THREE ESSAYS ON MONETARY POLICY, INFLATION TARGETING RULES, AND AGGREGATE SHOCKS: EVIDENCE FROM EMERGING MARKET COUNTRIES

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DEDICATION

I dedicate this dissertation to my mother Jane Charity Kasonkomona.

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ABSTRACT

This dissertation investigates macroeconomic performance in emerging-market countries (EMCs) with inflation targeting (IT) regimes. The first chapter examines the role of the exchange rate in IT for a set EMCs, asking whether interest-rate policy responds to exchange-rate fluctuations and if so why. Despite adoption of IT, the exchange rate tends to be a key objective in policy interest-rate reaction functions in EMCs. The often cited possible reasons for this behavior are fear-of-floating (Calvo and Reinhart 2002) and fear-of-inflation (Ball 2000). The central question we explore is whether the weight on the exchange rate reflects efforts to minimize fluctuations in inflation and output (i.e., *optimal* behavior consistent with IT goals), or otherwise constitutes *suboptimal* behavior because policy is not focused on IT goals, but on other priorities such as trying to stabilize financial institutions by attenuating exchange-rate swings. Features in EMCs that may complicate use of IT include weak domestic financial institutions and underdeveloped domestic financial markets, thin foreign-exchange markets, high exchange-rate pass-through to inflation and vulnerability to sudden stops in capital inflows. The analysis estimates a set of empirical equations to identify standard targeters and mixed strategy targeters (with significant weight on the exchange rate) and to delineate whether these patterns are consistent with optimal behavior or not. We find

the choice of having the exchange rate in the reaction function to reflect optimal policy concerns more than concerns with financial-vulnerability. EMCs have achieved a reduction in average inflation regardless of whether they implement standard or mixed-strategy alternatives.

The second chapter asks how the adoption of IT in South Africa has influenced wage- and price-setting behaviors. If credible, IT is expected to durably anchor inflation expectations and change the inflation process by defining how shocks to aggregate demand and aggregate supply affect core price inflation dynamics and growth (Clifton et al. 2001). Agents will prefer longer contracts substantially reducing the responsiveness of the wage-price setting process to inflation shocks. For South Africa, the questions we examine are whether IT has induced a shift in forward- vs. backward-looking influences on wage-price-setting, which has reduced or even eliminated wage-price-indexation (i.e., workers and firms will adjust wages/prices less frequently in response to inflation shocks); and whether IT has resulted in a structural shift in the inflation-cost trade-off (i.e., marginal costs will be *less sensitive* to inflation shocks). We estimate a hybrid-New Keynesian Phillips curve (NKPC) because the price-rigidity implied in the NKPC has important implications for the role of IT in affecting price dynamics and real unit costs. We report evidence of a significant structural shift consistent with IT encouraging more forward-looking wage-price setting behavior relative to backward. The IT program appears to induce a quantitative improvement in the tradeoff between inflation and real marginal costs.

Finally, the third chapter focuses on the role of IT in offsetting exogenous shocks to aggregate demand and supply in South Africa. The key question is whether inflation,

output, and the short-term interest rate have become more resilient in the face of amplified aggregate shocks. South Africa is susceptible to unique exogenous shocks as a result of fluctuations in global commodity demand, which presents serious challenges for monetary policy. While direct first-round effects from such shocks have been large, second round effects which manifest through wage markup demands and sharp rises in inflation expectations exert huge pressures on prices and output. We estimate a structural Vector Autoregression (SVAR) system identified via a small open-economy New Keynesian Model. We find evidence that pass-through of shocks to inflation, output and the short-term policy interest rate is resilient in the inflation targeting period and these variables have been stable relative to the size of aggregate shocks.

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CHAPTER 1

INFLATION TARGETING, POLICY RULES AND MACROECONOMIC PERFORMANCE IN EMEs: PANEL DATA EVIDENCE

1.1 *Introduction*

In recent years, an increasing number of emerging-market countries have adopted inflation targeting (henceforth IT) as their monetary policy regime.[1] Countries that have joined the bandwagon of IT since January 2000 include Hungary, the Philippines, the Slovak Republic, and South Africa. At the turn of the century, four Latin American countries (Brazil, Chile, Colombia and Mexico) and two countries from emerging Europe (Czech Republic and Poland) had already adopted IT. The earliest emerging-market country to adopt IT was Israel, which shifted to inflation targeting in 1992. Unlike advanced industrial countries, many emerging-market economies (EMEs) cannot be described as having robust financial institutions and sound financial markets, which play a key role as a buffer for smoothing out pronounced external shocks, and as such most countries are susceptible to adverse effects of sudden stops in capital flows and terms of trade shocks. Consequently, for EMEs facing the problem of thin foreign-exchange markets, authors such as Calvo (2001) worry that large external shocks could imply large and abrupt swings in the real exchange rate, which could in turn trigger inflationary pressures. In the case of countries with high and un-hedged foreign currency liabilities, exchange rate depreciation could engender a financial crisis by impacting the profitability and balance sheets of firms and financial institutions and the fiscal balance of the government sector.

[1] See Fraga et al (2003) for an assessment of inflation targeting in EMEs.

In this essay, the important question to be investigated is whether emerging-market countries that have officially elected to pursue IT will in practice either exhibit behavior that seeks to minimize fluctuations in inflation and output, or whether their revealed monetary policy rules will instead reflect behavior consistent with policy objectives beyond long-run stabilization of inflation and output around their targets. This implies examining whether the central bank's interest responses are consistent with optimal behavior under IT or whether they are otherwise sub-optimal since they take into account other factors such as financial stability concerns. The central bank's systematic behavior under IT, as represented by a Taylor-type rule, can reflect either standard IT or a mixed-strategy IT in which the exchange rate figures as an added objective. Countries that exhibit mixed-strategy behavior usually have limited incentive to publicly pre-commit to a mixed strategy, as this could send the wrong signals about their commitment to the inflation target and could put the credibility of the inflation control program in question. This implies that, even if a mixed strategy may have some benefits, its effects on expectations and its incentive effects on financial markets and incentives may tend to dampen them.

To date, there has been little systematic investigation of IT strategies in which the exchange-rate is given some weight, nor any comparison of their macroeconomic performance relative to countries that practice standard IT. In this regard, this chapter estimates a set of empirical models to explain why one EME would choose to put some weight on the exchange rate and another EME would not, and to identify the key determinants that underpin the decision. We investigate whether or not the exchange rate appears in the Taylor-rule in terms of important structural characteristics of emerging-

market countries, namely, the degree of exchange rate pass-through to inflation and structural factors that underpin the relationship between the volatility of the exchange rate and the external risk premium. Here we expect the degree of domestic financial development and robustness, terms of trade positions, and private capital flows to be of special importance.

The Chapter proceeds in eight sections. Section 1.2 gives an overview of the concepts of financial-market soundness and stability and relates these notions to flexible exchange rates, which many analysts take to be required under the strict/standard form of inflation targeting (Eichengreen, 2002). In Section 1.3, we present a review of the recent literature on the role of the exchange rate in an inflation targeting regime. In Section 1.4, we formalize our investigation of our hypotheses using a four-equation approach consisting of a Taylor rule, an accelerationist Phillips curve, a dynamic panel-data binary choice model, and a dynamic fixed-effects panel-data model. Section 1.5 reviews the data to be used and provides descriptive statistics and selected macroeconomic indicators for the sample countries. In Section 1.6, we describe our results and analyze their implications. Section 1.7 compares our results with other studies. Section 1.8 summarizes and concludes the chapter, and section 1.9 points at future opportunities for extending the research.

1.2 *Inflation Targeting and Financial Market Soundness*

1.2.1 The Concept of Sound Financial Markets: Definitions and Indicators

In the analysis that follows, we define sound financial markets in terms of a country's ability to issue long-term debt denominated in the domestic currency at

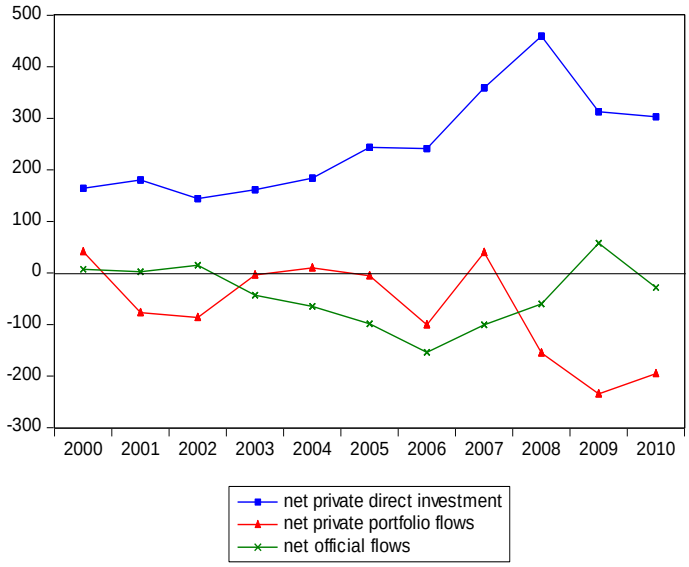
internationally competitive yields (Freedman and Otker-Robe, 2010). This implies that the credibility of domestic currency and of the country's financial markets and institutions are sufficiently high that required amounts of borrowing can be done at yields equal to or close to those on the highly-rated emerging-market bonds. In contrast, financial markets are not considered to be sound if there is limited demand for debt instruments denominated in the domestic currency on international capital markets, and/or the government is not able to borrow long-term from domestic investors.

There are various propositions in the literature about why some financial markets may fall short of soundness in this sense. Calvo and Mishkin (2003) trace fragile financial markets to weak fiscal and monetary institutions in emerging markets, which do little to assure the credibility of macroeconomic and financial policies, and hence make countries vulnerable to bursts of high inflation and sharp currency depreciations. Other economists argue that weaknesses in laws and regulations governing counterparty commitments to financial contracts bring about market incompleteness in most emerging-market countries, which is referred to as the problem of "original sin."[2] The lax regulatory requirements of domestic capital markets, thin foreign exchange markets and the lack of depth and sophistication in financial instruments can force many firms, households and governments in EMEs to borrow in foreign currency (see Calvo and Mishkin, 2003). This leads to liability dollarization and problems of mismatches in currency-denominations and maturities of assets and liabilities. Liability dollarization

[2] The leading proponent of this view is Eichengreen and Hausmann (1999), who contend that when a country is unable to use the domestic currency to borrow abroad or to borrow long term, even domestically, financial fragility is unavoidable because all domestic investments will have either a currency mismatch or a maturity mismatch.

reinforces the already existing structural weaknesses and exacerbates vulnerability to sudden stops in capital inflows.

Figure 1.1 below shows net capital flows to emerging and developing economies. The figure shows some substantial swings in capital flows, particularly with regard to private equity and debt, underlining the potential for problems of sudden stops or sudden reversals in capital flows.[3]



Source: IMF World Economic Outlook, April 2009

Figure 1.1. **Net Private Capital Flows to Emerging and Developing Economies**

(Billions of U. S. dollars)

[3] Emerging markets were hard hit by the escalation of the financial crisis which began in 2007. Equity prices dropped, bond spreads widened sharply, new securities issues were curtailed and exchange markets came under heavy pressure. Policy rates were lowered in response to weakening economic prospects, although less aggressively than in mature markets in view of concerns about pressure on the external accounts from a reversal in capital flows. The turbulence exposed internal vulnerabilities within many emerging economies, bringing attention to currency mismatches on borrower balance sheets, weak risk management and excessively rapid bank credit growth (IMF WEO, 2009).

Batini et al. (2005) provide a more technical characterization of the health of emerging-market financial systems based on six indicators of the degree of development and degree of soundness of the banking and financial systems. Two indicators capture financial soundness, namely: (a) the ratio of bank regulatory capital to risk-weighted assets, and (b) the extent of banks' foreign currency open positions, where the latter indicates the degree of currency mismatch of assets and liabilities. Four measures reflect financial-market depth or development, including (c) the ratio of stock market capitalization to GDP, (d) stock market turnover, (e) the ratio of private bond market capitalization to GDP, and (f) the maximum maturity of privately traded nominal bonds. In a special survey to assess the role of preconditions for the adoption of IT, Batini et al. (2005) show that all emerging-market inflation targeters scored relatively poorly on these indicators at the time they adopted IT regimes.[4]

1.2.2 Flexible Exchange Rates and Financial System Stability

Since "strict IT" implies flexible exchange rates, such factors as financial-system vulnerabilities, heavy reliance on commodity exports, and the central role of the exchange rate in the monetary-policy transmission mechanism have prompted critics to raise questions about the feasibility of implementing standard IT in emerging-market settings.[5] For example, Mishkin (2004) suggests that liability dollarization could place an

[4] Batini et al.'s data come from a questionnaire completed by central banks of 21 inflation-targeting countries and 10 non-inflation-targeting central banks. The emerging-market inflation-targeting countries in the sample were Brazil, Chile, Colombia, Czech Republic, Hungary, Israel, Korea, Mexico, Peru, The Philippines, Poland, South Africa, and Thailand.

[5] Additional challenges for emerging market countries commonly cited in the literature include high pass-through to inflation of swings in the real exchange rate, low credibility of monetary institutions, currency substitution and liability dollarization, rigidities in labor markets, perverse back-ward wage-price indexing, and weaknesses in the

additional constraint on emerging market countries' inflation-targeting strategies. In practice, interest-rate decisions in a number of EME targeters seem to exhibit some level of concern about exchange rate stability, prompting debate about the underlying reasons for this behavior. A primary motivation most commonly cited in the literature is related to the "fear-of-floating" idea of Calvo and Reinhart (2002). Others have cited fear-of-inflation, motivated by arguments based on pass-through from exchange rates to domestic inflation. For example, Ball (2000) argues that a modification to the standard Taylor-type rule that gives a role to the exchange rate enables policy makers to adjust interest rates to offset the effects of exchange rates on spending, averting unnecessarily large fluctuations in inflation and output.

In line with Ball (2000), we posit that the exchange rate's appearance in a Taylor-type rule is consistent with optimal use under IT when the purpose is to smooth through high-frequency fluctuations in the exchange rate, as a matter of minimizing fluctuations in inflation and output and reducing uncertainty about trajectories of inflation, growth, and interest rates.[6] However, the exchange rate's appearance in a Taylor-type rule is sub-optimal if it serves other purposes, like stabilizing the exchange rate to ward off problems in financial markets and institutions. Following the central arguments in Cespedes et al (2000) and Gertler et al. (2001), we expect that the high demand for foreign capital (mostly U.S. dollar-denominated) and the relatively large role of exports in economic growth expose emerging-market countries to uncertainties in external financing flows and

monetary policy transmission channels (see, for example, Mishkin (2004); Calvo and Mishkin (2003)).

[6] See Ball (2000) for a theoretical discussion of optimal IT practice in a small open-economy setting.

exchange-rate risk premia respectively.[7] With domestic financial markets that are incapable of perfectly substituting for external funds and with grossly thin foreign-exchange markets, sudden stops in capital inflows or shocks to terms of trade and commodity prices tend to have serious implications for the volatilities of the real exchange rate and the external risk premium. For example, a fiscal deficit could cause an adverse shock to the current account and a real exchange-rate depreciation, which in turn could exacerbate the country's risk profile and magnify real exchange-rate depreciation. While the first-round effect of the shock may include an improvement in the trade balance and a lower risk premium, this could be offset disproportionately by deterioration on the real side of the economy due to negative balance-sheet effects (see, for example, Garcia et al (2011)). Hence, the potential threat posed to the economy by pronounced exchange-rate volatility, as amplified through the financial accelerator mechanism, may oblige constrain a country into giving a role to the exchange rate in its monetary policy rule.[8] The government is therefore being forced into this defensive reaction due to its perception of future risks given its financial architecture and as such the responses are sub-optimal because they are not induced by the actual or measured output gap. This could result in a tightening of monetary policy at times when inflation forecasts and inflation expectations do not suggest upside inflationary pressures, or vice versa. In the

[7] We use external financing in a restrictive sense to refer to funding coming from foreign entities. This is in contrast with the standard use, where a firm's reliance on self-financing or internal funds is gauged against use of external funds from third parties, which could include domestic residents (see, for example, Clerc and Pfister (2003)).

[8] See Kiyotaki and Moore (1997) for a formal development of the model with balance sheet effects and a discussion on how credit constraints can affect the business cycle.

next section, we discuss the literature on the role of the exchange rate in inflation targeting regimes.

1.3 *IT in Emerging Market Countries: Theory and Evidence*

During the first decade of IT implementation in the 1990s, most research on macroeconomic performance under inflation targeting was focused on OECD countries. By 2000, a number of emerging market countries had adopted IT as their primary strategy for monetary policy (see Goncalves and Salles (2008)). Since then, this number has been on the rise. With this development, researchers are keen to examine macroeconomic outcomes of EME targeters against the backdrop of weak institutional capacity for implementing IT and pronounced vulnerability to macroeconomic shocks, relative to advanced industrial countries. To this effect, Mishkin (2004) and Fraga et al. (2003) provide an excellent overview of important issues which require attention by emerging-market countries if inflation targeting is to become a viable option for them.

Early literature in this area focused on institutional and policy preconditions that potential targeting countries have to meet to ensure that monetary-policy was able to prioritize inflation stability without being unduly constrained by other policy objectives (such as the need to monetize government borrowing) or to avoid IT itself becoming a destabilizing factor on economic outcomes. Freedman and Otker-Robe (2010) identified three key preconditions to adopting IT: central bank independence, sound fiscal policy, and resilience to changes in exchange rates and interest rates .[9] The last precondition is

[9] See Masson, et al. (1998) or Carare, et al. (2002) for a discussion of prerequisites identified in the literature as important for countries considering adoption of inflation targeting.

said to be satisfied when a country has sound financial institutions and deep-enough markets to insure against effects of shocks to the exchange rates and to absorb the placement of public and private debt instruments. The concern for a robust financial system follows on the assumption that strict or standard IT implies a flexible exchange-rate system on the grounds that the central bank cannot prioritize both inflation stability and exchange-rate stability; as such, prioritizing inflation stability implies accepting some amount of exchange rate volatility as inevitable. Still, high volatility in the exchange rate is not without implications for price stability or the real economy. Notably, high exchange-rate volatility through direct pass-through effects and its impact on inflation expectations may lead to excessive inflationary volatility in EMEs. Moreover, because of over-leveraged external debt positions in many EMEs, sharp fluctuations in exchange rates will have large impacts not only on the profitability of firms, but also on their balance sheets and that of the banking and government sectors (Amato and Gerlach, 2002).

Following the relative success of IT regimes in many EMEs even with relatively weak fiscal and under-developed financial systems, two additional strands of literature -- theoretical and empirical/analytical, respectively -- have emerged regarding the optimal role of the exchange rate for countries that decide to target inflation. From the first category, Ball (2000) puts forward a tractable theoretical exposition which supports the notion that it can be optimal for an IT-central bank to put some weight on the exchange rate in the interest rate rule in furtherance of medium-to-long-run inflation and output stabilization objectives. Ball states that developing countries, most of which have economies highly integrated into the global economy, are prone to shocks that precipitate

shifts in exchange rates, exports and world commodity prices, making policy rules developed for large, relatively closed economies like the U.S. inadequate for responding to such shocks. He shows through a theoretical model of a simple open economy that targeting "long-run inflation," a modified measure of inflation adjusted to remove the transitory effects of exchange rate movements, is the optimal solution which leads to stable inflation and stable output in open economies. He argues that, in contrast, targeting ordinary inflation keeps inflation stable, but produces much more output variability than is necessary. He points out that policy makers in EMEs require an opportunity to adjust interest rates to offset the effects of exchange rates on spending so as to ward off large fluctuations in inflation and output.

Since Ball (2000), a number of researchers have provided empirical and analytical evidence that addresses the concept of an optimal policy reaction function that includes the exchange rate among its arguments. Thus far, the empirical base of the literature has focused on the estimation of open-economy monetary-policy rules for stratified samples of countries and comparing results across samples on the basis of the character and magnitude of the interest response to the exchange rate (e.g. Aizenman and Hutchison, 2010). The analytical evidence is based on calibration results of inflation and output-volatility performance in a typical robust or vulnerable economy under a set of interest rate rules that include an exchange rate objective. This analysis draws results of which rules produce the best macroeconomic outcomes (e.g. Garcia et al. (2011) and Moron and Winkelried (2005)). The empirical results show that numerous central banks take into account the exchange rate in their *de facto* monetary-policy rules, and the analytical

results give support to the theoretical proposition that interest-rate responses to the exchange rate can be optimal, particularly for financially vulnerable countries.

Aizenman and Hutchison (2011) investigate IT in emerging markets in the context of a theoretical model motivated by Ball (2000). They present empirical evidence showing that IT emerging markets are following a mixed-IT strategy whereby central banks systematically respond not only to inflation and output, but also to the real exchange rate in setting policy interest rates. They also report that IT countries with a particularly high concentration in commodity exports change interest rates much more proactively to real exchange-rate movements than non-commodity-intensive targeters. The authors link the objective of real exchange-rate stabilization in the central banks' interest rate rules, not to inflation control indirectly predicated on real depreciation being a good predictor of future inflation, but rather to adverse real output effects associated with real exchange rate volatility. However, they do not indicate the channel through which output could be affected.

