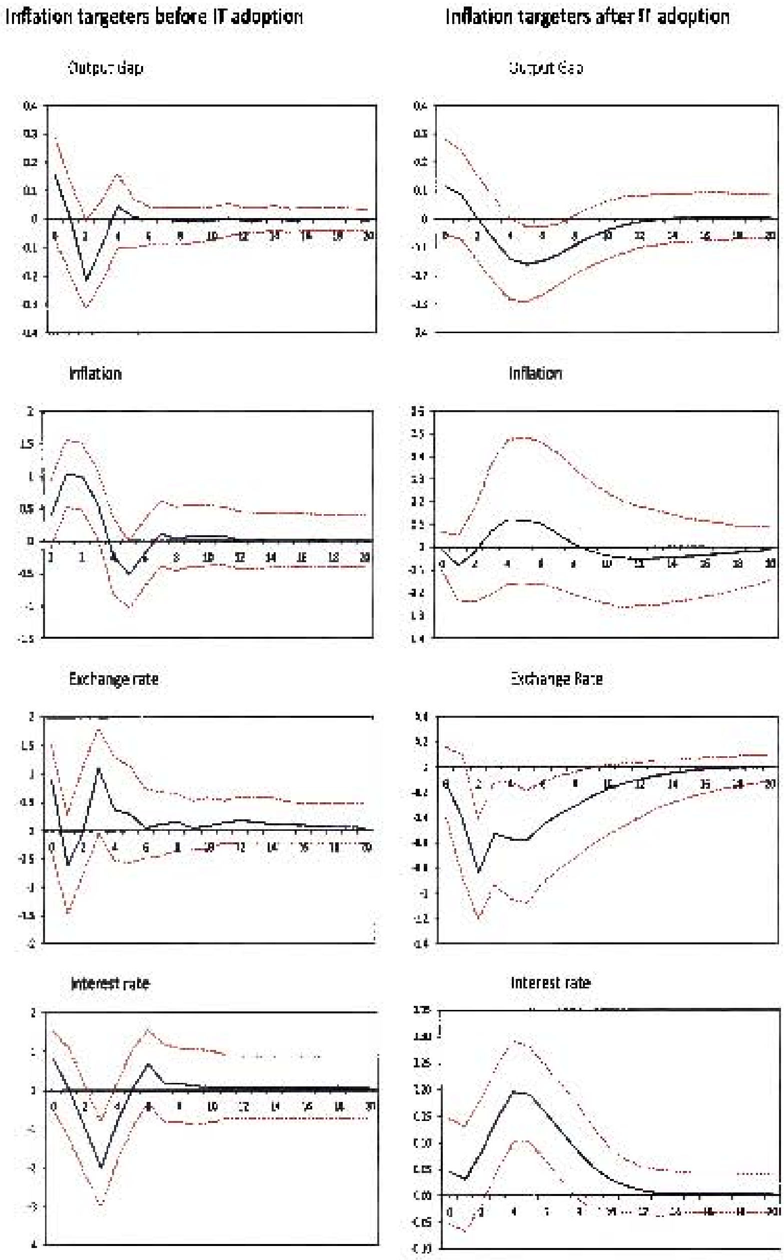
Errors are 5% on each side generated by Monte- Carlo simulations with 500 repetitions

Figure C.8: Impulse responses of variables to CTOT shocks: Inflation targeters, monetary targeters and exchange rate targeters excluding big economies.



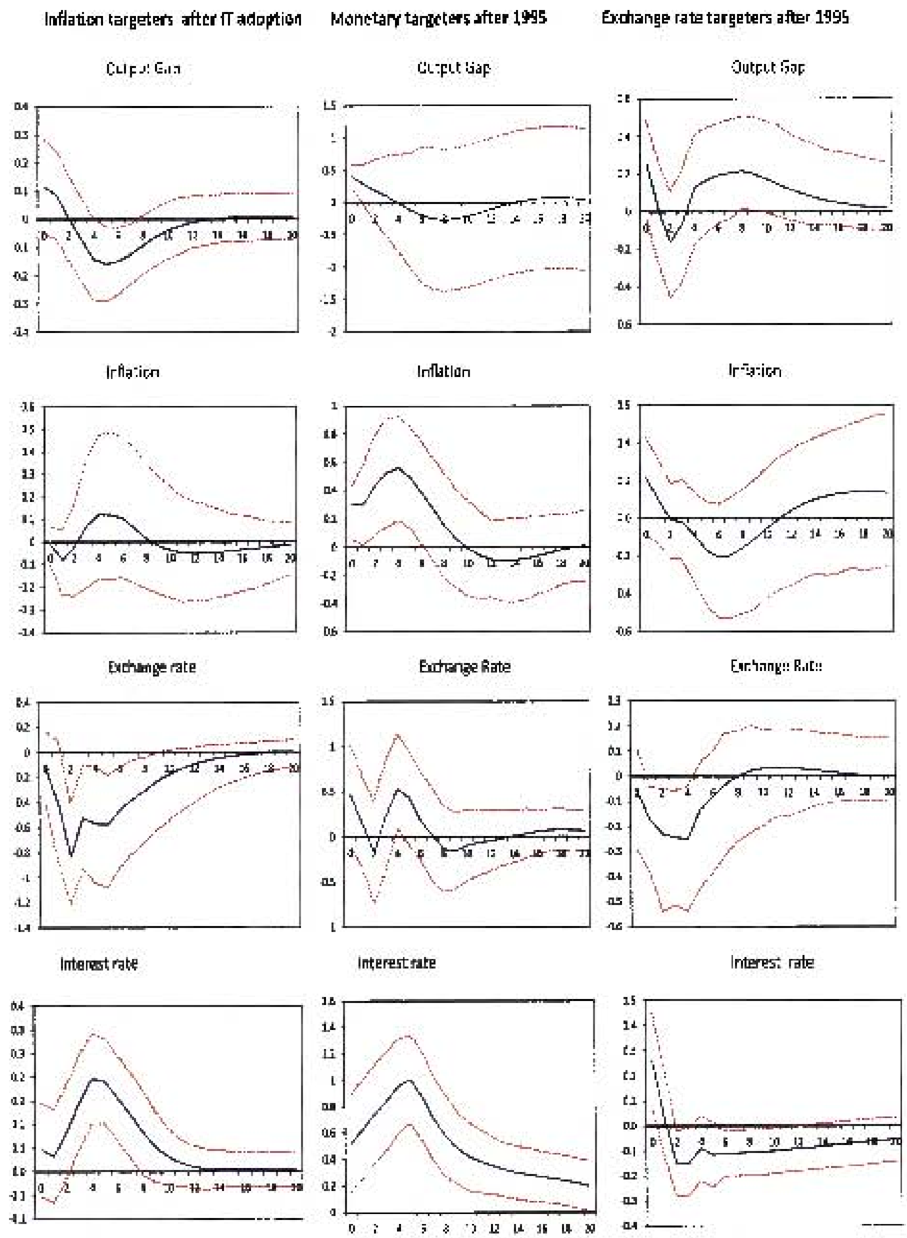
Errors are 5% on each side generated by Monte- Carlo simulations with 500 repetitions