Garcia et al. (2011) argue that adjusting interest rates systematically in response to exchange rate movements is consistent with an open-economy IT approach, since the dampening of exchange rate volatility should be consistent with the non-inflationary long-term equilibrium of the economy. The authors use calibration to show that hybrid policy rules (rules with an exchange rate objective) can outperform "plain vanilla" IT rules (i.e. strict IT) in emerging market settings, since they lead to lower inflation and output volatility. They argue that by allowing the interest rate to rise just enough to offset the demand stimulus of a weaker currency, hybrid rules work to dampen inflation consequences.

Moron and Winkelried (2005) attempt to answer the question of which type of rules might be optimal for IT regimes in which balance-sheet effects matter. The authors compare performance of a set of policy rules in two calibrated economies – one financially robust and the other financially vulnerable. They conclude that in the short run it is optimal to defend the real exchange rate if its fluctuations would cause volatility in output, inflation, and/or the nominal interest rate. Cespedes et al. (2000), Ragan (2005) and Cavoli and Rajan (2006) also argue that there may be some benefit to including the exchange rate in the policy reaction function of a central bank in a financially vulnerable economy. Other relevant studies include Mohanty and Klau (2004), who report a statistically significant coefficient on real exchange-rate changes in ten countries, with a conclusion that this observation supports the "fear of floating" hypothesis. Also, Edwards (2006) reports that countries with a history of high inflation and high real exchange rate volatility tend to have a higher response to the real exchange rate in Taylor-rule equations.

While the view that it may be optimal for central banks in financially vulnerable economies to take into account of the exchange rate in their monetary policy rules is well established, the empirical literature has not yet systematically explored why some countries place some weight on the exchange rate in their monetary-policy reaction functions, while others do not. Researchers have pointed to fear-of-inflation and fear-of-floating as the determining factors, but there is not much in the way of empirical evidence to validate the claim. Therefore, an important missing cog in the literature is empirical evidence based on country-specific data that links the fundamentals of the two 'fears'

mentioned above, to the policy behaviors exhibited by IT countries that put some weight on the exchange rate.

In this essay, we attempt to fill this gap by explicitly modeling the relation between the central bank's choice of whether or whether not to put some weight on the exchange rate and various fundamental economic factors, specifically, the degree of exchange rate pass-through to inflation, a measure of the burden of foreign indebtedness, stock market capitalization, net private capital flows, and the trade balance. Our approach will permit us to conditionally delineate the choice of an exchange rate objective under the IT regime as either optimal or sub-optimal, based on the underlying factors for each significant exchange rate objective. We believe a country's motive in favor of or against an exchange rate objective has important implications for its inflation outcomes, particularly relative to other IT countries without or with a significant exchange rate objective respectively.

Our proposed empirical approach is novel in the sense that it introduces the study of Taylor rules in the context of wider external and financial sector variables. This study also provides country-specific empirical evidence that should support and buttress the assumptions that underlie financial vulnerability in calibrated models. We also intend to overcome the empirical shortcoming of previous studies that used stratified samples, which have potential to introduce bias in sample selection, and to mitigate the problem of limited replication of results by using a wide range of countries with different economic fundamentals. The remit of our methodological approach is to bridge the empirical gap that exists in accounting for the determinants of the observed choice in favor or against

the use of the exchange rate as a driver of policy in emerging market countries pursuing IT. In the next section we present our empirical approach.

1.4 *Methodological Framework*

To identify IT-practicing countries that place some weight on the exchange rate in their monetary-policy rules and identify the factors that lead countries to do so, we compile data on IT-practicing countries and estimate a set of four key equations: (i) an implicit Taylor-type rule for each country; (ii) an open-economy accelerationist Phillips curve for each country, which gauges the degree of exchange rate pass-through to inflation; (iii) a dynamic panel-data probit model estimated for all IT countries in the sample, with predictor variables based on factors that could determine decisions to place a significant weight on the exchange; and (iv) a dynamic panel-data fixed-effect model that quantifies how inflation performance differs between standard IT targeters and mixed-strategy targeters.

The multi-equation empirical approach will address the hypothesis that a country's choice to place a significant weight on the exchange rate in its interest policy rule could either be consistent with the optimal strategy of smoothing fluctuations in inflation and output, or it could be influenced by structural factors that underpin the soundness and depth of the domestic financial system. In essence, in a forward-looking monetary framework like IT, using a second companion policy rule that has the exchange rate as the policy target amounts to reacting optimally to deviations in output caused by the exchange stimulus (Ball, 2000). On the other hand, a rule that entails putting a weight on the exchange rate when setting the interest rate is consistent with fear of floating if the

objective is to keep the rate at par with an anchor currency so as to avoid potential destabilization to the financial sector. This chapter hypothesizes that due to structural factors, countries may have the exchange rate appear in the reaction function either for optimal reasons (e.g. because it plays a role in stabilizing output and inflation) or for suboptimal reasons (fear of floating, which includes expected financial (de)stabilization). It is not straight-forward to extricate these two effects after the estimation of the Taylor rule, hence the approach laid out in this section. In general, a mixed strategy based on fear of floating arises out of *expectation* of destabilization while an optimal mixed strategy responds to stabilize output after the fact.

Stabilizing the domestic financial system is not a valid component of optimal interest-rate policy because the sort of destabilization to the domestic financial system being envisaged is that which works through the financial accelerator mechanism where shocks to the exchange rate and the real economy feed off each other (See Kiyotaki and Moore (1997)). For example, sharp exchange rate shifts may result in severe negative impacts on borrowers' balance sheets. This could affect the liquidity and profitability of banks potentially leading to wide spread weaknesses in the banking and real sectors (Amato and Gerlach, 2002). When this happens, any effort to loosen policy under the second companion policy rule in order to stimulate output would only exacerbate the exchange depreciation.

From the foregoing, the volatility of the real exchange rate, under domestic financial conditions that are not deep enough and do not meet the criteria of being sufficiently sound, is likely to have important implications for the short-term interest rate, inflation, output and broader financial sector stability. This implies a significant interest-

rate response to exchange rate appreciation/depreciation could be predicated on either concern for inflationary pressure through, for example, 'pass-through to inflation effects' or concern for factors such as the adverse impact on the tradable sector of the economy and on financial system stability and viability.

The conceptual/economic rationale for the equations to be estimated in this section draws on the literature of small open-economy models with an inflation target. Specifically, the relevant models are those presented in Fraga et al (2003) and Kuttner and Posen (1999). The central feature of these models is the emphasis on the optimal control problem of a central bank that faces challenges of conservatism, credibility, and transparency in the wake of responding to macroeconomic shocks.[10] The stylized models reflect the common characteristics of an aggregate demand and an aggregate supply relation supported by an interest rate rule which is the policy instrument. The models specify the IT mechanism as working through the central bank's influence of aggregate demand which it controls using the policy interest rate. Thus, the models would characterize a country's IT strategy choice (standard or mixed) as a specific strategy within the conventional model of IT with the implication for central bank behavior being embodied in the Taylor rule.

Further, underlying our conceptual approach is the notion that the problem of monetary policy is to manage aggregate demand in a way that minimizes the deviation of inflation and output from their targets, and possibly the exchange rate relative to some

[10] The modeling framework in Fraga et al. is descended from features of the McCallum and Nelson (2000) formulation while that in Kuttner and Posen (1999) is set from a conventional model of time inconsistency in monetary policy extended from the basic Barro-Gordon (1983) framework.

measure of some underlying equilibrium rate and/or some other reference rate (such as the value of an anchor currency). We assume that a typical central bank responds to macroeconomic shocks through an appropriate choice of interest rates. This means we assume that all monetary authorities in IT countries have instrument independence and hence access to a short-term policy interest rate tool during the inflation targeting period. This assumption is necessary because we recognize that before the switch to inflation targeting, a central bank would have pursued some alternative operational strategy for monetary policy such as money or exchange rate targeting, both of which target inflation indirectly. The intermediate target for policy under IT is the inflation forecast for some horizon.

The intermediate variable for strategies that primarily target monetary aggregates or the exchange rate would be the growth rate of monetary aggregates and the level of the exchange rate of an anchor currency, respectively. Although it is a viable alternative to control the nominal money stock and the level of the exchange rate through the use of monetary policy instruments such as open-market operations, reserves requirements and foreign-reserve management strategies, IT requires the use of a more transparent instrument like the policy rate so that agents could clearly discern policy actions and their relation to the inflation target.[11] More so, to effectively and durably anchor inflation expectations, interest rate policy provides a more transparent mechanism since money targets can be cumbersome to follow by the markets.

[11] The use of reserve-deposit ratio based systems with different liquidity requirements for collateral assets is still a favored option for a number of developing countries.

In this essay, the empirical implications of addressing the hypothesis of the apparent dualistic style of IT implementation by EME countries within this conceptual framework are captured in a four-equation approach. The approach rests on the idea that each EME country's systematic interest-rate response can be interpreted strictly within two distinct operational strategies of IT which approximate an estimable optimal state-dependent rule for the policy interest rate – one with an objective for the exchange rate and the other without. Thus, the *first* equation in the framework estimates a Taylor rule for each country, enabling us to identify IT countries that have monetary-policy reaction functions in which the exchange rate has played a systematic role. The *second* equation is an accelerationist Phillips curve – which explains current inflation as a function of lagged values of output or unemployment and the lagged inflation rate -- for each country.[12] This equation identifies the determinants of the dynamic process of inflation, where the question of central interest is the extent to which changes in the real exchange rate are fundamental to the inflation process in the country in question. In the literature, inflation is generally considered to be affected by the exchange rate in particular via the prices of imported consumption goods (see Gali and Monacelli, (2000)), if not also intermediate inputs and capital goods (Fraga et al.).

[12] The "accelerationist" Phillips curve is so named because it implies that unemployment can only be kept low (or output high) at the expense of an increasing inflation rate, and thus an accelerating price level. Friedman (1968) assumes that inflation expectations evolve over time as a result of actual past experience. Simple formulations of this assumption of adaptive expectations assume that inflation expectations are determined by what happened last period. The accelerationist property becomes apparent when the relationship between inflation and output is presented in terms of the first differences.

Ball (2000) on the other hand cites the demand channel, which induces interest rates to be adjusted to offset the effects of exchange rates on spending, to avert unnecessarily large fluctuations in inflation and output. The empirical approach in this paper considers both these channels. The accelerationist Phillips curve implies the specification by Gali and Monacelli and Fraga et al. The approach postulates a higher and more rapid correlation between exchange-rate changes and the inflation rate supported by previous findings of a high degree of pass through in emerging market countries (Goldfajn and Werlang, 2000). The criterion for incorporating the demand specification is explained below.

The empirical relevance of the accelerationist Phillips curve follows from the conceptual foundation of the primacy of price stability as the core focus of policy under IT. Thus, the idea is to establish whether the systematic role of the exchange rate objective in the Taylor rule is consistent with the systematic effect on the inflation rate, through the Phillips curve, of the fluctuations in the real exchange rate. At this point, the a priori reason for the Taylor rule to react systematically to the exchange rate is as an indirect response to inflation implications of exchange-rate variations through pass-through. The evidence for or against this hypothesis will come from the estimate of the accelerationist Phillips curve. Essentially, the side by side comparison of the estimates of the two functions is meant to establish the extent to which interest responses in the Taylor rule reflect (or *do not reflect*) the influence of the real exchange-rate variation on inflation. The result of this preliminary test feeds into the next empirical step.

The *third* step investigates the exchange rate's systematic relationship with a set of variables. The purpose is to identify whether the factors that seem to be systematically

influencing decisions about how to practice IT are more reflective of factors that would be expected from considerations of optimal policy or are instead consistent with wanting to stabilize the financial sector. To achieve this delineation, we estimate the dynamic panel-data probit model based on a stylized information set of macroeconomic and structural financial market factors. For optimal policy, the interest rate response to the real exchange rate in the Taylor rule should reflect the desire to minimize fluctuations in inflation and output around their targets. The absence of such a link in the preceding test and the presence of a systematic relationship between the real exchange rate and one or more macroeconomic and structural financial market factors in the probit test could suggest a policy objective to stabilize the relevant sector.

The last equation to be estimated is the dynamic panel-data fixed-effects model. This model is meant to assess the efficacy of the two identified targeting strategies in the core conceptual approach - an exchange rate object relative to having no objective – on inflation performance of sample countries. In particular, the purpose is to determine which one of the two strategies delivers a lower average level of inflation or a lower variance between actual inflation and its target during the targeting period.

In what follows, we explain the features of each of the four equations in detail. First, for each of the IT countries in our sample (to be described below), we use ordinary least squares to estimate a Taylor-type policy rule of the form

$$i_t = \beta_0 + \beta_1 i_{t-1} + \beta_2 \pi_{t-1} + \beta_3 Gap_{t-1} + \beta_4 App_{t-1} + e_t \qquad [1]$$

where i_t is the short-term nominal interest rate at time t, π_t is a measure of the *deviation* of inflation from its target, Gap_{t-1} is a measure of the lagged output gap derived using an Hodrick-Prescott filter, and App_{t-1} is lagged real appreciation of the currency. The rationale for using a one-period lag of inflation as opposed to forecasted inflation for estimation of the Taylor rule comes from the broader argument that because inflation tends to be highly persistent, information on lagged inflation is a central variable in the inflation forecast.[13]

In line with related literature such as Woglom (2003) and Minella et al (2003), we use one-period lags of output gap and real exchange appreciation to take account of the lag in availability of data for real variables to policy makers, especially in EME contexts. Following Ball (2000), we include the lagged value of the short-term interest rate to take account of interest rate smoothing.[14] We expect that with the adoption of IT, the central bank's reaction to shifts in inflation, growth and the exchange rate will become systematic rather than discretionary. Thus, we should see $\beta_2 > 0$ and statistically significant for most countries during the targeting period to reflect inflation control as the overriding goal of monetary policy. We expect a non-zero weight on the real exchange rate, $\beta_4 < 0$, and we expect this coefficient to be statistically significant only for the fraction of targeters who opt to react to fluctuations in the exchange rate. The negative

[13] Taylor (1999) argues that since forecasts of the future are based on current and lagged data, rules based on inflation forecasts are no more forward-looking than rules explicitly based on current and lagged data.

[14] The periodicity for our data is quarterly hence the requirement for a smoothing variable.

sign reflects the inverse relationship between the policy interest rate and the real exchange rate appreciation.

We also expect the weight on the output gap to have the correct sign, $\beta_3 > 0$, but with varying degrees of significance across countries. The long-run effect of an increase in inflation on the policy interest rate is $\beta_2/(1-\beta_1)$. Therefore, in order for monetary policy to stabilize the long-run inflation rate, we expect the long-run response of the nominal interest rate to inflation to be $\beta_2/(1-\beta_1) > 1$, i.e., *Taylor principle*. The Taylor principle requires that in order to achieve a determinate price level the central bank should adjust nominal interest rates more than one for one in response to any change in inflation (see for example Gali, 2008).

The estimated Taylor rule identifies the central bank's "revealed" choice of monetary policy reaction function by observing its interest rate responses to the three key objectives. Yet there is little attention in the literature on how economic and financial conditions that give rise to fear-of-inflation and fear-of-floating influence the choice of objectives the policy rate should react to. Then the second equation addresses real exchange appreciation as a potential source of inflation concern. Equation [2] estimates the open-economy accelerationist Phillips curve, based on Goldfajn and Werlang (2000), which characterizes how the exchange-rate depreciation and other key variables affect inflation dynamics.

$$\pi_t = \gamma_0 + \gamma_1 \pi_{t-1} + \gamma_2 App_{t-1} + \gamma_3 Gap_{t-1} + \gamma_4 Open_{t-1} + u_t \qquad [2]$$

where $Open_{t-1}$ is a measure of the lagged degree of openness to the rest of the world, measured as the sum of imports plus exports divided by GDP. The other predictor variables are defined as in equation [1] above . The coefficient γ_2 represents the rate of pass-through from the exchange rate to prices. Goldfajn and Werlang argue that in a small, more open economy with a larger relative importance of imports and exports, a given depreciation (appreciation in our case) has a larger positive effect on domestic prices. This view is often contrasted with that held by Romer (1993) who shows how openness directly affects inflation by putting a check on inflationary finance in a Barro-Gordon (1983) type model without a commitment technology. Romer argues that because the harms of real depreciation are greater in more open economies, the output benefits of unanticipated monetary expansion are decreasing in the degree of openness, providing a disincentive for monetary finance (that is, monetization of a fiscal deficit).[15] The absence of binding pre-commitment is important in driving Romer's interpretation of the results. Since our sample constitutes inflation targeting countries that we expect to put the first priority on inflation stability rather than output expansions, inflation effects of openness are likely to be in line with the characterization by Goldfajn and Werlang. Equation [2] provides the basis for testing for the systematic role and the statistical significance of the exchange rate in the inflation process.[16] However, estimating equation [2] over the span

[15] See Romer (1993) for detailed cross-country empirical evidence on the strong and robust link between openness and inflation.

[16] We expect the intensity of pass-through to decline in the post-targeting period as the anchor for inflation expectations shifts or begins to shift from the exchange rate to the forward-looking inflation target. The formal verification of this phenomenon is beyond the remit of the research of this dissertation.

of the pre and post periods implies considerable difficulties, because we expect the dynamics of some of the explanatory variables to shift fundamentally in the post targeting period. Following Kuttner and Posen (1999), we extend the model in equation [2] by adding a dummy variable that multiplies all regressors for the inflation targeting period. Specifically, we estimate the following equation using Ordinary Least Squares,

$$\pi_t = \gamma_0 + \gamma_1 * \text{post(t)} + \gamma_2 \pi_{t-1} + \gamma_3 * \text{post(t)} \pi_{t-1} + \gamma_4 App_{t-1} + \gamma_5 * \text{post(t)App}_{t-1} + \gamma_6 Gap_{t-1} + \gamma_7 * \text{post(t)} Gap_{t-1} + \gamma_8 Open_{t-1} + \gamma_9 * \text{post(t)} Open_{t-1} + u_t \quad [3]$$

where post is a dummy variable equal to 1 for periods when the country was practicing IT and zero otherwise. The rest of the variables are defined as in equation [2]. The inclusion of dummy variables for the post targeting period should determine if there are statistically significant structural shifts in relationships between inflation and its determinants over the two sub-sample periods. For each country, we estimate equation [3] to test whether coefficients in the post period significantly differ from those in the pre period. If there is a significant change in the interrelationships between inflation and its determinants between the pre- and post-period, the coefficients γ_5 for the post-targeting period should be statistically significant. Thus, the average effect of real exchange appreciation in the post period on inflation will be captured by the sum of the coefficients γ_4 and γ_5.

At this point, we connect the estimated effect of exchange-rate appreciation in the Taylor rule, β_4, from equation [1] to the interpretation of the coefficients γ_4 and γ_5 from equation [3]. Since the central bank responds to inflation pressures arising from exchange rate movements indirectly through its reaction to the exchange rate, we can compare the estimate, β_4, to the estimate of the exchange rate pass-through-to-inflation coefficients

from equation [3] so as to assess optimality of interest rate responses. Following Ball's criteria, policy interest responses under IT are expected to be targeted at smoothing out pass-through effects and therefore should typically be consistent with γ_4 or its sum with γ_5, when both are statistically significant. This implies computing the statistic,

$$\text{Diff} = (\gamma_4 - \beta_4)/\text{S.E}(\gamma_4) \leq 1.96 \sim_{2\ \text{SDs}}$$

or its equivalent

$$\text{Diff'} = (\gamma_4 + \gamma_5 - \beta_4)/\text{S.E}(\gamma_4 + \gamma_5) \leq 1.96 \sim_{2\ \text{SDs}}$$

where Diff (normalized) is the difference between the real exchange appreciation and the interest response in the Taylor rule, S.E is the standard error of the coefficient estimate of γ_4 or its sum with γ_5 when both are statistically significant and SD is the standard deviation. We evaluate the quantitative importance of β_4 by determining whether its estimated value is consistent with the central bank's desire to *fully* address the exchange pass-through to inflation effect. In particular, we expect the typical interest-rate response to real exchange appreciation, β_4, to be consistent with optimal criteria only when its deviation from typical real exchange appreciation is within two standard deviations of the estimate of the coefficient, γ_4 or its sum with γ_5 when both are statistically significant. This implies in order to allow for statistical margin of error in the adjustment of the policy rate, the normal variation of β_4 around the long-run value of γ_4 or its sum with γ_5 is expected to be within the two standard-deviations margin of error. In the event that a country's typical interest rate response falls outside the two standard deviation band, this would suggest possible behavior not consistent with smoothing out inflationary effects of pass-through from real exchange appreciation.

In terms of the post-estimation mechanics, the basic criterion for the Diff statistic is to account only for those values that show statistical significance. Otherwise, if not significant, the estimate is coded with a 'zero'. This is synonymous to restricting the coefficient that does not exhibit statistical significance to equal zero. This criterion implies the test is not relevant for understanding pass-through for a mixed strategy country with pass-through to inflation which is not statistically significant. Conceptually, such a country will have no pass-through challenges. Gonzalez (2000) and Muinhos (2004) report evidence that inflation targeting can be accompanied by a decline in the degree of pass-through to inflation. Often a substantial and statistically significant reduction in pass-through between the pre and post-periods can lead to a low value of the sum of γ_4 and γ_5 (expected to be negative) and this sum may not be significant.

Again, as stated above, estimation of equation [1] identifies those countries which place a significant weight on the exchange rate in the Taylor rule. Estimation of equation [3] is meant to take into account the influence of real exchange appreciation on inflation dynamics which might cause a country to 'rationally' take the exchange-rate into consideration in its Taylor rule. However, having significant exchange pass-through in equation [3] matched with a significant coefficient β_4 is not by itself a sufficient condition for a country to be identified as responding to the exchange rate from considerations of optimal policy. While equations [1] – [3] are meant to yield evidence of countries which are mixed-strategy targeters, the degree of exchange pass-through to inflation, and how much of this pass through potentially feeds into interest rate responses, the procedure does not conclusively explain mixed-strategy responses. This is because a country's response in the Taylor rule could either be stronger or weaker than what is

required to counteract the inflation effect of exchange-rate appreciation. Also countries will take the exchange rate into account even in the absence of significant real exchange pass-through to inflation. At the other extreme, some countries will not take real exchange-rate appreciation into account even in the presence of significant pass-through to inflation. Note that up until now the methodology employed is aimed at recursively taking into account or even discounting the 'exchange rate variation - inflation - interest rate response' link as a key factor in mixed strategy targeting.

Therefore, the next step is to determine whether it is optimal considerations or financial-vulnerability that has explanatory power, after having taken into account one factor that might cause a country to 'rationally' take the exchange-rate into consideration in its Taylor rule. The financial vulnerability variables to be taken into consideration are those commonly identified in the literature as key structural variables that influence financial vulnerability; they are described in detail below. This next step is purely statistical and employs a probabilistic model. To examine whether mixed-strategy targeting can be explained by factors other than the objective of medium-to long-run macroeconomic stabilization, the dynamic panel-data probit model with fixed effects is estimated as follows:

$$pr[y_{it} = 1|\mathbf{x}_{it}] = F(\mathbf{Fiv}_{it}\boldsymbol{\beta_1} + \mathbf{OPT}_{it}\,\boldsymbol{\beta_2} + \lambda_i + \boldsymbol{e}_{it}) \qquad [4]$$

where y_{it} is an indicator variable for country i at time t, taking the value one in the post-targeting period if the Taylor rule estimated for country i contains a negative and

statistically significant coefficient on the exchange rate and zero otherwise.[17] **x** is a vector of predictor variables, including **Fiv** which is a vector of measures of financial vulnerability; **OPT,** which is a vector of targeted macroeconomic variables for the optimal stabilization of inflation and output); and λ_i is a vector of fixed effects peculiar to country i**.** The residual e_{it} is assumed to be normally distributed with variance σ_{eit}^2.[18] Estimating the model in equation [4] with individual fixed effects is meant to control for omitted but persistent sources of variation across countries, such as their dependence on primary-commodity exports, degree of economic openness, degree of exchange rate pass-through, and political factors.

In line with related literature, we take the variables in the vector **Fiv** to be those variables which co-vary with the external risk premium. For example, Cespedes et al. (2000) point out that the elasticity of the external risk premium to the real exchange rate is proportional to the ratio of dollar-denominated debt to investment. The key stylized measures of financial vulnerability include net private capital flows, ratio of debt-to-GDP, stock market capitalization-to-GDP, the fiscal deficit, and the trade balance.[19] The details of the data and criteria for measuring financial vulnerability and optimal variables

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[17] This means y_{it} will be zero for both standard and mixed strategy targeters during the pre-targeting period.

[18] The state-choice- contingency of the indicator variable (y = 1 or y = 0) is determined from the estimation results of equation [1] above. When the coefficient β_4 in the estimated Taylor rule for a country is negative and statistically significant the dependent variable in the probit takes the value of one in the post targeting period, otherwise it takes the value of zero.

[19] Borio and Lowe (2002) construct an index of possible predictors of future problems in the financial system for a group of countries from both the industrial and emerging world using movements in asset prices, credit and investment, which take as given the underlying structure of the domestic financial markets.

are explained in the next section. Following Korajczyk (1985), the external risk premium is defined as the difference between the real interest differential and the expected change in the real exchange rate. This characterization emphasizes the existence of the premium not only because of the interest rate variation but also because of variations in the real exchange rate. Henceforth, this creates an incentive for authorities to manage external risk by managing the volatility of the real exchange rate.

The choice of empirical measures of financial vulnerability is motivated by contemporary literature on sources and characteristics of financial risk in emerging market countries. Some of the key factors that have been identified to underlie risk in emergent economies are limited development of domestic financial markets, weak links with the international financial system, and thin foreign exchange markets (Cespedes et al. 2000, Gertler et al. 2001, Caballero and Krishnamurthy (2000)). The high demand for foreign capital induced by structural deficiencies in domestic financial markets exposes emerging market countries to uncertainties in external financing flows and exchange risk premia. With domestic financial markets that are incapable of perfectly substituting for external funds, sudden stops/reversals in capital inflows tend to have serious implications for the volatilities of the real exchange rate and the external risk premium.

From the foregoing, the issue of portfolio capital flows is given special prominence in the functional specification of variables that constitute the **Fiv** vector in equation [4] because evidence indicates that foreign factors play a substantial role in accounting for episodes of capital inflows and outflows. For example, Calvo, Leiderman, and Reinhart (1996) show that fluctuations in world interest rates are a key factor inducing capital flows for small open economies. The other external factors include

terms-of-trade developments, the international business cycle and its impact on profit opportunities, and any regulatory changes that affect the international diversification of investment portfolios at the main financial centers. The authors find that foreign factors account for 30 to 60 percent of the variance in real exchange rates and reserves, depending on the country. Similarly, Chuhan, Claessens, and Mamingi (1993) find that external variables explain about half of the bond and equity flows from the United States to a panel of six Latin American countries. They conclude that external factors account for about one third of bond and equity flows into the Asian region. While external factors are very predominant in this filament of literature, internal structural factors most often cited relate to the introduction of institutional reforms, such as the liberalization of the domestic capital market (Obstfeld, 1986) and the opening of the trade account (Calvo, 1988). Evidence shows that capital inflows have been associated with a marked real exchange rate appreciation in most developing countries (Kinda, Combes, and Plane, 2011).

Therefore, the main point here is to illustrate whether portfolio capital flows, in compliance with other structural measures of financial vulnerability in the **Fiv** vector can explain the mixed strategy option of IT or whether optimal variables in the **OPT** vector (to be described shortly) are otherwise adequate to explain the choice of mixed strategy targeting. The key assumption of the functional form of equation [4] therefore captures the implications of private capital flows on the choice of the real exchange rate taking as *given* the underlying structure of the domestic financial market. Since private capital flows essentially reflect exposure to external conditions the $\boldsymbol{\beta_1}$ vector constitutes private capital flows as an independent effect and as an interacted effect with the other measures

of financial vulnerability in the domestic financial markets. Intuitively, the interaction is meant to isolate the effects of new portfolio capital flows due to its exposure to existing foreign currency denominated debt, domestic equity capital markets, the fiscal environment, and the goods market.

The above characterization ensures that the marginal effect of portfolio capital flows depends not only on its own effect, but also on the level of the other covariates so as to reflect the role of "soundness and depth of the domestic financial system". The **OPT** vector constitutes measures of the deviation of inflation from target and the output gap details in next section). The influence of shocks to the terms of trade and commodity prices on real exchange volatility will be captured in the fixed effect variable λ_i.[20]

We expect the estimates of constituent parameters of the vector $\boldsymbol{\beta}$ to be positive for the measure of external indebtedness and stock market capitalization, and negative for net private capital flow and the trade balance. The key post-estimation output is the marginal effect of each variable in the **x** vector on the probability $pr[y_{it} = \mathbf{I} | \mathbf{x}_{it}]$, computed at the mean values of all predictors. To compute the marginal effects, estimates of coefficients, at mean values of all predictors, are fitted into equation [4] so as to compute a predicted probability at which the marginal effects could be derived. The marginal effect will indicate by how much the predicted probability of placing a significant weight on the exchange rate should change in the absence or presence of one

[20] In this dissertation our remit is not to assess financial vulnerability per se, but rather to recognize its effects on monetary policy vide a statistical relationship between known measures of financial vulnerability and the probability of responding to the exchange rate. However, there appears to be great scope for further research into a fully-fledged structural model that definitively identifies the functional relationships of financial vulnerability.

of the **Fiv** or **OPT** vector variables.[21] The interpretation for the expected negative sign on the private capital flows and trade balance would be that not having negative capital flows and/or a trade deficit lowers the probability of practicing mixed strategy targeting. The power of the variables in the **x** vector to explain the variation of the short-term interest rate to movements in the real exchange appreciation will be evaluated on the basis of the goodness-of-fit of the predicted probability and the marginal effects at standard levels of significance.[22]

The fourth equation evaluates the impact of IT on inflation performance between standard and mixed-strategy inflation targeters (countries that have a significant estimate of β_4 in equation [1]) relative to those that pursue standard inflation targeting. Here we estimate the following dynamic-panel fixed-effects model:

$$\prod_{it} = \alpha_0 + \alpha_1 \prod_{it-1} + \alpha_2 App_{it-1} + \alpha_3 Target(it) + \alpha_4 Target(it)*Strategy(it) + \mu_i + \nu_{it} \quad [5]$$

where *i* denotes the country, *t* is the year, $\prod_{it}$ is the quarterly inflation rate[23], α represents the overall constant in the model, App_{it-1} is the lag of real appreciation, *Target(it)* is a

[21] We compute the marginal effect by taking the derivative of the fitted probit function with respect to the relevant Fiv variable.

[22] Following Hill et al. (2005) the model in equation [4] can be used to "predict" choice by restricting some values of predictor variables in the 'fitted' probit equation. For example, if the observed share of IT countries placing a positive weight on the exchange rate is one-quarter, countries with predicted probabilities around one-quarter are on the borderline, where they are equally likely to choose standard IT or mixed strategy IT. Beyond that, y = 1, meaning a country would most certainly put a significant weight in its interest rate rule. This dissertation will not delve into the prediction strand of the research as it is beyond the current remit.

[23] This measure is in large case because here we employ panel data as opposed to country- level estimations employed for equation [2].

dummy variable indicating that country i had adopted standard IT in period *t*, *Strategy(it)* is a dummy variable that takes on the value 1 when country i is mixed-strategy targeter during period *t* or 0 when a country is a standard targeter (does not place a significant weight on the exchange rate in the estimate of equation [1]), u_i represents the cross section or the individual country-level fixed effects which are not time-varying,[24] and ν_{it} are the error terms for i = 1, 2, ….., M cross-sectional units observed for the dated periods t = 1, 2,……., T and the error terms are assumed to have zero mean, constant variance and $cov(\nu_{it}, \nu_{is}) = 0$. α_3 is the effect of shifting to standard IT and $\alpha_3 + \alpha_4$ is the effect of adopting mixed-strategy IT, and the significance of the coefficient α_4 tells whether there is a difference in average inflation between standard and mixed-strategy IT countries. Again, whether β_4 in equation [1] is statistically significant is used to identify countries practicing mixed-strategy IT. So the 'Target' variable captures the benefits of the shift to standard IT for a given country, as well as differences across countries that do and do not practice IT. Therefore, we assume these benefits are constant across targeting countries in the sample.

The presence of a lagged dependent variable among the regressors in equation [5] implies that least squares estimates will no longer be unbiased and consistent. The variable, $\prod_{t-1}$, will then be necessarily correlated with the disturbance through individual heterogeneity captured by μ_i (Achen 2000, Baum et al. 2003, Kennedy 2008). Hence the

[24] This variable captures country level differences such as level of development of financial systems, degree of fiscal autonomy, degree of central bank independence, dependence on primary commodity exports and experience with implementing inflation targeting.

utilizing of an Instrumental Variable (IV) estimating procedure is meant to alleviate the problem of estimating [5] with an endogenous regressor. Specifically, Equation [5] is estimated using dynamic-panel data methodologies: the Arellano-Bond (A-B) (1991) approach and the Blundell and Bond (B-B) (1998) estimator or system Generalized Method of Moments (GMM) approach. By virtue of belonging to the class of IV estimators, both these methods provide attractive features for correcting the bias and inconsistency that arises from the OLS method.

The Arellano–Bond estimator sets up a generalized method of moments (GMM) problem, which basically differences the model to get rid of the individual specific effects and, along with them, any time invariant regressor. This operation gets rid of any endogeneity that may be due to the correlation of these individual effects and the right-hand-side regressor. The A-B method relies on the knowledge that within the structure of the dynamic panel model there is available a large surplus of instrumental variables when the difference Δ operator is applied to the data.[25] The necessary instruments are based on lagged values of the dependent variable while allowing for the inclusion of external instruments as well. By construction, the difference transformation ensures that the recovered instruments are orthogonal to the differenced errors thereby releasing the required moment conditions for unbiased estimation.

The B-B estimator improves on the A-B approach by incorporating extra moment conditions while at the same time estimating the model as a system (hence system GMM). The estimator uses a combination of equations in levels and equations in first

[25] See Baltagi (2013) for a detailed and rigorous derivation and treatment of the mechanics of the A-B approach.

differences with lagged differences of the dependent variable as instruments for the former and lagged levels of the dependent variable as instruments for the latter.[26] Using Monte Carlo experiments, Blundell, Bond, and Windmeijer (2000) found that the system GMM estimator does improve the precision and does reduce the finite sample bias which is usually apparent with the A-B method in short panels and persistent series.[27]

The over-identification restrictions used to implement the two approaches are established via orthogonality conditions between the instrumental variables claimed from within the framework of equation 5 and the differenced error term. The parameters are identified in terms of the orthogonal empirical moment equations,

$$E[(\prod_{is} (v_{it} - v_{it-1}))] = 0 \qquad [6]^{28}$$

Equation 6 implies that all lagged values of $\prod_{is}$ for s previous to *t-1* together with other strictly exogenous regressors and/or predetermined variables are available as instruments. Additionally, the rank condition is assumed to hold for equation 6 so that all the moment conditions will not be redundant. The rank condition implies the order condition by the

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[26] Ahn and Schmidt (1995) showed that under the standard assumptions used in a dynamic panel data model, there is still more information through potential additional nonlinear sample moments conditions that can be brought to bear on estimation using a broader GMM estimator, that are ignored by the A-B estimator.

[27] See Green (2008) for a formal technical derivation of the unbiased and consistent system GMM estimator under an optimally determined weighting matrix.

[28] While the above transformation removes the individual country-level fixed effect, u_i, it still leaves the time effects for the targeting dummy variable and its interaction with the strategy dummy variable to be modeled with a time-specific dummy variable (see Green, 2008).

sheer large number of possible instruments available within the system to generate the moment conditions necessary to estimate the parameters in equation 5. Hence, we assume an order condition $z \geq k$, where k is the number of parameters to be estimated and z is the number of possible instruments. The postestimation test for over-identification will be Sargan's difference statistic which test the null that overidentifying restrictions are valid. Evidence against the null implies that the moment conditions used are redundant. The A-B test for first-order and second-order serial correlation in the disturbance will also be utilized. In order to assure the models are not misspecified, the null of no autocorrelation of first order should be rejected and the absence of second order serial correlation should not be rejected.

We expect adoption of IT to have a significant negative effect on inflation under both strategies.[29] We expect optimal behavior by mixed targeters to produce inflation performance comparable to standard targeters. Otherwise non-optimal behavior is expected to achieve relatively second best results.[30] In theory, mixed-strategy targeters

[29] In view of the fact that advanced industrial countries that practice IT have precise inflation targets, some may question whether EMEs that practice IT have committed to well-defined inflation targets since some have target ranges as opposed to point targets and many have inflation levels much higher than those of advanced-industrial countries. First, in an uncertain environment, a range objective may be seen as preferable to a point objective for credibility purposes. Second, a range appears suitable to EMEs since most countries had to go through episodes of disinflation before adoption of IT. With inflation relatively volatile post IT, a range therefore may be a credible and transparent way of conveying the central bank's capacity to meet the announced target. Castelnuovo et al. (2003) report evidence that suggest that neither a point nor a range target makes any appreciable difference over the other in anchoring inflation expectations.

[30] In theory, mixed-strategy targeters may be accepting a somewhat higher inflation rate than standard-IT countries since by construction the additional exchange objective adds to the volatility of money supply –which could put a damper on anchoring inflation expectations. However, in practice one may not be able to detect a statistically significant difference if the magnitude of the difference is relatively small.

may be accepting a somewhat higher inflation rate than standard-IT countries since by construction the additional exchange objective may add to the volatility of money supply –potentially putting a damper on meeting the inflation target. In practice, however, one may not be able to detect a statistical significance in the inflation difference between the standard and the mixed strategy if the magnitude of the difference is relatively small. The degree of significance notwithstanding, we expect a quantitative "wedge" in average inflation to exist between the two strategies. In the next section, we describe the data and its sources, present some descriptive statistics, and we discuss relevant economic specifications and key considerations for including each country and variable into the final sample.

1.5 *Data and Descriptive Statistics*

1.5.1 Data

Our sample of emerging-market countries practicing IT includes 12 countries who by 2006 had had at least 6 years of experience with inflation targeting: Brazil, Colombia, Czech Republic, Hungary, Israel, Korea, Mexico, Peru, The Philippines, Poland, South Africa and Thailand (see Appendix 1.3 for IT adoption dates). The two key considerations for including each country into the final sample are (i) a country should have the required data across all the key variables over the sample period, and (ii) a

country should have an independent currency/autonomous monetary policy framework during the sample period.[31] [32]

The data consist of quarterly observations on the inflation rate, real GDP growth, the short-term interest rate (discount rate), and appreciation of the trade-weighted real effective exchange rate.[33] We specially emphasize that the variable of interest for estimation of equations [1]-[3] is the output *gap* and not necessarily the real GDP growth rate. To measure the output gap, we use the Hodrick-Prescott filter to detrend the growth rate of real GDP into its aggregate cyclical variation, i.e., the difference between actual real GDP growth series and the recovered trend. The rest of the variables are annual observations on measures of financial vulnerability used in the estimation of equation [4], namely: ratios of net private capital flows, total external debt stocks, stock market capitalization, fiscal deficit and the trade balance to GDP. Annual data is utilized for the probit estimation because comprehensive data coverage from established sources is only available at yearly frequency. As mentioned in the previous section, private capital flow

[31] The sample is a subset of the 57 emerging market countries published in the June 2010 report "How Did Emerging Markets Cope in the Crisis?" by the International Monetary Fund.

[32] Our list of IT countries is similar to that used by Aizenman and Hutchison (2010), except that ours also includes South Africa. Like Aizenman and Hutchison, we decided to drop Chile from the sample because its estimated interest rate function appears anomalous. This may be due to the country's early adoption of IT, at a time when its inflation rate was still quite high (above 20%), and/or shifts in the practice of IT unique to that country's circumstances and experiences.

[33] The good disinflation record of some countries that have previously gone through hyperinflation episodes has often been attributed to generic mean reversion and not necessarily to the effect of inflation targeting (see, for example, Ball and Sheridan (2005)). To avoid the potential confounding effects of previous hyperinflation countries on model estimates, our sample only includes countries with an average inflation rate of not more than 20 percent during the 12 quarters prior to adoption of IT.

is interacted with the other four measures to isolate its effects through exposure to the following variables, all expressed relative to GDP: existing debt denominated in foreign currency, the value of equity in capital markets, the value of the fiscal deficit, and the value of the trade balance, respectively. The optimal control variables used in the estimation of equation [4] are year-over-year measures of the output gap and the deviation of inflation from the officially announced target. The dataset runs from 1990:Q1 to 2008:Q4. We use the discount rate as our measure of the policy interest rate and we use a measure of the real exchange rate that is trade-weighted. Table 1.1 reports key inflation targeting parameters for each country in the sample. Table 1.2 gives variable definitions and data sources for key variables, and Table 1.3 shows descriptive statistics. Our data sources are the IMF's International Financial Statistics (IFS), World Bank's World Development Indicators (WDI), United Nations Statistics Division, Global Development Finance, Bank for International Settlements (BIS) and central bank sources.