Figure C.9: Impulse responses of variables to CTOT shocks: Inflation targeters before and after IT adoption excluding oil exporters



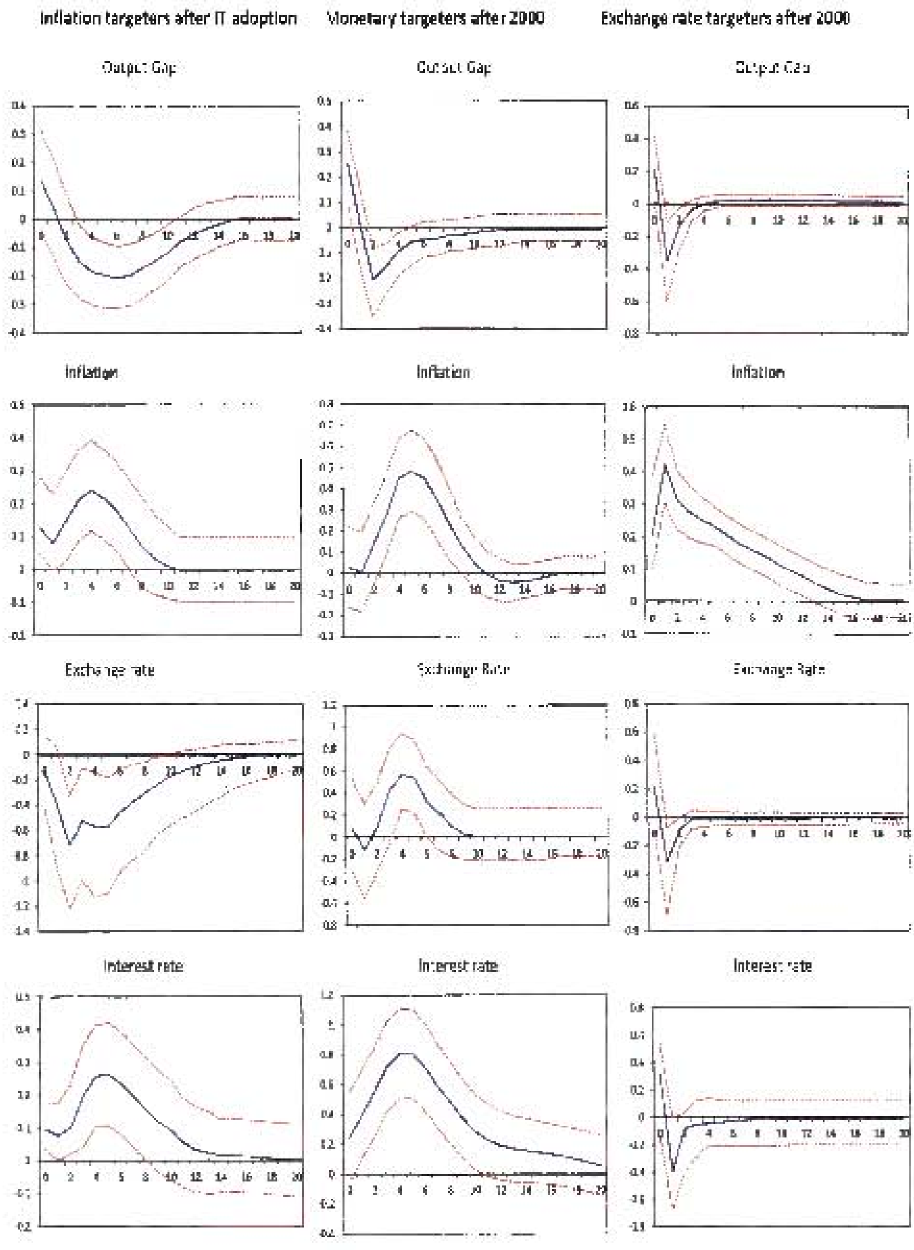
Errors are 5% on each side generated by Monte- Carlo simulations with 500 repetitions

Figure C.10: Impulse responses of variables to CTOT shocks: Inflation targeters, monetary targeters and exchange rate targeters excluding oil exporters.



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

Figure C.11: Impulse responses of variables to CTOT shock: Inflation targeters, monetary targeters and exchange rate targeters after 2000.



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