The start date of 1990:Q1 for our dataset is justified by the need, as much as practicable, to exclude inflation realizations of above 20 percent from the sample, which are typically regarded as high enough to preclude a country from operating a credible price stabilization program under inflation targeting ahead of a strict disinflation program before a country can begin to target inflation. To isolate the price stabilization effects of IT from disinflation effects, authors such as Ball and Sheridan (2005), Levin et al. (2004) and Hyvonen (2004) have made similar treatment to the data in their assessment of the impact of IT on inflation performance. By 1990 all the countries in our sample had attained an inflation rate below 20 percent.

TABLE 1.1
INFLATION TARGET PARAMETERS

Country	IT Adoption date [1/]	Target Horizon	Target Measure	Point Target (in percent)	Target range (in percent)	Re-adjusted Point Target (in percent)
Brazil	06/1999	Annual/multi-year	CPIA (Broad)	4.0	+/- 2.5	
Colombia	09/1999	Annual/long-term	CPI	3.0	2 - 4	
Czech Republic	01/1998	Annual/multi-year	CPI	2.0	+/- 1	
Hungary	06/2001	Annual/long-term	CPI	2.0	+/- 1	
Israel [2/]	01/1992	Indefinite	CPI	none	+/- 1.5	2.5
Korea [2/]	09/1998	Annual/medium-term	CPI	none	2.5 - 3.5	2.5
Mexico	01/1999	Annual/long-term	CPI	3.0	+/- 1	
Peru	01/2000	Indefinite	CPI	2.5	+/- 1	
Philippines [2/]	01/2002	Annual	CPI	none	4 - 5	3.0
Poland	01/1999	Indefinite	CPI	2.5	+/- 1	
South Africa [2/]	02/2000	Annual/medium-term	CPI	none	3 - 6	4.5
Thailand [2/]	05/2000	Indefinite	Underlying Index	none	0 - 3.5	1.75

This Table is generally adapted from Roger and Stone (2005). 1/ IT adoption dates are based on Batini et al. (2005), Fraga et al. (2003), Corbo, Landerretche, and Schmidt-Hebbel (2001) and Mishkin and Schmidt-Hebbel (2007); 2/ The re-adjusted Point Target for Israel is the latest previous point target; for Korea, The Philippines, South Africa and Thailand, the re-adjusted Point Target is the mid-point of the Target range.

TABLE 1.2
DEFINITIONS AND DATA SOURCES FOR KEY VARIABLES
Sample: 1990:01-2008:12

Variables	Quantity	Unit of measurement	Equation Variable	Source
Inflation rate[a]	Consumer price index	Percent Change of index over Corresponding Period of Previous Year	π	IFS
Short-term interest rate	Discount rate	End of period (annualized)	i	IFS
Real Effect Exch Rate	REER index	End of period (annualized)		IFS
Real GDP growth rate[b]	Real GDP growth index	Percent Change of index over Corresponding Period of Previous Year		IFS
Real Appreciation[c]	REER index	Percent Change of index over Corresponding Period of Previous Year	App[1]	IFS
Output gap	Real GDP growth index	Hodrick-Prescott filter	GAP[2]	IFS
Portfolio Capital flows		Net Private Capital flow as percent of GDP	Fiv	WDI
Total external debt stock		debt stock to GDP	Fiv	GDF
Stock mrkt capitalization		stock market capitalization as percent of GDP	Fiv	WDI
Budget deficit		Fiscal deficit to GDP	Fiv	GDF WDI
Trade balance		trade balance as percent of GDP	Fiv	WDI

Note: International Monetary Fund's International Financial Statistics (IFS), World Development Indicators (WDI), Global Development Finance (GDF), Bank for International Settlements (BIS), United Nations Statistics (UNS). All data is measured at a quarterly frequency.

1. a,b, and c are measured as year-over-year rates: $\log(x_t)$-$\log(x_{t-4})$, where (x_{t-4}) is the fourth lag of the variable. The f financial vulnerability variables, Fiv, are measured as annual averages.

2. To measure the output gap, we use the Hodrick-Prescott filter to detrend GDP growth rate into its aggregate cyclical variation, i.e., the difference between actual real GDP growth series and the recovered trend.

TABLE 1.3
DISCRIPTIVE STATISTICS: MEANS AND STANDARD DEVIATIONS (percent)
Sample: 1990:01-2008:12

	Whole sample†		Pre-IT Period		Post-IT Period	
Panel A: Inflation	Mean	Std dev	Mean	Std dev	Mean	Std dev
Brazil	7.0	3.2	4.4	1.6	7.2	3.2
Colombia	14.8	8.9	22.2	5.7	6.5	1.5
Czech Republic	6.4	5.2	11.5	4.6	3.4	2.6
Hungary	14.7	9.6	20.3	8.0	6.1	2.2
Israel	6.8	6.0	17.9	1.5	5.3	4.6
Korea	3.6	1.7	6.3	1.9	2.9	1.2
Mexico	13.3	10.8	20.9	10.8	6.0	3.4
Peru	5.5	5.2	10	5.4	2.6	1.7
Philippines	7.3	4.1	8.3	4.4	5.6	2.7
Poland	7.3	6.7	16.1	5.3	3.8	3.1
South Africa	8.1	4.0	9.7	3.7	6.1	3.4
Thailand	3.6	2.6	4.6	2.3	3.0	2.0
AVERAGE	7.4	5.0	9.9	4.9	4.9	3.7
Panel B Real Appreciation						
Brazil	1.9	17.3	-33	2	3.7	15.7
Colombia	2.5	10.1	3.4	10.4	2.7	9.6
Czech Republic	4.8	7.1	4.1	8.2	4.7	6.1
Hungary	4.1	5.8	3.5	5.3	4.1	6.3
Israel	-0.2	5.6	1.7	3.2	-0.1	5.7
Korea	-0.14	3.2	-0.5	4.6	-0.03	2.2
Mexico	1.6	11.5	2.1	15	-0.1	6.5
Peru	0.0	1.3	-0.1	1.5	0.1	1.1
Philippines	1.1	8.9	0.1	9.8	3.8	6.9
Poland	7.3	14.6	11.9	18.4	3.8	9.3
South Africa	-1.4	11.3	-1.7	6.6	-0.3	15.7
Thailand	-0.04	2.6	-0.2	3.9	0.04	1.1
AVERAGE	1.8	8.4	1.6	7.9	2.1	9.0

TABLE 1.3 (continued)
DISCRIPTIVE STATISTICS: MEANS AND STANDARD DEVIATIONS (percent)

	Whole sample†		Pre-IT Period		Post-IT Period	
Panel C: Output gap	Mean	Std dev	Mean	Std dev	Mean	Std dev
Brazil	0.2	2.5	-0.5	3.3	0.5	2.0
Colombia	0.1	2.2	-0.6	3.2	0.5	1.4
Czech Republic	0.2	2.2	-0.2	3.7	0.4	1.5
Hungary	0.2	1.2	0.1	1.2	0.3	1.2
Israel	0.2	2.9	1.5	2.4	0.0	3.0
Korea	0.0	3.6	-0.8	4.0	0.8	3.1
Mexico	0.2	3.0	0.1	3.7	0.3	2.2
Peru	0.0	5.3	0.0	6.8	0.0	2.1
Philippines	0.0	2.5	-0.3	2.0	0.6	3.1
Poland	0.2	1.9	0.0	2.5	0.2	1.7
South Africa	0.0	1.4	-0.2	1.7	0.3	1.0
Thailand	0.0	3.8	-0.2	5.6	0.2	1.7
AVERAGE	0.1	2.7	-0.1	3.3	0.4	2.0
PANEL D Discount rates						
Brazil	17.1	3.7	20	1.4	17	3.7
Colombia	25.1	13.1	36.5	6.1	12.3	2.9
Czech Republic	6.3	4.3	10.9	3.0	4.1	2.8
Hungary	15.7	7.0	20.3	4.9	8.6	1.8
Israel	9.5	4.2	13.8	1.8	8.9	4.2
Korea	2.6	0.4	5.5	1.1	2.7	0.4
Mexico	7.9	0.4	n/a	n/a	7.9	0.4
Peru	6.0	3.8	19.7	5.9	5.6	3.4
Philippines	9.1	3.8	11.3	2.7	5.2	1.2
Poland	9.6	5.9	18.4	4.4	8.5	5.0
South Africa	12.9	3.6	15.5	2.4	10	2.1
Thailand	2.6	1.2	1.5	0.0	2.7	1.2
AVERAGE	9.2	4.4	11.5	3.6	7.1	3.9

Data source: IMF's International Financial Statistics Interactive Database. †Whole sample period: 1990:1-2008:4. Std dev refers to standard deviation.

We deliberately chose to have our sample end in Q4 of 2008 to avoid requiring the models to explain the unique volatilities of the global financial crisis. We have chosen our data frequency to be quarterly because this represents the highest frequency adequately available across most of the countries in our sample. For the purpose of delimiting pre-targeting and post-targeting periods, we follow the convention in previous literature by dating the adoption of inflation targeting with the start of full-fledged inflation targeting. This implies using the first full quarter of IT implementation as the break-point between the pre-targeting and the post-targeting sub-periods.[34] Batini et al. (2005) and Fraga et al. (2003) provide a useful and relatively comprehensive compilation of start dates for effective adoption of full-fledged IT for a broad set of industrial and emerging market countries. Other compilations include Corbo, Landerretche, and Schmidt-Hebbel (2001) and Mishkin and Schmidt-Hebbel (2007). In the three cases where the above studies indicate some disparity, we have taken recourse to the *de jure* pronouncements by national authorities on the adoption dates of IT for their respective countries. Table 1.1 shows IT adoption dates and specific features of the inflation targets (i.e., point targets with bands or range targets) for the sample countries.

1.5.2 Descriptive Statistics

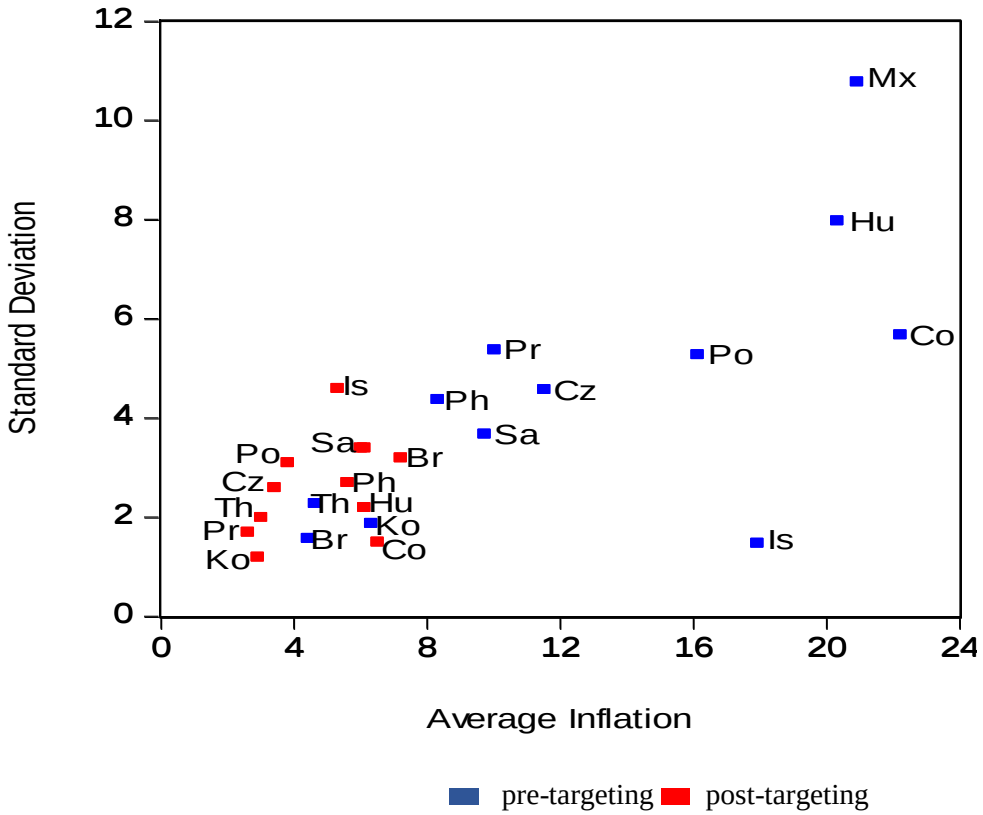
In panels A-D of Table 1.3 below, we show descriptive statistics for the pre- and post-targeting periods of our sample, of the key macroeconomic variables used in the estimation of equations [1], [3], and [5] described in section 1.3 above: inflation rate,

[34] For a detailed discussion on timing of transition periods toward full-fledged inflation targeting see Schaechter et al. (2000).

short-term interest rate, output gap and the real exchange appreciation.[35] In panel A, we note that the average level of inflation for the whole sample has come down during the post-targeting period by about half its pre-targeting level; i.e., from an average of 9.9 percent in the pre-sub-sample period to an average of 4.9 percent in the post-sub-sample period. The decline in the level is accompanied by a reduction in volatility, which dropped from 4.9 percent during the pre-sub-sample period to 3.7 percent in the post-sub-sample period. Overall, average post-targeting inflation suggests substantial reduction in inflation bias for the whole sample. The reduction in the level of inflation and its volatility in the post-targeting period suggest a *prima facie* argument for positive causality between adoption of IT and disinflation and price stabilization.

Figure 1.2 displays data on average inflation and volatility by country for the pre- and post-targeting periods. The data suggest a systematic reduction in inflation and its volatility during the post-targeting period relative to the pre-targeting period for the sample countries. This is reflected in the systematic bunching of inflation-standard deviation trade-offs for individual countries into the lower left quadrant in the post-targeting period. Only three countries (Brazil, Korea and Thailand) had initial (pre-targeting) inflation-volatility combinations comparable to that of the average for the post-targeting period. The rest of the sample countries exhibit a movement toward the south-west corner during the targeting period.

[35] For reference, Appendix 1.2 presents correlation coefficients for the key variables.

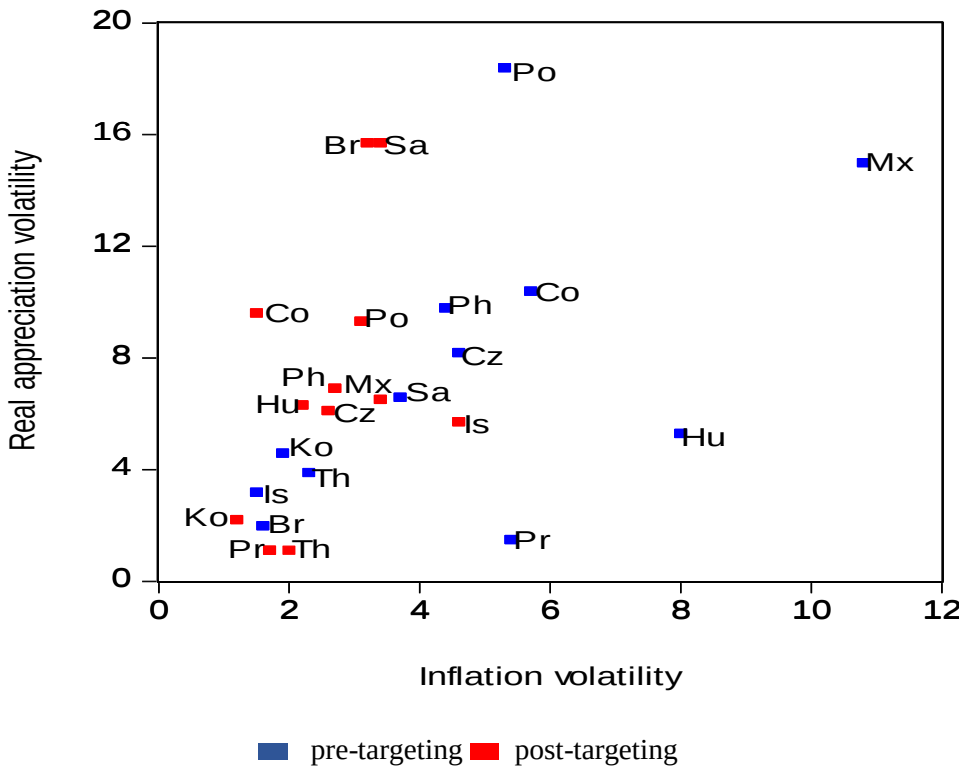


Brazil [Br], Colombia [Co], Czech Republic [Cz], Hungary [Hu], Israel [Is], Korea Republic [Ko], Mexico [Mx], Peru [Pr], The Philippines [Ph], Poland [Po], South Africa [Sa], Thailand [Th].

Figure 1.2

Average Inflation-volatility Trade-offs for Sample Countries (in percent): 1990-2008

In Panel B of Table 1.3, we report the volatility of real appreciation for the sample countries. While the average volatility for the whole sample has increased from 7.9 percent in the pre-targeting period to 9.0 percent in the post-targeting period, this increase masks substantial reductions in individual countries' volatilities of real exchange depreciation. Figure 1.3 below displays data on inflation volatility and real appreciation volatility for the pre- and post-targeting periods. The dispersion of the scatter plot indicates that the average volatility of real appreciation declined for the sample countries during the targeting period.



Brazil [Br], Colombia [Co], Czech Republic [Cz], Hungary [Hu], Israel [Is], Korea Republic [Ko], Mexico [Mx], Peru [Pr], The Philippines [Ph], Poland [Po], South Africa [Sa], Thailand [Th].

Figure 1.3

Inflation-real Appreciation Volatilities for Sample Countries (in percent): 1990-2008

Out of twelve countries, eight achieved a straight decline in both volatility of inflation and real depreciation, two showed an increase in volatility of real appreciation but with a decrease in volatility of inflation, and two others exhibited an increase in both volatilities.

The increases in real appreciation volatilities for Brazil and South Africa in the post-targeting period appear counterintuitive relative to the average result for other countries. We believe the rand depreciation episode of the fourth quarter of 2001 and the real (Brazilian currency) depreciation of September 2008 could account for these outliers. Figure 1.3 suggests a strong influence of real appreciation volatility as an anchor for

inflation volatility in the pre-targeting period. However, with IT in place, the association between real appreciation volatility and inflation volatility appears to have weakened.

While several countries appear to have a relatively low average volatility of the real exchange rate in the post-targeting period, there are indications that a number of them are responding to movements in the real exchange rate. This is suggested through Granger causality tests between the measure of the real exchange rate and the short term interest rate (discount rate). Table 1.4 reports the results for the causality estimation for the post targeting period using between two to four lags selected with Schwarz and Akaike information criteria as the case may allow for each country. We can reject the null hypothesis that the real exchange rate does not Granger-cause the discount rate for seven of the twelve countries in the sample. We can also reject the null hypothesis of the absence a reverse causality in four of the twelve countries in the sample.

Panel C of Table 1.3 demonstrates that the volatility of the output gap has generally declined between the two sample periods. This observation is in line with the suggestion that targeting could engender long-run output stability, particularly more so under open-economy-type IT regimes (see, for example, Svensson (1998)).
Panel D shows similar statistics for the short-term interest rate (discount rate). Mean discount rates dropped from an average of 11.5 percent in the pre-sub-sample period to 7.1 percent in the post-sub-sample period. The average volatility of the rates appears to have gone up, albeit marginally. The relatively lower levels of post-targeting discount rates may suggest a lower output cost of implementing monetary policy under the IT regime.

TABLE 1.4
GRANGER CAUSALITY TESTS: REAL EXCHANGE RATE AND THE DISCOUNT RATE
Sample: 2000:2-2010:4

Country	Null Hypothesis: The Real Exchange rate does not Granger cause the Discount rate		Null Hypothesis: The Discount rate does not Granger cause the Real Exchange rate	
	F-Statistic	P-Value	F-statistic	P-value
Brazil	9.12	0.0008	0.42	0.6629
Colombia	0.12	0.8843	0.35	0.7074
Czech Rep	3.67	0.0354	6.40	0.0042
Hungary	0.33	0.7228	0.45	0.6419
Israel	0.38	0.6833	6.62	0.0026
Korea	2.57	0.0917	5.84	0.0067
Mexico	0.58	0.5673	3.31	0.0493
Peru	5.12	0.0128	0.74	0.4868
Philippines	2.33	0.123	0.31	0.7373
Poland	2.65	0.086	0.63	0.5403
South Africa	6.88	0.0037	0.36	0.6987
Thailand	0.12	0.8891	1.75	0.1931

Note: The table reports results estimated using between two to four lags selected with Schwarz and Akaike information criteria as the case may allow for each country. We measure the real exchange rate using the REER (see Appendix 1.1 for details)

Table 1.5 reports key statistics for the measures of financial vulnerability used in the estimation of equation [4].

Lastly, it is worth noting that the descriptive statistics suggest that the sample of 12 countries does contain sufficient variation among the countries along the dimensions of interest to ensure meaningful estimation results under the methodologies discussed in section 1.4 (Appendix 1.1 provides additional descriptive statistics).

TABLE 1.5
MEASURES OF FINANCIAL VULNERABILITY
Sample: 1990-2008

Variable		Mean	Std. Dev.	Min	Max	Observations
Debt	overall	45.00	23.99	12.62	154.42	N = 215
	between		20.29	17.18	79.3	n = 8
	within		14.96	16.15	120.13	T = 18
Private capital	overall	3.12	2.98	-4.19	15.89	N = 215
	between		1.83	0.79	7.189	n = 11
	within		2.43412	-4.86	11.82	T = 18
Market cap	overall	50.27	49.52	0.17	291.28	N = 222
	between		42.21	15.77	171.18	n = 12
	within		28.09	-41.23	228.6	T = 18
Trade	overall	-1.15	4.56	-16.12	15.89	N = 228
	between		2.53	-5.75	1.92	n = 12
	within		3.86	-11.66	12.81	T = 19

Notes: Debt, Private Capital, Market Cap, and Trade refer to Total External debt, Net Private Capital Flows, Market capitalization, and the Trade balance all measured as percent of GDP; 'between' and 'within' refer to variation within a group unit and between individual units.

1.6 *Results of the Estimations*

1.6.1 Description of Results

Table 1.6 shows estimation results for equation [1]. Judging by the R-squareds of the regressions, the estimated policy rules generally fit the data relatively well and convey the expected systematic relationship between the policy interest rate and its predictors. LM Tests for autocorrelation of the residuals (presented in Appendix 1.3) do not reject the hypothesis of no serial correlation up to order four for all the countries except for Mexico.

TABLE 1.6

ESTIMATION OF THE INTEREST-REACTION FUNCTION (Equation 1)

Dependent Variable: Discount rate (i_t)

Country	C	i_{t-1}	$\pi^{¥}_{t-1}$	GAP_{t-1}	App_{t-1}	Adj R^2	SE
Brazil	0.22	1.07*	-0.23	0.31*	-0.03	0.79	1.73
	(1.64)	(0.11)	(0.14)	(0.12)	(0.02)		
Colombia	1.13	0.73*	0.29	0.31*	-0.01	0.91	0.81
	(0.53)	(0.10)	(0.20)	(0.12)	(0.01)		
Czech Rep	0.63	0.74*	0.12*	0.05	-0.06*	0.97	0.40
	(0.10)	(0.05)	(0.05)	(0.05)	(0.01)		
Hungary	1.9	0.78*	0.03	0.03	-0.05	0.57	1.16
	(1.10)	(0.11)	(0.16)	(0.26)	(0.05)		
Israel	0.47	0.82*	0.20*	0.12*	-0.06*	0.93	1.09
	(0.36)	(0.06)	(0.05)	(0.05)	(0.03)		
Korea	1.1	0.74*	0.15*	0.01	-0.002	0.57	0.28
	(0.50)	(0.14)	(0.07)	(0.01)	(0.005)		
Mexico	1.37	0.66*	0.28*	0.26*	0.01	0.94	1.02
	(0.55)	(0.12)	(0.13)	(0.09)	(0.04)		
Peru	0.45	0.81*	0.16	0.14	-0.005	0.93	0.86
	(0.34)	(0.05)	(0.12)	(0.08)	(0.05)		
Philippines	2.25	0.42*	0.19*	-0.03	-0.07*	0.70	0.71
	(0.69)	(0.16)	(0.08)	(0.05)	(0.03)		
Poland	0.34	0.71*	0.57*	0.02	-0.07*	0.98	0.68
	(0.25)	(0.08)	(0.16)	(0.08)	(0.02)		
South Africa	1.11	0.88*	0.004	0.02	-0.04*	0.91	0.64
	(0.51)	(0.07)	(0.046)	(0.12)	(0.01)		
Thailand	0.44	0.84*	0.14*	0.02	-0.02	0.85	0.46
	(0.39)	(0.05)	(0.05)	(0.10)	(0.011)		

Notes: *i* is the nominal rate, π the annual rate of inflation, GAP the output gap, APP real appreciation, Adj R^2 is adjusted R^2 and SE refers to the standard error of the residuals/regression. We measure inflation, π_{t-1}, as deviation from the inflation target for that period. HAC (Newey-West) Standard errors are in parentheses. * indicates significance at 5 percent confidence level. LM Tests indicate no significant autocorrelation in the regression residuals (see Appendix 1.3).

Serial correlation in the residuals for Mexico disappears with the inclusion of a second lag of the short-term interest rate among the predictors.[36] The estimated coefficients for all countries have the correct signs, except for a handful of estimated coefficients which are anyway not statistically significant (those on inflation for Brazil, the output gap for the Philippines, and real exchange-rate appreciation for Mexico). The results in Table 1.6 indicate a significant role for the exchange rate in the interest-rate reaction function of five targeting EMEs: the Czech Republic, Israel, the Philippines, Poland and South Africa. The interest response to its lagged value, expected to reflect smoothing, is statistically significant in all 12 sample countries. 7 out of 12 countries exhibit significant short-term interest response to inflation variation, while 4 out of 12 countries show significant interest reaction to movements in the output gap.

Table 1.7 shows calculations of the long-run interest response to inflation for sample countries. Brazil has the largest long-run response. Apparently, this may be explained away by the ambiguous negative response to inflation in the short term. However, by keeping the interest smoothing parameter above the 1 percentage point level, the country appears to credibly pursue a characteristically tight long-term interest policy. Poland exhibits the next largest quantitative value, followed by Israel, while Hungary and South Africa have the smallest. Table 1.8 reports parameter estimates of equation [3]. The model generally fits the data. The estimates of the exchange pass-through coefficient carry the correct sign for all the countries, except Hungary.

[36] The estimated equation for Mexico includes a second lag of the short-term interest rate. While the parameter estimate for this variable is not reported it is available from the author on request.

TABLE 1.7

LONG-RUN INTEREST RESPONSE TO INFLATION: β2/(1-β1)[37]

Country	LR RESP
Brazil	3.29
Colombia	1.07
Czech Republic	0.46
Hungary	0.14
Israel	1.11
Korea	0.58
Mexico	0.82
Peru	0.84
Philippines	0.33
Poland	1.97
South Africa	0.03
Thailand	0.88

Note: LR RESP refers to long run response.
Source: Author's calculations.

The same is true for estimates of the autoregressive component of inflation.[38] The estimates indicate that the pass-through from the exchange rate to inflation is statistically significant in 8 of the 12 countries. Further, the results suggest that there is a significant structural shift in pass-through from the exchange rate to inflation in 5 of the 8 countries in the post targeting period. All five countries that show significant structural change in pass-through demonstrate not only a statistically significant reduction in the pass-through

[37] The major value of the multiplier is as a measure of degree of compliance with the "Taylor Principle." Section 1.6.2 below (Analysis of results) explains in detail this computed multiplier with respect to the Taylor principle, which requires that in order to achieve a determinate price level the central bank should adjust nominal interest rates more than one for one in response to any change in inflation.

[38] Coefficient estimates for the output gap and openness are omitted from Table 1.8. Suffice to mention that coefficients on these two variables broadly have the correct signs and are statistically significant at 5 percent confidence level in a number of cases. (See Appendix 1.4)

coefficient, but also a quantitatively important reduction in pass-through during the post-targeting period.

TABLE 1.8
ESTIMATION OF THE ACCELERATIONIST PHILLIPS CURVE (Equation 3)
Dependent Variable: Quarterly Inflation rate (π_t)

Country	C	π_{t-1}	post(t)π_{t-1}	App_{t-1}	post(t)App_{t-1}	Adj R^2
Brazil	0.38	0.82*	0.03	-0.04	-0.02	0.9
	(0.70)	(0.09)	(0.09)	(0.12)	(0.12)	
Colombia	2.60	0.84*	-0.11*	-0.05*	-0.04	0.98
	(1.13)	(0.06)	(0.05)	(0.02)	(0.03)	
Czech Rep	-0.6	0.42	0.50*	-0.21*	0.10	0.94
	(0.60)	(0.24)	(0.25)	(0.07)	(0.07)	
Hungary	-0.47	0.88*	0.07	-0.34*	0.21*	0.8
	(0.7)	(0.03)	(0.09)	(0.07)	(0.07)	
Israel	1.22	1.26*	-0.38*	-0.51*	0.49*	0.93
	(0.78)	(0.13)	(0.13)	(0.17)	(0.16)	
Korea	0.61	0.84*	-0.23	-0.05*	0.04	0.83
	(0.60)	(0.08)	(0.18)	(0.02)	(0.03)	
Mexico	2.9	0.85*	-0.08	-0.33*	0.29*	0.97
	(0.66)	(0.03)	(0.06)	(0.03)	(0.05)	
Peru	-1.23	0.81*	0.07	-0.15*	0.12*	0.97
	(0.89)	(0.03)	(0.10)	(0.05)	(0.03)	
Philippines	3.1	0.78*	0.15	-0.21*	0.16*	0.86
	(0.99)	(0.07)	(0.16)	(0.06)	(0.03)	
Poland	0.54	1.07*	-0.03	-0.07	0.01	0.98
	(0.92)	(0.07)	(0.07)	(0.09)	(0.09)	
South Africa	1.39	0.90*	-0.11	-0.06	-0.01	0.89
	(0.68)	(0.05)	(0.09)	(0.04)	(0.04)	
Thailand	0.85	1.11*	-0.38	-0.02	0.01	0.85
	(0.53)	(0.13)	(0.21)	(0.01)	(0.03)	

Notes: π is the year-on-year rate of inflation, APP is real appreciation, $p \equiv post(t)$ is the Dummy variable for the targeting period, Adj R^2 is adjusted R^2. HAC (Newey-West) Standard errors are in parentheses. * indicates significance at 5 percent confidence level. LM Tests indicate no significant autocorrelation in the regression residuals. Since we measure real appreciation as: $\log(x_t))-\log(x_{t-4})$, where (x_{t-4}) is the fourth lag of the variable, positive realizations indicate appreciation and negative realizations indicate depreciation. Therefore, real appreciation attenuates inflation, hence $\gamma_2 < 0$.

TABLE 1.9

STRUCTURAL SHIFT OF PASS-THROUGH TO INFLATION

Country	Pass-through[1]	Structural shift[2]	Interest response[3]
Brazil	no	No	no
Colombia	yes	No	no
Czech Republic	yes	No	yes
Hungary	yes	Yes	no
Israel	yes	Yes	yes
Korea	yes	No	no
Mexico	yes	Yes	no
Peru	yes	Yes	no
Philippines	yes	Yes	yes
Poland	no	No	yes
South Africa	no	No	yes
Thailand	no	No	no

Notes:*1* pass-through from exchange rate to inflation, *2* structural change in the pass-through parameter during the targeting period, *3* countries that place a significant weight on the exchange rate in the Taylor Rule. *Yes* refers to evidence of statistical significance and *no* otherwise.

For example, in the case of Hungary, Mexico, and Peru, the pass-through coefficient falls from -0.34, -0.33, -0.15 before adoption of inflation targeting to -0.13, -0.04, -0.03, respectively, after adoption. In essence, pass-through due to exchange-rate appreciation ceases to be statistically significant for Hungary, Israel, Mexico, Peru, and the Philippines after correcting for the structural change.[39] There is also evidence of a structural shift in inflation response to its autoregressive coefficient in 3 countries.

Table 1.9 looks at the results for pass-through and structural shift next to results on whether countries placed a weight on the exchange rate in the Taylor rule. Of the eight countries with significant pass-through, five are standard inflation targeters and three are

[39] The proposition of a weakening influence of real appreciation volatility as an anchor for inflation expectations and actual inflation that we made in figure 3, above, is borne out in this empirical result.

mixed-strategy targeters. Out of the five countries with significant shift in exchange pass-through to inflation three are standard targeters and two are mixed strategy targeters. While the results indicate that South Africa and Poland are mixed strategy targeters, the countries do not exhibit any significant pass-through.

Table 1.10 reports the computation of the quantity Diff' = $(\gamma_4 + \gamma_5 - \beta_4)/S.E(\gamma_4 + \gamma_5)$ ≤ 2 SDs from the estimates in Tables 1.6 and 1.8 using the categorization in columns 2 and 4 of Table 1.9.[40] Column 4 of Table 1.10 presents four distinct cases of the Diff variable. A zero (0) entry is an outcome for no significant pass-through and no significant weight on the exchange rate in the Taylor rule. A positive entry from a standard targeter (e.g., Colombia) is a not a viable solution ('corner solution"), though its value will invariably always be greater than two. The "n.a." (not applicable) entry rules out the motive for responding to the exchange rate as an intermediate target for stabilizing inflation.[41] Finally, a positive entry for a mixed targeter suggests some form of response to ward-off inflation pressures, subject to testing criteria. Therefore, for the Czech Republic, the deviation of the interest rate response to the exchange rate (estimate of β_4) from the exchange pass-through-to-inflation coefficient (estimate of γ_2) is at least two standard deviations of the pass-through coefficient (Diff = 2.14 > 2.0). The reading

[40] Table 1.10, column 2, indicates that Hungary, Israel, Mexico, Peru, and the Philippines have no significant pass-through because of the significant downward structural shift in pass-through during the post-targeting period (see table 1.8).

[41] The "n.a." (not applicable) entry refers to cases where γ_4 (or plus γ_5) is not significant thus implying the test is not relevant for understanding pass-through.

for Diff for other mixed strategy countries is "n.a." while that for strict inflation targeting countries, the difference measure $[(\gamma_2 - \beta_4)/SE(\gamma_2)] \geq 2$ is trivial.

TABLE 1.10
COMPARISON OF PASS-THROUGH AND INTEREST RESPONSE COEFFICIENTS (Equations 1 and 2)

Country	Pass-through coefficient	Coefficient on exchange rate in Taylor rule	Difference §
			$(\gamma_4 + \gamma_5 - \beta_4)/S.E(\gamma_4 + \gamma_5)$
	γ_2	β_4	
Brazil	0	0	0
Colombia	-0.05	0	2.5
Czech Rep	-0.21	-0.06	2.14
Hungary[1]	0	0	0
Israel[1]	0	-0.06	n.a
Korea	-0.05	0	2.5
Mexico[1]	0	0	0
Peru[1]	0	0	0
Philippines[1]	0	-0.07	n.a.
Poland	0	-0.07	n.a
South Africa	0	-0.04	n.a
Thailand	0	0	0

Notes: γ_2 represents inflation response to real depreciation. † refers to the estimate of the coefficient on the exchange rate in the Taylor rule equation. § column reports the computed test statistic 't-statistic' for the *interest effort* response to counter inflation (*interest effort* is inversely proportional to Diff); minimum effort is Diff ≤ 1.96~2 standard deviations. We use absolute values for the estimates of coefficients in columns 2 and 3 to get the difference in column 4. A value of zero is allocated for a 'no' reading in Table 1.9 and the estimated value is allocated for a 'yes'. *1*. refers to coefficients adjusted to correct for downward significant structural shift which leaves post-targeting pass-through insignificant; the "n.a." refers to cases where γ_4 is not statistically significant and thus implies the test is not relevant for understanding pass-through.

It is worth noting that four of the five mixed-strategy targeters are in the top half of countries with lowest volatility of the real exchange rate in the period before each adopted IT (see Appendix 1.1).

Table 1.11 reports maximum likelihood estimates of the dynamic probit model estimated with random effects. All the coefficient estimates have the correct signs.

TABLE 1.11
PROBIT MODEL OF ESTIMATED EFFECTS OF FINANCIAL-VULNERABILITY VARIABLES (Equation 4)
Dependent variable: Mixed IT Strategy (y=1)

	Parameter Estimates			Marginal Effects		
variable[1/]	Coef. Est.	Std. Error	p > |z|	Coef. Est.	Std. Error	p > |z|
Private Capital	-4.66+	2.75	0.09	-0.26+	0.14	0.08
Capital-Debt	0.02	0.02	0.20	0.04	0.04	0.26
Capital-Stock-Mkt	0.05+	0.03	0.08	0.10+	0.06	0.09
Capital-Deficit	0.06	0.12	0.60	0.01	0.02	0.61
Capital-Trade	-0.44+	0.26	0.09	-0.18+	0.10	0.06
Inf-Deviation	0.58	0.44	0.19	0.11	0.10	0.27
Output-gap	1.92*	0.88	0.03	0.35*	0.14	0.02

- $pr[y_{it} = I|\mathbf{x}_{it}] = 0.54$
- Sample mean values of predictors: PC[2.2], CD[0.02], CSM[146], CDef[-6.5], CT[-1.9], ID[2.0], OG[0.6]

Notes: y = 1 is choice of whether to place some weight on the exchange rate in the interest-rate rule; 1/ All variables are weighted with a targeting period Dummy variable; The regressors Capital-Debt(CD), Capital-Stock-Mkt(CSM), Capital-Deficit(CDef), and Capital-Trade(CT) are interaction variables between Private Capital on one hand and each of Total External debt, Stock Market Capitalization, Fiscal Deficit, and the Trade balance, respectively, all measured as percent of GDP; Inf-Deviation(ID) is deviation of inflation from its Point Target; Output-gap(OG) is the HP filtered cyclical component of growth; Marginal effects are conditionally computed at the mean values of the variables in the sample; + and ** indicate statistical significance at the 10% and 5% levels, respectively.

The coefficient on the output gap is statistically significant at the standard 5 percent level. The coefficients for private capital flows and its interaction with stock market capitalization and the trade balance are statistically significant at the 10 percent level. However, none of the effects are statistically significant at any of the standard thresholds for those coefficients relating to the total external debt, fiscal deficit and the inflation deviation from the target.

The marginal effects are conditionally computed at the mean values of the independent variables for the sample. Table 1.11 indicates a significant marginal effect of the output gap on the probability of being a mixed-strategy targeter. For example, the coefficient estimate of 0.35 means that *on average*, having positive output gaps - output gaps inconsistent with trend output - raises the probability of practicing mixed strategy targeting by about 35 percentage points.[42] By the same token, at 10 percent significance, the negative signs, -0.26 and -0.44, on PC and CT respectively means that on average, not having negative capital inflows and trade deficits lowers the probability of practicing mixed strategy targeting by about 26 percentage points plus 18 percentage points *times* the value of the trade surplus and vice versa. The predicted or fitted probability, $pr[\mathbf{y}_{it} \neq 0| \mathbf{Fiv}_{it}] = 0.54$, given that all predictors are set to their mean values, is above the break-even proportion of 0.41, hence the model suggests that the output gap (at 5 percent) and other financial variables (at 10 percent) are good predictors of mixed strategy behavior.[43] Both the Wald and the Lagrange Multiplier tests support the validity of the estimation results in Table 1.11.

We considered an alternative specification for the explanatory variables instead of the level measure, ***Fiv***. We used the variable, $DFiv = Fiv_i$ - AV*Fiv*, which is the differential between the measure of *Fiv* for an individual country *i* and the average

[42] 'on average' relates to marginal effects computed using the mean values of the sample.

[43] For example, if the observed share of IT countries placing a positive weight on the exchange rate is one-quarter, countries with predicted probabilities around one-quarter are the ones on the borderline at which a country can choose either standard or mixed strategy targeting.

measure, AV, for the whole sample. The maximum likelihood estimates were not materially different from the results reported for the benchmark estimation. However, this methodology has an interesting interpretation when the constant is estimated with a negative sign - when a country's measure of *Fiv* is equal to that of the average so that *DFiv* = 0, a country may have a bias against placing a significant weight on the exchange rate. This means a zero differential skews the country toward implementing standard IT relative to mixed-strategy IT. Similarly, the interpretation of the estimates of coefficients changes - an increase in financial vulnerability relative to the average increases the probability that an individual country will place a significant weight on the real exchange rate.

Table 1.12 reports estimation results of equation [5]. The estimates of the Blundell-Bond approach, as indicate the p-values, are marginally more precise than the counterpart approach, the Arellano-Bond estimator. However, both models to fit the data with matched statistical significance.

The coefficient estimates of the effect of the lags of inflation and real appreciation and the targeting dummy all carry the expected sign and are significant at 5 percent confidence level. The results suggest that standard IT countries and mixed-strategy IT countries do not have a significant difference in their inflation performance. Both these strategies have led to lower inflation by almost 4 percentage points in the post-targeting period. The forgoing notwithstanding, the estimate of the coefficient for mixed targeting is significant at 10 percent confidence level. Thus, in 9 out of 10 cases mixed-strategy may exert a quantitatively important damper on the level of inflation that is achievable by standard targeters. Average inflation rates for mixed-strategy countries will be captured

by the sum of the coefficients on target and strategy [-3.78 + 1.43- and -3.94 + 1.54]. At the 10 percent level of significance, barring committing a Type I error, standard targeters will have quantitatively lower inflation by about 2.35 (A-B) or 2.40 (B-B) percentage points than their mixed-strategy counterparts.

TABLE 1.12

DYNAMIC-PANEL ESTIMATES OF DETERMINANTS OF INFLATION (Equation 5)

Dependent Variable: Quarterly Inflation rate (π_t)

Sample: 1990:01-2008:04

	Arellano-Bond estimator			Blundell-Bond system GMM		
Variable	Coef. Est.	Std. Error	p > |z|	Coef. Est.	Std. Error	p > |z|
π_{t-1}	0.83*	0.21	0.000	0.85*	0.20	0.000
App_{t-1}	-0.21*	0.11	0.023	-0.23*	0.12	0.015
DumApp(t-1)	0.13*	0.08	0.056	0.14*	0.08	0.051
Output(t-1)	0.54	0.55	0.330	0.54	0.47	0.520
Target	-3.78*	1.87	0.042	-3.94*	1.44	0.036
Mixed	1.43+	0.99	0.074	1.54+	1.03	0.068
Sargan test:						
p > chi2			0.802			0.819
AB Test ar(1)			0.004			0.004
AB Test ar(2)			0.712			0.720

Notes: π is the year-over-year rate of inflation, APP is real appreciation, DumApp is real appreciation during the targeting period, TARGET is a dummy variable for adoption of IT, and STRATEGY is a dummy variable for mixed IT. + and * indicate that the coefficient is significant at the 10% and 5% levels, respectively. The instrument sets for the A-B and B-B approaches comprises four lags of inflation and three lags each of the output gap and real appreciation. The Sargan test reports the null that over identifying restrictions are valid; the AB test is the Arellano-Bond test for serial correlation under the null of no autocorrelation. We adjusted the data to remove hyperinflation observations for Brazil and Peru at the beginning of the 1990s.

The Sargan test does not reject the null hypothesis that the overidentifying restrictions are valid. Therefore, the set of instruments used in the estimation appear to be appropriate. The AB tests presents no significant evidence of serial correlation in the

first-differenced errors at order 2. Hence, the moment conditions used appear valid with no evidence of model misspecification.

The models in Table 1.12 were also estimated with the variable "inflation minus its target level" as the dependent variable. The purpose was to determine which one of the two strategies delivers a lower variance between actual inflation and its target during the targeting period. The results appear to closely align with those of Table 1.1 with standard targeters performing marginally better than mixed strategy targeters.

1.6.2 Analysis and Interpretation of the Results

The evidence presented in the previous section is consistent with inflation having declined for all countries that have shifted to inflation targeting as the primary goal of monetary policy. The results do render support to the notion that emerging-market countries have concern for real exchange-rate appreciation in their conduct of monetary policy under inflation targeting. Almost half of the sample countries respond to real exchange rate appreciation in their interest rate policy rule.[44] Except for Colombia, Israel and Poland, post-targeting long-run responses to inflation for individual countries are not consistent with the *Taylor principle* of stabilizing long-run inflation by adjusting the

[44] On the surface it seems an argument could be made that a country with a low pre-adoption volatility of the real exchange rate has an incentive to pursue mixed strategy IT so as to avoid a potential increase in volatility when the switch is made to IT. This sounds reasonable since the exchange rate is usually a prominent point of anchor for inflation expectations and also a sensitive proximate variable in the monetary transmission mechanism to inflation and output in most emerging markets (see Moron and Winkelried, 2005; Eichengreen, 2002). However, the plausibility of this argument is weak since two of the countries with low real exchange volatility adopted strict targeting and two high volatility countries adopted mixed-strategy targeting.

policy rate in response to inflation and output gaps only. The Taylor principle requires that in order to achieve a determinate price level the central bank should adjust nominal interest rates more than one for one in response to any change in inflation.

The results suggest that interest rate responses to real exchange appreciations for mixed-strategy targeters are generally for reasons of articulating and achieving the long-run output stabilization objective. While the Czech Republic appears to be countering inflation pressures, its interest rate effort toward real appreciation falls below the minimum required. The other four mixed strategy countries have an intuitively indeterminate reason, after *correcting-off* inflation pressures from pass-through, to place a weight on the exchange rate. The estimates of interest rate responses to the real exchange appreciation for Israel, the Philippines, Poland, and South Africa are not relevant against the estimate of the pass through coefficient because their appears not to be significant pass-through challenges in these countries. In essence, the Czech Republic along with the other four mixed strategy targeters appear to be responding to the exchange rate not for reasons of addressing exchange pass-through to inflation. Gauged against the criterion of pass-through, IT in these five countries suggests a concern for real depreciation, not necessarily because of immediate inflationary ramifications through pass-through. More so, the statistical significance of pass-through has disappeared in the post-targeting period for Hungary, Israel, Mexico, Peru and the Philippines and the magnitude has declined precipitously from the pre-targeting levels.[45] The decline in pass-

[45] This result runs parallel to the findings by Calvo (2001) and Mishkin and Savastano (2000) that pass-through may be regime-dependent.

through further suggests a diminishing role for the exchange rate in anchoring the inflation process for the targeting period.

The low explanatory power of the exchange pass-through to inflation for the optimal interest response of mixed-strategy targeters necessitates a broader look at other potential factors that could help explain the choice of mixed strategy IT. The results suggest a credible case of mixed strategy countries responding to the real exchange appreciation for reasons of long-run stabilization of output. The conditional evidence suggests that a persistent output gap increases the probability of choosing an IT regime with a significant weight on the exchange rate for mixed strategy targeters. This result highlights that interest responses in mixed strategy countries that appear not be consistent with curtailing immediate inflation effects of real appreciation may in essence be a reaction to stabilize real factors. The result also resonates with the proposition that the mixed-strategy form of IT can be consistent with an optimal strategy for implementing IT when the purpose is to offset transitory fluctuations in inflation and output emanating from the demand stimulus of a weaker currency (Ball 2000, Garcia et al. (2011).

The evidence confirms the proposition that even though monetary policy under mixed-strategy IT may be geared toward offsetting frequent and large swings in inflation, output, and the real exchange rate, attention to financial market vulnerability may also play an important role in influencing the policy interest rate to maintain the external value of the currency at some stable level. Therefore, we can predict that typical interest responses to the real appreciation by the Czech Republic, Israel, the Philippines, Poland and South Africa were at the very least precipitated by financial market stabilization objectives, although in most likelihood the underlying concern was output and long-run

inflation stabilization. Hence, the actions by these countries were generally consistent with optimal criteria, which should aim at long-run stabilization of inflation and output.

The results from the previous section indicate that countries that have adopted IT have achieved a reduction in average inflation regardless of whether they implement standard or mixed strategy targeting. However, it appears mixed strategy targeters may be at risk of achieving modest inflation gains compared to standard targeters. The results suggest IT has enabled all emerging-market adoptees to reduce inflation bias to a comparable level. The fact that emerging-market countries, whose initial conditions are usually underscored by financial vulnerabilities, can achieve statistically significant inflation reduction under IT is encouraging. However, the result that standard IT may lead to a lower average level of inflation below that of mixed strategy targeters is still quantitatively important.

1.7 *Comparison with Results of Other Studies*

A number of researchers have relied on estimated Taylor-type rules to explore an array of questions regarding conduct of monetary policy under IT (see, for example Aizenman and Hutchison (2010); Naraidoo and Raputsoane (2011) and Akyurek et al. (2011)). While the specification of the interest rules and the empirical estimation strategies differ across the various studies, there seems to be general agreement to the finding that interest responses have become more counter-inflationary under IT. Our Taylor rule estimation results are no exception since they indicate a prioritization of the inflation control objective over other objectives.

Our observation that, with IT in place, the incidence of exchange rate pass-through to inflation declines significantly is also consistent with the results of earlier studies. For example, Gonzalez (2000) reports a decline in the degree of exchange-pass in a group of Latin American economies, Muinhos (2004) reports evidence of low pass-through and absence of financial instability in Brazil in the episode following the switching to inflation targeting and a floating exchange rate in 1999, and Gagnon and Ihrig (2004) report evidence of significant decline in pass-through and variability of inflation for eleven industrial countries which had monetary policies with strong emphasis on stabilizing inflation in the 1990s.

As mentioned earlier, one of the innovative contributions of this study is the analysis of Taylor-type rules in the context of wider economic factors, hence the probit model. Interestingly, the key result from the probit estimation conforms quite well to the findings of analytical models presented by authors such as Garcia et al. (2011), Moron and Winkelried (2005) and Cespedes et al. (2000). Our results provide country-specific empirical evidence, which buttresses the predictions of these analytical models that countries with financially vulnerable economies have an option under the IT framework to cultivate an optimal role for the exchange rate in their monetary policy reaction rules. Lastly, the estimation results of the dynamic fixed effects model are consistent with previous results that have predicted that IT leads to a reduction in inflation and its volatility, such as Goncalves and Salles (2008), Johnson (2002) and Neumann and von Hagen (2002).

1.8 *Summary and Conclusions*

The chapter attempts to make an assessment of inflation targeting in 12 emerging market countries along two distinct dimensions- those countries that put a significant weight on the exchange rate in their interest rate rule and those that do not. This delineation is necessitated by the commonly held view that IT may not be suitable for emerging-market countries due to a potential lack of resilience to large shifts in exchange rates as implied by the level of development of domestic financial markets.

The evidence in this chapter demonstrates that mixed-strategy IT is an attractive alternative to standard IT for countries that are potentially deficient in robust domestic financial markets. However, for mixed-strategy IT to be consistent with optimal behavior, it should be consistent with smoothing out transitory inflationary pressures arising from real depreciation. The evidence in this chapter points toward an additional concern by some countries for real appreciation not necessarily because of immediate inflationary ramifications of exchange pass-through to inflation, but because of the need to keep the real exchange rate at some level consistent with long-run output stabilization.

Overall, the results of this chapter indicate that measures of financial vulnerability appear to be important in explaining the role of the exchange rate in the interest rate rule, but only at higher levels of significance. Further, evidence shows that average inflation between countries that choose an exchange rate objective and those that do not is not significantly different. However, there is still an important difference in inflation between standard targeters and mixed-strategy targeters, which is quantitatively lower in favor of standard targeters.

Given the aforementioned, it is conceivable that mixed strategy countries could achieve comparable inflation performance to that of standard IT countries if macroeconomic and structural policy reform was directed toward improving sectors that account for financial vulnerability. One key innovation of this study is the use of the binary choice model as a rule for detecting the potential factors underlying the systematic concern for the real exchange rate. When, on average, the predicted probability of placing a significant weight on the exchange rate is relatively high, this may be an indicator of underlying risks in the domestic financial sector, particularly when output stabilization is not the significant factor.

1.9 *Future Research*

There are several potential dimensions for extending this study. A study which casts the analysis in this chapter in the DSGE framework could be potentially interesting. This would allow for comparison of calibrated optimal interest and pass-through responses with estimated responses and then additional information can be mined from the recovered "residuals". Another such avenue would be a comparative study between standard IT and mixed-strategy IT on determining the volatility of inflation and output. This would make an interesting study when cast in the context of a vastly robust estimation procedure such as panel-data vector autoregression (PVAR) methodology. Lastly, could be the question of the propensity to comply with the inflation target between standard targeters and mixed-strategy targeters. A methodology like the Threshold Autoregressive model (TAR) would render a strong empirical basis for analyzing such a topic.

APPENDIX 1.1

MACROECONOMIC INDICATORS FOR THE INFLATION TARGETING SAMPLE COUNTRIES

COUNTRY	Date of IT Adoption	Exchange Rate Regime~	Volatility in Exchange Rates~	GDP/capita[1]	real Growth[1]	inflation[1]	Exports as % of GDP[1]	Imports as % of GDP[1]	Commodities as % of total exports[2]	Current a/c balance as % of GDP[2]	Total Reserves as % of total external debt[2]	Real interest differential[3]
Brazil	06/1999	Crawling peg	24.5	3639	0.0	3.2	6.9	8.9	31.26	-4.0	18.2	72.1
Chile	01/1991	Crawling band	8.9	3068	3.7	26.0	33.1	29.4	43.9	-1.5	35.3	16.6
Colombia	09/1999	Crawling band	13.9	2610	0.6	18.7	11.1	18.1	54.26	-4.9	26.5	17.2
Czech Republic	01/1998	Fixed peg/band/managed floating	8.2	5281	-0.7	8.5	49.8	54.3	16.9	-6.3	-	-1.1
Hungary	06/2001	Crawling band	5.3	4543	4.2	9.8	74.6	78.1	11.81	-8.6	-	-6.0
Israel	01/1992	Pegged/Crawling band	3.2	15507	5.6	19.0	26.2	33.5	6.7	-2.2	-	3.8
Korea	09/1998	Managed float/Independent float	15.6	10491	4.7	4.4	31.7	32.2	17.16	-1.6	-	1.4
Mexico	01/1999	Independent float	11.3	5413	5.0	15.9	28.0	29.9	22.84	-3.8	20.0	2.8
Peru	01/2000	Managed float/Independent float	4.6	2032	0.9	3.5	14.8	17.1	32.26	-2.7	31.0	22.2
Phillippines	01/2002	Managed float/Independent float	9.8	1048	2.9	6.8	46.0	52.9	9.92	-2.3	26.9	1.4
Poland	01/1999	Crawling peg/Crawling band	11.3	4065	5.0	11.7	26.0	30.8	21.97	-4.0	-	5.3
South Africa	02/2000	Managed float/Independent float	6.6	2972	2.4	5.2	25.3	22.7	30.7	-0.5	31.4	2.4
Thailand	05/2000	Fixed peg/Independent float	7.45	1877	4.4	0.3	58.3	45.7	15.55	10.1	35.9	5.8

Data source: World Development Indicators (WDI), International Financial Statistics (IFS), United Nations Statistics Division and Websites of central banks. Data source on exchange rate regimes: IMF Working Paper WP/02/155. List of IT emerging market countries based on Mollick et al (2011) and Inflation adoption dates are based on central bank sources. ~ refers to status in the year(s) preceding the the year of adoption of IT; 1. GDP/capita, real growth, inflation, exports/imports (percent of GDP), current a/c bal (% of GDP), and total reserves (% of total external debt) refers to the value of the variable at outset of the IT period. 1. GDP per capita is measured in constant 2000 US$. 2. This column is adapted from Aizenman and Hutchison (2010): commodity intensities for 2006. Except for Chile and South Africa which are based on author's own calculations. 3. Real Interest differential is calculated as the difference between the domestic lending rate and the average of the rate in the three financial centres (USA, UK, and HongKong); the reading is for the year prior to the adoption of targeting in each country. Appendix 1.1 highlights key structural and macroeconomic differences across the sample countries. There is observed disparity in the variation of the real exchange rate, pre-adoption GDP per capita, degree of external openness, current account balance, the external reserves position and the real interest differential.

APPENDIX 1.2

CORRELATION MATRICES

Panel A: pre and post-targeting periods

	Dis_ rate	Dis_ rate (-1)	Infl	Infl (-1)	O_gap (-1)	Re_Ap	Re_Ap (-1)
Dis_ rate	1						

Dis_ rate (-1)	0.95	1					
	(84.06)	-----					
Infl	0.69	0.68	1				
	(26.64)	(25.78)	-----				
Infl (-1)	0.72	0.73	0.91	1			
	(29.06)	(29.67)	(62.24)	-----			
O_gap (-1)	-0.08	-0.09	-0.09	-0.02	1		
	(-2.36)	(-2.58)	(-2.46)	(-0.55)	-----		
Real_ App	-0.05	-0.03	-0.11	0.02	0.15	1	
	(-1.29)	(-0.95)	(-3.16)	(0.54)	(4.22)	-----	
Real_ App(-1)	-0.01	0.02	-0.16	-0.05	0.1	0.79	1
	(-0.2)	(0.69)	(-4.39)	(-1.34)	(2.69)	(36.09)	-----

Panel B: pre- targeting period

	Dis_ rate	Dis_ rate (-1)	Infl	Infl (-1)	O_gap (-1)	Re_Ap	Re_Ap (-1)
Dis_ rate	1						

Dis_ rate (-1)	0.94	1					
	(34.63)	-----					
Infl	0.55	0.57	1				
	(8.25)	(8.74)	-----				
Infl (-1)	0.53	0.56	0.93	1			
	(7.91)	(8.51)	(30.74)	-----			
O_gap (-1)	-0.11	-0.14	-0.2	-0.18	1		
	(-1.38)	(-1.79)	(-2.61)	(-2.3)	-----		
Real_ App	-0.24	-0.22	0.21	0.3	-0.01	1	
	(-3.15)	(-2.84)	(2.64)	(3.99)	(-0.1)	-----	
Real_ App(-1)	-0.23	-0.26	0.02	0.17	0.05	0.81	1
	(-2.92)	(-3.34)	(0.27)	(2.14)	(0.62)	(17.18)	-----

PANEL C: post-targeting period (Appendix 1.2 cont.)

	Dis_ rate	Dis_ rate (-1)	Infl	Infl (-1)	O_gap (-1)	Re_Ap	Re_Ap (-1)
Dis_ rate	1						

Dis_ rate (-1)	0.94	1					
	(48.05)	-----					
Infl	0.67	0.62	1				
	(15.57)	(13.79)	-----				
Infl (-1)	0.67	0.68	0.92	1			
	(15.93)	(16.08)	(42.17)	-----			
O_gap (-1)	-0.08	-0.15	-0.01	-0.08	1		
	(-1.42)	(-2.64)	(-0.17)	(-1.44)	-----		
Real_ App	-0.04	0.02	0.02	0.13	0.04	1	
	(-0.7)	(0.35)	(0.34)	(2.32)	(0.71)	-----	
Real_ App(-1)	-0.06	-0.01	-0.08	0.05	0.06	0.77	1
	(-1.1)	(-0.26)	(-1.44)	(0.86)	(1.0)	(21.28)	-----

Note: t-statistics are in parentheses Disc_rate ≡ Discount rate, Infl ≡ Inflation, O_gap ≡ Output gap, Re_Ap ≡ Real Appreciation, and (-1) refers to one lag of the variable.

APPENDIX 1.3

LM TEST FOR AUTOCORRELATION OF RESIDUALS (TABLE 1.6 p-values)

Sample: 1990:01-2008:12

	one-lag	**four-lags**
Brazil	0.1085	0.3564
Colombia	0.9073	0.7453
Czech Rep	0.9711	0.8841
Hungary	0.4864	0.2099
Israel	0.4143	0.1638
Korea	0.0776	0.2574
Mexico	0.0813	0.274
Peru	0.2237	0.3964
Philippines	0.7339	0.7873
Poland	0.5464	0.2448
South Africa	0.1143	0.1135
Thailand	0.2134	0.7222

APPENDIX 1.4 (see Notes on next page in Appendix 1.5)

ESTIMATION OF THE ACCELERATIONIST PHILLIPS CURVE (Equation 3), Dependent Variable: Quarterly Inflation rate (πt)

Country	**C**	**π_{t-1}**	**pπ_{t-1}**	**App$_{t-1}$**	**pApp$_{t-1}$**	**GAP$_{t-1}$**	**p*Gap*$_{t-1}$**	**Open$_{t-1}$**	**p*Open*$_{t-1}$**	**Adj R^2**	**SE**
Brazil	0.38	0.82*	0.03	-0.04	-0.02	0.04	0.26	0.0	0.0	0.9	1.13
	(0.70)	(0.09)	(0.09)	(0.12)	(0.12)	(0.10)	0.14	(0.0)	(0.0)		
Colombia	2.60	0.84*	-0.11*	-0.05*	-0.04	0.15	0.01	0.0	0.0	0.98	0.83
	(1.13)	(0.06)	(0.05)	(0.02)	(0.03)	(0.08)	(0.12)	(0.0)	(0.0)		
Czech Rep	-0.6	0.42	0.50*	-0.20*	0.10	0.10	0.06	0.032*	-0.03*	0.94	0.89
	(0.60)	(0.24)	(0.25)	(0.07)	(0.07)	(0.10)	(0.16)	(0.01)	(0.01)		
Hungary	-0.47	0.88*	0.07	-0.34*	0.21*	0.20	-0.18	0.001*	0.0	0.8	0.79
	(0.7)	(0.03)	(0.09)	(0.07)	(0.07)	(0.16)	(0.25)	(0.0003)	(0.0)		
Israel	1.22	1.26*	-0.38*	-0.51*	0.49*	0.02	-0.07	-0.001*	0.001*	0.93	1.56
	(0.78)	(0.13)	(0.13)	(0.17)	(0.16)	(0.30)	(0.31)	(0.0002)	(0.0002)		
Korea	0.61	0.84*	-0.23	-0.05*	0.04	0.18*	0.14	0.0	0	0.83	0.99
	(0.60)	(0.08)	(0.18)	(0.02)	(0.03)	(0.08)	(0.10)	(0.0)	(0.0)		
Mexico	2.9	0.85*	-0.08	-0.33*	0.29*	0.24	-0.09	0.0	0.0	0.97	1.65
	(0.66)	(0.03)	(0.06)	(0.03)	(0.05)	(0.13)	(0.19)	(0.0)	(0.0)		
Peru	-1.23	0.81*	0.07	-0.15*	0.12*	-0.12*	0.17	10.0*	-6.16*	0.97	0.87
	(0.89)	(0.03)	(0.10)	(0.05)	(0.03)	(0.05)	(0.09)	(3.02)	(1.61)		
Philippines	3.1	0.78*	0.15	-0.21*	0.16*	0.07	0.02	-0.01*	0.003	0.86	1.48
	(0.99)	(0.07)	(0.16)	(0.06)	(0.03)	(0.14)	(0.18)	(0.002)	(0.002)		
Poland	0.54	1.07*	-0.03	-0.07	0.01	0.26*	-0.05	0.004*	0.005*	0.98	0.75
	(0.92)	(0.07)	(0.07)	(0.09)	(0.09)	(0.09)	(0.14)	(0.0002)	(0.0002)		
South Africa	1.39	0.90*	-0.11	-0.06	-0.01	0.10	0.43	0.0	0.0	0.89	1.28
	(0.68)	(0.05)	(0.09)	(0.04)	(0.04)	(0.13)	(0.30)	(0.0)	(0.0)		
Thailand	0.85	1.11*	-0.38	-0.02	0.01	0.20*	-0.07	-0.003*	0.003*	0.85	0.89
	(0.53)	(0.13)	(0.21)	(0.01)	(0.03)	(0.04)	(0.15)	(0.002)	(0.002)		

APPENDIX 1.5

ESTIMATION OF THE ACCELERATIONIST PHILLIPS CURVE (Equation 2), pre-period

Dependent Variable: Quarterly Inflation rate (π_t)

Country	C	π_{t-1}	App_{t-1}	GAP_{t-1}	$Open_{t-1}$	Adj R^2	SE
Brazil	1.84	0.81*	-0.06*	0.04*	-0.0001	0.98	0.48
	(1.61)	(0.12)	(0.01)	(0.02)	(0.0001)		
Colombia	11.95	0.5*	-0.06*	0.08	-0.0006	0.7	0.98
	(4.5)	(0.16)	(0.03)	(0.09)	(0.0004)		
Czech Rep	5.19	0.17	-0.3*	0.06	-0.01	0.65	1.00
	(3.40)	(0.26)	(0.08)	(0.12)	(0.02)		
Hungary	1.88	0.80*	-0.21*	0.23	9.66E-05	0.97	0.79
	(1.26)	(0.04)	(0.07)	(0.20)	(3.89E-04)		
Israel	22.4	0.79*	-0.14	0.46	-0.001	0.62	2.36
	(17.07)	(0.39)	(0.25)	(0.37)	(0.0007)		
Korea	2.63	0.63*	-0.10*	0.29*	2.20E-05	0.76	0.78
	(0.97)	(0.12)	(0.03)	(0.10)	(1.13E-05)		
Mexico	1.24	1.05*	-0.40*	0.24	0.0002	0.97	1.83
	(0.82)	(0.19)	(0.05)	(0.18)	(0.0007)		
Peru	62.77	3.60*	-3.86*	0.44	0.0058	0.94	0.85
	(30.15)	(0.55)	(0.77)	(0.39)	(0.0048)		
Philippines	3.4	0.76*	-0.16*	0.06	-0.008*	0.87	1.50
	(0.86)	(0.06)	(0.02)	(0.10)	(0.002)		
Poland	1.72	1.00*	-0.05	0.26*	-8.67E-05	0.96	0.84
	(8.3)	(0.29)	(0.09)	(0.05)	(0.0001)		
South Africa	3.15	1.07*	-0.07	2.00E-02	-7.37E-06	0.86	1.03
	(2.32)	(0.11)	(0.04)	(0.13)	(6.85E-06)		
Thailand	1.56	1.07*	-0.02*	0.21*	-0.004	0.77	1.03
	(0.75)	(0.18)	(0.01)	(0.05)	(0.002)		

Notes: π is the annualized rate of inflation, APP is real appreciation, GAP is the output gap, Open is a measure of openness of the economy, Adj R^2 is adjusted R^2 and SE refers to the standard error of the residuals/regression. HAC (Newey-West) Standard errors are in parentheses. * indicates significance at 5 percent confidence level. LM Tests indicate no significant autocorrelation in the regression residuals except for Korea, Mexico, Peru, and South Africa. However, inclusion of a third- quarter seasonal dummy variable for Mexico and Peru and fourth-order autoregressive term for Korea and South Africa eliminates the serial correlation (see Appendix 1.7, Panel A). Since Israel adopted IT in January 1992, two years from the beginning of our sample, the pre-targeting observations are not sufficient in number, therefore we use the coefficients estimated for data for the period 1986q4-1992q1 as applicable for the pre-targeting period. Inflation in Israel fell below 20 percent in q4 of 1986 from a hyperinflation high of 636 percent in q2 of 1985. For Peru, we dropped the hyperinflation observations of 1990q1-1994q1 from the estimation period (for LM test results, see Appendix 1.7, Panel A).

APPENDIX 1.6

ESTIMATION OF THE ACCELERATIONIST PHILLIPS CURVE (Equation 2), post-period

Dependent Variable: Quarterly Inflation rate (π_t)

Country	C	π_{t-1}	App_{t-1}	GAP_{t-1}	$Open_{t-1}$	Adj R^2	SE
Brazil	1.25	1.23*	-0.07*	0.17	0.0	0.89	1.05
	(0.79)	(0.11)	(0.02)	(0.09)	(0.0)		
Colombia	-0.27	0.90*	-0.03*	0.05	7.91E-05*	0.87	0.5
	(0.88)	(0.08)	(0.01)	(0.05)	(3.75E-05)		
Czech Rep	-0.54	0.87*	-0.10*	0.19*	0.003	0.85	0.85
	(0.68)	(0.05)	(0.02)	(0.06)	(0.002)		
Hungary	-1.13	1.1*	-0.16*	0.46*	3.67E-04*	0.8	0.79
	(0.88)	(0.13)	(0.03)	(0.08)	(1.61E-04)		
Israel	1.91	1.33*	0.08*	0.08	2.4E-05*	0.92	1.23
	(0.78)	(0.14)	(0.03)	(0.08)	(0.0)		
Korea	0.54	0.73*	-0.01	0.002	4.54E-06	0.67	0.64
	(0.59)	(0.11)	(0.01)	(0.04)	(5.05E-06)		
Mexico	0.16	0.86*	-0.03	0.02	1.90E-04	0.96	0.56
	(0.89)	(0.05)	(0.02)	(0.06)	(2.88E-04)		
Peru	0.22	1.42	-0.17*	0.08	-0.75	0.87	0.64
	(0.54)	(0.08)	(0.04)	(0.09)	(1.33)		
Philippines	3.9	1.65*	-0.05	0.11	0.002	0.88	0.9
	(2.91)	(0.14)	(0.06)	(0.07)	(0.004)		
Poland	-0.83	0.99*	-0.04*	0.13	0.00001	0.94	0.5
	(0.65)	(0.05)	(0.02)	(0.09)	(6.48E-06)		
South Africa	1.38	0.94*	-0.07*	0.75	2.79E-06	0.95	0.75
	(0.99)	(0.36)	(0.02)	(0.58)	(3.98E-06)		
Thailand	-0.13	1.30*	-0.03	0.01	0.0038	0.64	1.16
	(1.09)	(0.31)	(0.08)	(0.28)	(1.11E-03)		

Notes: π is the annualized rate of inflation, APP is real appreciation, GAP is the output gap, Open is a measure of openness of the economy, Adj R^2 is adjusted R^2 and SE refers to the standard error of the residuals/regression. HAC (Newey-West) Standard errors are in parentheses. * indicates significance at 5 percent confidence level. LM Tests indicate no significant autocorrelation in the regression residuals except for Israel, Poland and South Africa. However, inclusion of a quarterly seasonal dummy variable for Israel, a fourth-order autoregressive, AR(4) term for Poland and adding AR(1) and AR(4) terms for South Africa eliminate the serial correlation (for LM test results, see Appendix 1.7, Panel B).

APPENDIX 1.7: PANEL A

LM TEST FOR AUTOCORRELATION OF RESIDUALS, APP 1.5 (p-values)

Sample: 1990:01-2008:12

	one-lag	four-lags
Brazil	0.4243	0.1654
Colombia	0.2082	0.0902
Czech Rep	0.1815	0.1281
Hungary	0.2645	0.0791
Israel	0.1179	0.111
Korea◊	0.5306	0.0859
Mexico◊	0.9257	0.0633
Peru◊	0.9178	0.0915
Philippines	0.223	0.1172
Poland	0.1155	0.0902
South Africa◊	0.8211	0.0944
Thailand	0.0769	0.1176

Note: ◊ These four countries exhibited serial correlation in the residuals. To account for it, we included third-quarter seasonal dummy variables for Mexico and Peru and an AR(4) autoregressive term for Korea and South Africa.

APPENDIX 1.7: PANEL B

LM TEST FOR AUTOCORRELATION OF RESIDUALS, APP 1.6 (p-values)

Sample: 1990:01-2008:12

	one-lag	four-lags
Brazil	0.2112	0.0686
Colombia	0.5972	0.2767
Czech Rep	0.5675	0.0565
Hungary	0.2017	0.2549
Israel◊	0.7555	0.6109
Korea	0.5816	0.0549
Mexico	0.602	0.1714
Peru	0.0793	0.1061
Philippines	0.2704	0.3351
Poland◊	0.0971	0.0899
South Africa◊	0.5372	0.1191
Thailand	0.9277	0.4619

Note: ◊ These three countries exhibited serial correlation in the residuals. To account for it, we included a quarterly seasonal dummy variable for Israel, an AR(4) autoregressive term for Poland and added an AR(1) and AR(4) terms for South Africa.

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CHAPTER 2

INFLATION TARGETING AND INFLATION DYNAMICS UNDER THE HYBRID NEW-KEYNESIAN PHILLIPS CURVE: THE EXPERIENCE OF SOUTH AFRICA

2.1 *Introduction*

As mentioned in the previous chapter, the shift to inflation targeting is expected to precipitate changes in institutional operating procedures of the central bank. But in addition, IT is expected to change the behavior of price and wage setters which ultimately should impact the dynamics of macroeconomic variables. In this chapter, we hypothesize that the implementation of IT in South Africa has made monetary policy sufficiently transparent and credible to anchor inflation expectations firmly to the inflation target, and through this channel act as an anchor for the inflation process. It follows that if inflation targets are perceived to be credible by the public, they should form the basis for future price and wage setting (Van der Merwe, 2004). We present evidence of changes for South Africa in the relationship between prices and real activity that would be consistent with the primacy of the goal of price stability in the eyes of both the monetary authorities and the public.

In this chapter, we seek to establish why and how there has been a fundamental change in the inflation process under inflation targeting in South Africa. Our investigation is formalized through estimation of the hybrid New Keynesian Phillips Curve (NKPC). [46] The approach of examining determinants of inflation via the Phillips

[46] The basic or standard NKPC is an integral component for characterizing the behavior of aggregate supply in the new Keynesian model, which has virtually become the standard framework for monetary policy analysis for most monetary economists (see, for example, Clarida, Gali and Gertler (1999), Svensson and Woodford (2005), Walsh (2010), and Woodford (2003)).

curve has the attraction of controlling for a variety of factors that affect prices. The forward-looking character of inflation adopted in the "hybrid" NKPC assumes that firms set prices on the basis of their expectations about the future evolution of demand and cost factors (Gali and Lopez-Salido, 2001). The role of IT in anchoring these expectations should be recognizable in the form of structural changes, as seen in the form of out-of-the-pre-subsample predictions of inflation with key model factors not substantially explaining the observed behavior of inflation during the post-targeting period.

Therefore, we evaluate whether the implementation of IT in South Africa has an effect on the reduced-form parameters of the hybrid NKPC in line with the predictions of theory and whether the shift (if any) in the parameters has implications for inflation outcomes during the post-targeting period relative to the pre-targeting period. We hypothesize that if targeting has significant effects on aggregate macroeconomic outcomes, it should have implications for the relative importance of forward- vs. backward-looking influences on price setting in the hybrid NKPC model, with forward-looking behavior becoming more prominent, and it should affect the nature of the trade-off between marginal cost and inflation. South Africa is a particularly interesting case because it is one of the few Sub-Saharan African countries that has some longstanding experience with IT. At this time, its 12 years of experience with IT has presumably been enough time to alter dynamic relationships between macroeconomic variables, with the public now recognizing that the central bank is reacting differently to incoming news about inflation and growth.[47]

[47] Moreover, South Africa is one of the increasingly influential 'BRICS' countries, along with Brazil, Russia, India and China that represents new regional poles in the global economy and is an anchor for monetary policy in its region. Several countries in southern

This chapter proceeds in seven sections. Section 2.2 provides a conceptual discussion of the relationship between policy credibility and inflation expectations with emphasis on the plausible effects of changes in inflation expectations on the price-setting environment, nominal rigidities and shocks to aggregate demand and aggregate supply. Section 2.3 describes the monetary policy regime in South Africa before the adoption of IT and its preparedness for inflation targeting. This section also outlines some stylized facts about the evolution of inflation, inflation expectations and productivity improvements in South Africa since the adoption of IT. Section 2.4 reviews the research that investigates inflation targeting through the lens of the Phillips curve relation. In Section 2.5 we attempt to formalize the aspects of the story that we develop in previous sections by formalizing our hypothesis in the context of an inflation process driven through an estimated hybrid New Keynesian Phillips Curve (NKPCs). Section 2.6 reviews the data used for this study and provides descriptive statistics. In Section 2.7 we present the results of our estimations and provide interpretations. Section 2.8 addresses recent developments and challenges in implementing monetary and fiscal policies in South Africa, and Section 2.9 summarizes and concludes the chapter.

2.2 *Inflation Expectations, Nominal Rigidities and Price Shocks*

Most researchers recognize the adoption of IT as a shift by a country to a regime that is functionally different from other monetary stabilization strategies and whose

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Africa, including those that are not members of the Southern African Customs Union (SACU), manage their currencies with respect to that of South Africa. SACU comprises five countries: Botswana, Lesotho, Namibia, South Africa and Swaziland. The non-members are Angola, Malawi, Mozambique, Zambia and Zimbabwe.

efficacy as a strategy for inflation control is as much dependent on the monetary policy style as it is on galvanizing agents' expectations of inflation around the inflation target variable. As Siklos (1999) observes, if IT represents a credible regime change, one could expect the impact of the new policy to be reflected in economic agents' model of inflation. Agents would expect that shocks to inflation would be brief, based on the rationale that monetary authorities would not tolerate persistent deviations from the inflation target. Agents would therefore expect inflation, if it were highly persistent before the adoption of a target, to become less persistent following the adoption of credible inflation targets.

The change in agents' expectations of inflation provides a vital channel for monetary policy transmission through affecting the short-run output-inflation trade-off and overall inflation dynamics.[48] For example, Clifton et al. (2001) observe that IT influences the private sector's incentives to engage in multi-period contracts or to incorporate price indexation into wage contracts. When a credible monetary policy regime produces a climate of low inflation, there is a greater belief in the inflation target and a greater willingness of workers and employers to use it when setting long-term wage-price contracts. Firms change their prices less frequently because they have low inflation expectations and thus are less afraid of having to catch up if costs increase. At the same time, as the central bank becomes more inflation averse, labor unions become less uncertain about inflation and may choose less wage indexation and lengthen their

[48] In line with the tenets of IT, agents should recognize the inflation forecast as the intermediate target variable, as they eschew the central bank's output and employment ambitions.

wage contracts. This diminishes the transmission of price shocks to wages and the potential for a wage-price spiral.

Thus, a higher consistency between the inflation target and agents' inflation expectations implies a steeper Phillips curve and a smaller output cost associated with offsetting an inflation shock, because there is less need for demand contraction to bring inflation back down. So in the short run, output costs of disinflation are determined by the short-run inflation-output tradeoff for given inflation expectations. However, the character of inflation expectations, degree of backward vs forward-looking, is important for the responsiveness of wages and prices to inflation shocks and the implication for the long-run inflation-output tradeoff and inflation. A preference for longer contract durations as inflation expectations come to be anchored by the inflation target will likely reduce the responsiveness of the wage-price setting process to inflation shocks with important implications for defining how shocks to aggregate demand and aggregate supply affect core price inflation dynamics and growth. For instance, an uptick in inflation does not typically cause an upward pressure on production costs and prices because workers and producers expect the uptick to be transitory. In general the increase in contract duration is usually consistent with an environment of low and stable inflation, particularly if the longer tenure is anchored by an inflation target so that it induces a persistent favorable shock to prices (Dwyer and Leong 2003).[49] Since the degree of

[49] In principle, greater nominal wage-price flexibility means less of a decrease in output following a contraction in demand. In particular, when actual inflation is less than the rate expected, with wage rigidity, realized real wages (costs) could exceed the level expected and employment would decline (Walsh, 2010). Therefore, lower average inflation under IT could increase nominal wage rigidities and could offset some or all of the direct effects of the improved credibility on the inflation-unemployment tradeoff in the event of a negative demand shock (see, for example, Hutchinson and Walsh, 1998). However, we

responsiveness of wages and prices to inflation shocks is directly dependent on the extent of forward wage-price setting influences relative to backward, we propose to use the hybrid NKPC to examine the nature of inflation dynamics in South Africa during the pre- and post-targeting periods, respectively.[50] The role of IT is recognizable when the strategy reduces the sensitivity of marginal costs to inflation shocks. This implies that the ability of mark-up shocks to wages and intermediate imports prices to affect unit cost mark-ups would be partly buffered by anchoring of inflation expectations.

2.3 *The Monetary Policy Making Environment in South Africa and Challenges*

2.3.1 Monetary Policy Regimes over the Past Three Decades

This section gives a brief description of monetary policies and instruments in South Africa over the last three decades, to provide background necessary to understand the adoption of IT in South Africa in February, 2000. Monetary policy from the late 1970s to the present can be classified into three broad categories. First, up until the early 1980s, the South African Reserve Bank's (SARB)'s monetary policy regime cannot be associated with a definitive intermediate target (Gidlow, 1995). The regime was characterized by quantitative controls on interest rates and credit. The key instrument employed was a liquid asset ratio-based system. The second regime came into full operation by mid-1985 and followed from the recommendations of the de Kock

assume that the adverse effect on output of this latter channel is more than compensated for by the improvement in the tradeoff due to greater belief in the inflation target.

[50] The structure of price-setting behavior is likely to show marked variation across countries in various stages of development, i.e., advanced industrial, emerging-market, and developing countries, respectively.

commission reports (1978, 1985). While under this second regime, the central bank followed the strategy of monetary targeting, the period could be categorized into two developmental phases. The first phase was a 'plain vanilla' episode where the intermediate monetary aggregate was the pre-announced target range for the growth rate of broad money supply (M3) (Aron and Muellbauer, 2007). The key monetary policy instrument for the first phase (and second) was a cash reserves-based system supported by a redefined role for the discount rate.

The beginning of the 1990s ushered in the second phase of the second regime. This phase saw the enrichment of the 'plain vanilla' episode with steps being taken to require monetary aggregate targets to be supplemented for the determination of policy actions by a far broader range of economic indicators that included the exchange rate, asset prices, output gap, balance of payments, wage settlements, credit growth and the fiscal stance (Stals, 1997). However, the role played by information variables was rather ad hoc and created increased uncertainty amongst monetary policy observers. The result of this approach was monetary policy decision -making during most of the 1990s that was labeled as eclectic, not very transparent and difficult to predict.

Toward the close of the century, it was apparent that South Africa needed a new monetary policy framework. The relationship between M3 and changes in interest rates, money supply, demand for goods and services and inflation had been significantly altered and had become obscure due to, among other things, shifts in money demand, liberalization of the South African capital market, relaxation of exchange restrictions, domestic financial deepening, and the growing integration of global markets. During this period inflation was on a downward trend but relatively highly volatile. The uncertainty

about inflation may have caused people to perceive the risk profile of South Africa as disadvantageous for trade and investment. For the policy makers, it became apparent that the change in the money supply had become a less reliable indicator of underlying inflation and as such a less reliable anchor for monetary policy.

After a close to two-year search for a nominal anchor, on February 23, 2000, South Africa formally adopted IT as a means of ensuring price and financial market stability, ushering in the third monetary-policy regime.[51] The switch to IT came as a timely prescription to addressing issues of transparency, accountability, and predictability that had marred policy during the 1990s.[52] Under IT, interest rate policy is determined by an eight -member Monetary Policy Committee (MPC) while the target range for inflation is set by the National Treasury in consultation with the SARB. The MPC has six scheduled meetings in a calendar year and a number of unscheduled meetings when need arises.[53] Since 2007, the SARB has specified its inflation target as a range of between 3 and 6 percent of the rate of increase in the overall consumer price index, excluding mortgage interest cost (CPIX), measured over a twelve-month period, which must be

[51] Van der Merwe (2004) indicates that the SARB was already applying "informal inflation targeting" during the period leading up to the formal announcement in February 2000 of adoption of the IT framework.

[52] In previous monetary policy frameworks for the SARB, the objective of monetary policy was to bring the domestic inflation rate down to those of the country's main trading partners and competitors without specifying a numerical target for inflation or indicating the time horizon in which the objective would be met.

[53] Van der Merwe (2004) provides a succinct and detailed account of the decision-making process of the MPC for the SARB and the core information requirements.

obtained continuously in every month. The policy rate is adjusted only after determination by the MPC.

2.3.2 Status of Financial and Economic Conditions for the Adoption of a Successful IT Regime in South Africa

Compared to other emerging market countries that adopted IT around the same time, South Africa's financial markets and central bank infrastructure for implementing IT were relatively well developed. In a special survey to assess the role of "preconditions" for the adoption of IT, Batini et al. (2005) show that South Africa's economic conditions at adoption of its IT program were comparable to those of Austria, Canada, Norway and Sweden at the time those countries adopted their IT regimes.[54] The survey indicates that South Africa had relatively better initial conditions than 11 other emerging market countries save for Mexico, which exhibited comparable initial conditions to South Africa.

In Table 2.1 below, we report measures of financial-market health and depth for South Africa along with that of Brazil, Poland and Thailand, three emerging market countries that adopted IT almost at the same period as South Africa during the 1999-2000 period (see Appendix 1.3 for adoption dates).

[54] The survey was conducted through a questionnaire completed by twenty-one inflation-targeting central banks and ten non-inflation-targeting emerging market central banks. Following Batini et al., we define economic conditions as those structural aspects of the macroeconomy that are often thought to affect the likelihood of success of inflation targeting, i.e., exchange-rate-pass -through to inflation, sensitivity of inflation to commodity prices, extent of dollarization and extent of trade openness.

TABLE 2.1

INDICATORS FOR THE DEGREE OF DEVELOPMENT AND DEGREE OF SOUNDNESS OF THE BANKING AND FINANCIAL SYSTEM

Year: 2000

INDICATORS	South Africa	Brazil	Poland	Thailand
Bank regulatory capital to risk-weighted assets (%)	8.7	12.1	7.1	7.5
Stock market capitalization to GDP	154.2	35.1	18.3	24.0
Private bond market capitalization to GDP◊	3.6	2.6	3.9	2.1
Stock market turnover ratio (%)	33.2	44.6	48.1	52.9
Maximum maturity of actively traded nominal bonds₱	9.2	15.8	10.0	7.3

Source: World Development Indicators (WDI), Global Development Finance (GDF) (2005). The indicators for financial system health are based on Batini, Kuttner and Laxton (2005). ◊ This indicator measures the depth of the private bond market. ₱ Due to data unavailability, we have used the average terms of new debt commitments as a guide to the maximum term for outstanding debt including bonds.

We see from Table 2.1 that South Africa had a relatively sound financial and banking system and a relatively well-developed capital market at adoption of IT when compared to three other emerging-market IT adoptees. The country's banking sector indicator looks relatively stronger than the other emerging market countries, albeit with Brazil showing a much stronger index. Based on the ratio of stock-market capitalization to GDP, the extent to which South African companies can raise risky capital through issuance of equity in the domestic markets is relatively stronger and by a factor of close to five if compared to Brazil, which is the second-best amongst the four countries that adopted IT in the 1999-2000 period. While South Africa has the lowest stock market turnover, this may potentially work in the country's favor insofar as it may suggest relatively lower volatility in the stock market. On the basis of market capitalization of private bonds, South Africa's capability to issue long-term debt is relatively comparable to high-performing emerging market countries such as Brazil, even though the average tenure for South African debt securities appears to be less than that of Brazil. The

importance of sound financial markets has been emphasized by authors like Batini et al. who contend that a healthy financial system is important so as to minimize on monetary policy potentially conflicting with financial stabilization objectives and also to guarantee effective monetary policy transmission.[55]

However, like most emerging market countries, South Africa seems to live with the challenge of implementing IT with a financial system that is still developing in both breadth and sophistication and hence is vulnerable to problems of exchange-rate changes. The country appears to be sensitive to commodity price variations imposed upon by its substantial reliance on exports of gold, platinum and other minerals for its foreign exchange earnings.[56] Moreover, while data availability seems to not be a problem, that is, the central bank has a rich data base with a wide scope of coverage, the country may have had deficiencies, especially initially, in developing systematic forecasting processes and modeling capabilities.

Nonetheless, South Africa exhibits relatively sufficient central bank institutional and technical capability matched with ample, but still vulnerable, financial and economic conditions for the adoption of a successful IT regime.[57] At adoption, the South African central bank had full autonomy and looked to be free from fiscal and political dominance.

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[55] Asset price and money and credit channels constitute two of the four important monetary policy transmission channels in South Africa. Others are the exchange rate and interest rate channels. See Smal and Jager (2001) for a detailed exposition of the monetary transmission mechanism in South Africa.

[56] In Chapter one, we identified South Africa among emerging market countries with significant exchange pass-through to inflation incidents.

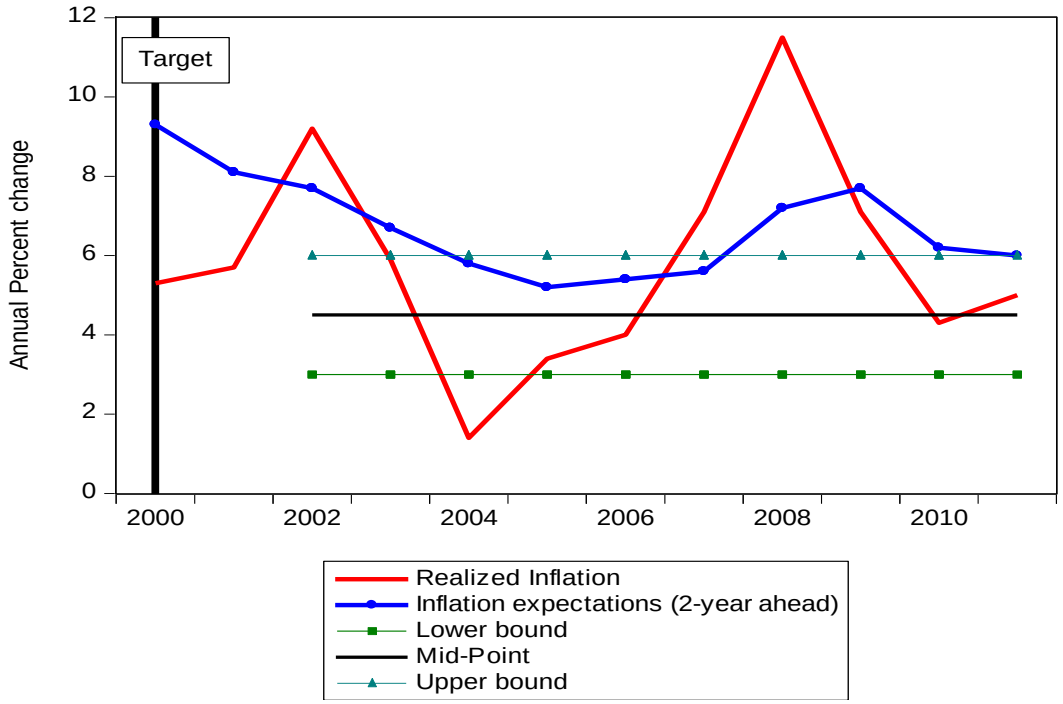
[57] The fact that none of the IT adoptees, both industrial and emerging, had strong preconditions at adoption suggests that the absence of 'perfect preconditions' may not by itself be an impediment to the adoption and success of IT.

2.3.3 Monetary Policy Credibility under Inflation Targeting

The evolution of inflation expectations and the role of the target are usually relevant variables for assessing the credibility of the central bank (Minella et al., 2003a). The first numerical target for South Africa was set for the year 2002. South Africa uses a band target as opposed to a point target. Save for a minor adjustment made during the formative period the SARB specifies it target range as 3 to 6 percentage points. From 2002 to 2009, the measure of inflation was specified as an annual average (12-month) rate of increase of the consumer price index excluding food and energy (CPIX). From 2009 on, the measure of inflation has been the year-on-year increase in the headline CPIX on a continuous basis, that is, the monthly change from the value 12 months before. In contrast to the earlier period where only the average was relevant for meeting the target the CPIX should continuously not breach the band. Figure 2.1 below shows that the introduction of inflation targets in South Africa in 2002 seemed to have had the desired effect on both inflation expectations and observed inflation until 2006.[58] After essentially having contained actual inflation within the target band for four straight years since adoption of IT, from 2007 to 2009 actual inflation rose above the upper bound of the target band. The figure also shows inflation expectations, as measured from a survey of financial analysts, business representatives, and trade union representatives. While inflation expectations responded with an upward movement, they still remained within the target interval until 2008. Since 2010, actual inflation has moved back within the

[58] Inflation expectations are two-year-ahead beliefs of all surveyed participants: financial analysts, business representatives, and trade union representatives (Source: SARB).

target band, but expected inflation remains slightly above the upper bound, except in 2011, when it showed indications of anchoring onto the upper bound of the target band.



Data Source: SARB.

Note: Inflation expectations are two-year-ahead beliefs of all surveyed participants: financial analysts, business representatives, and trade union representatives; The Target band is based on Van der Merwe (2004).

Figure 2.1

12-month Ahead Expected Inflation, the Inflation Target and Actual Inflation

The picture in Figure 2.1 seems to reflect that the central bank was potentially having some difficulty in re-establishing its credibility track record towards the later part of the period.

2.3.4 Inflation Dynamics, Productivity and Unit Labor Costs in South Africa

The dynamics of inflation in South Africa during the period 1990-2010 appear to be segmented into two distinct systematic episodes. As shown in Figure 2.2, during the period leading up to the year 2000, CPI inflation (henceforth "inflation") was on a downward course. The restraint in inflation during this period was, of course, not unique to South Africa, as a number of other industrial and emerging-market countries, including those without explicit inflation targets, had posted reasonably benign inflation outcomes during this same period (Dwyer and Leong, 2003).

As discussed above, South Africa adopted inflation targeting as its monetary strategy in February 2000. In the period following, however short, inflation appears to have been on a systematically stable path except for two peculiar episodes that occurred in the last quarters of 2001 and 2007, when inflation was adversely impacted by shocks to the nominal exchange rate. In 2001, the rand depreciated sharply when the SARB commenced implementation of substantial changes to the foreign-exchange market system. The 2007 depreciation was due to the effects of the global financial meltdown. Inflation dynamics in South Africa can be understood as being fundamentally determined by wage adjustment, real appreciation and import prices. In Figures 2.3-2.5, we plot inflation against wage inflation, import-price changes, and real appreciation of the rand currency. Inflation appears to reasonably track the movement of each of these variables. However, observing the inflation process in the post-targeting period relative to the pre-targeting period, it is easy to notice some differences in the evolution of inflation and its determinants.

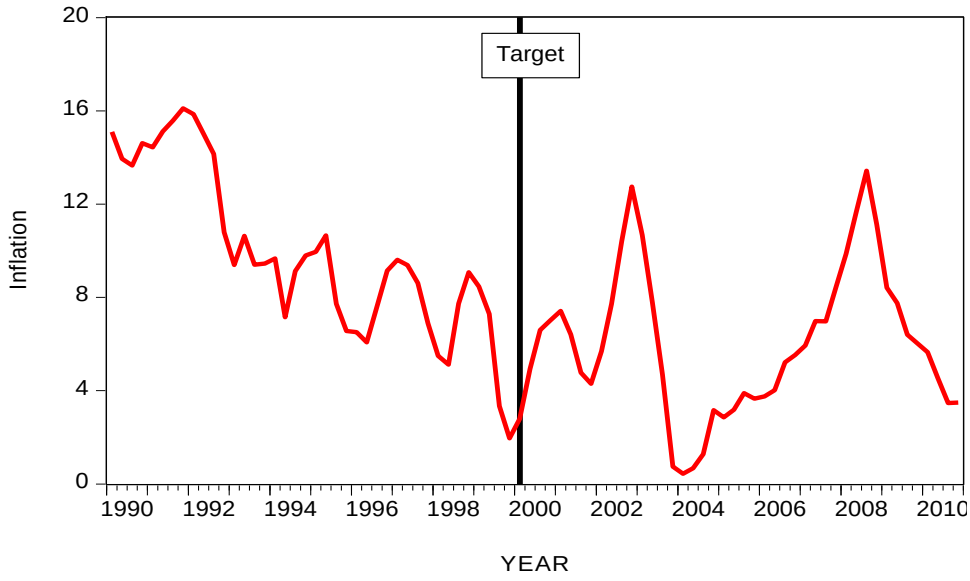


Figure 2.2

Quarterly Inflation – Year-on-Year

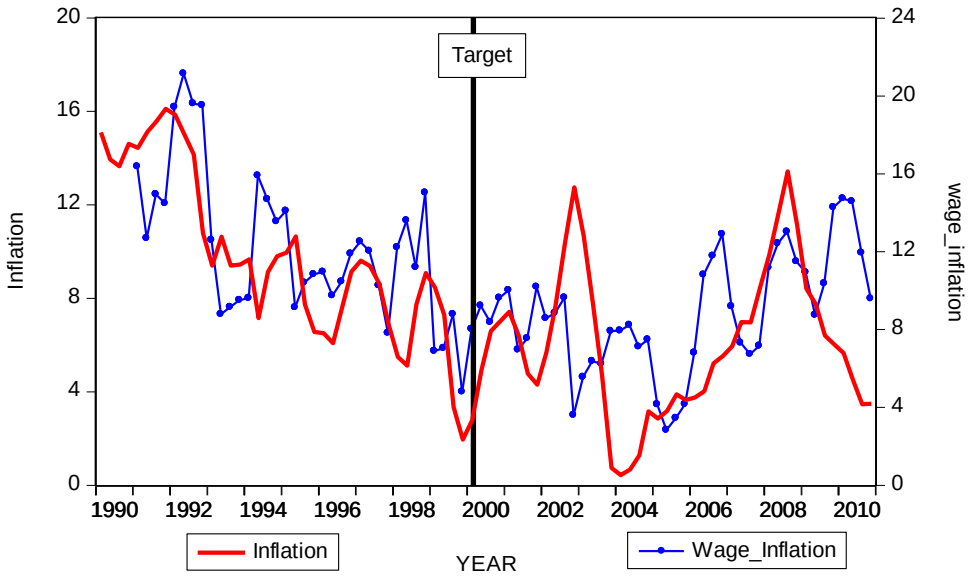


Figure 2.3

Wage Inflation and Inflation

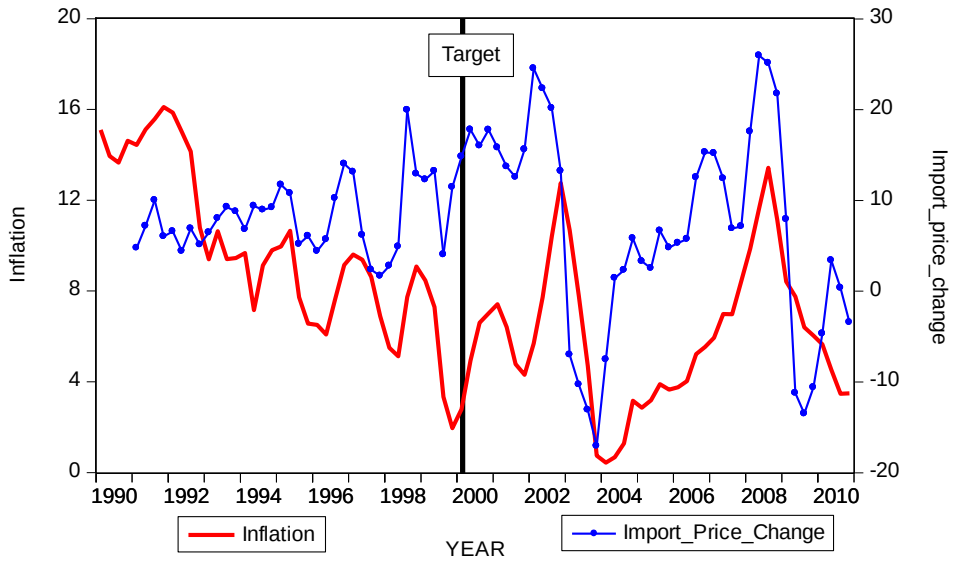


Figure 2.4

Import Price Change and Inflation

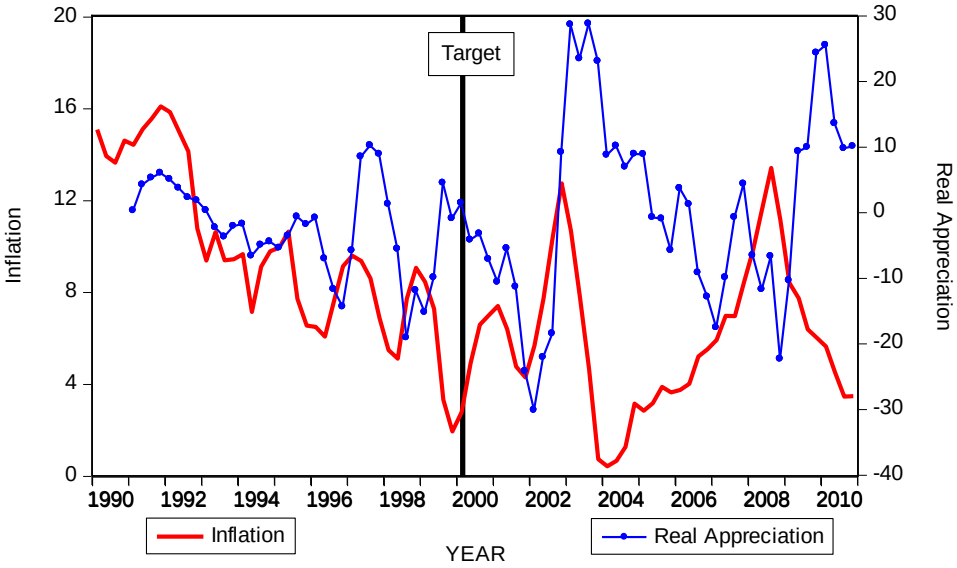


Figure 2.5

Real Appreciation and Inflation

Figure 2.3 to 2.5 suggest a discernible shift after the adoption of IT in the influence of shocks to wages, import prices, and exchange rates on inflation, compared to the earlier the period. We hypothesize that this is due to the adoption of the IT strategy.

However, productivity growth may also play a role in the behavior of prices, insofar as increased productivity growth may tend to dampen growth in prices (Macklem and Yetman, 2001). Focusing on the experience of the past decade, Table 2.2 reports a general downward trend in the South African economy's productivity gains from 2001 to 2011 as measured by labor productivity, the ratio of real output to labor input, taken to be employment numbers.[59] As expected, the slowdown in productivity growth is reflected in the increasing trend of unit labor costs over the period. The decline in productivity growth appears not to be accompanied by a commensurate decline in rate of growth of real remuneration per worker during the same period. In fact, the rate of change of real remuneration has generally been trending upwards. This suggests that growth in real wages has not tapered down with productivity growth, particularly in the period after 2008. The data suggests that the noticeable wedge between the growth in productivity and growth in real remuneration may be attributable to the relatively high growth in nominal remuneration per worker (column 2). The consequence of this is also reflected in the growth of unit labor costs (column 5).

The trends in growth in real remuneration per worker and growth in unit labor costs in Table 2.2, which appear not to comply with growth in productivity, suggest a wage-price setting environment in which workers and firms tend to respond according to

[59] Labor productivity growth is the change in labor productivity.

beliefs on past and future evolution of prices. Agents appear to face frictions in the labor market, possibly as a result of union pressure and/or governmental regulation.

TABLE 2.2
SOUTH AFRICA: GROWTH IN NOMINAL AND REAL REMUNERATION, LABOR PRODUCTIVITY AND LABOR COSTS
Annual averages^, in percentages

Year	Nominal remuneration per worker	Real remuneration per worker	Labor Productivity	Unit labor costs
2001	8.4	1.1	3.9	4.3
2002	11.7	1.6	3.0	8.5
2003	8.4	2.3	4.7	3.5
2004	9.1	3.4	2.4	6.5
2005	7.1	1.9	4.3	2.8
2006	7.5	1.6	2.8	4.5
2007	6.7	-0.9	2.9	3.7
2008	12.8	3.1	1.7	11.0
2009	11.8	2.6	1.7	9.8
2010	13.5	5.5	3.9	9.3
2011	7.2	1.7	1.2	5.9

Source: South African reserve Bank
Note: Data for non-agriculture sector. ^The average of annualized rates in the monthly data.

As a result, the labor market appears to exhibit real-wage rigidities and an aversion to erosion in real wages.[60] In an IT framework, this could be a challenge when wages do not adjust to productivity movements and particularly when firms insist on maintaining their mark ups so as to maintain their overall margins without deteriorating their financial structure. The ability to keep the inflation target would depend on the credibility of

[60] Gali and Lopez-Salido (2001) emphasize that it is these labor market frictions that in principle explain the inertia observed in the behavior of real marginal costs. The authors' evidence on the NKPC for Spain indicates that it is the inertial behavior in marginal costs that opens up the possibility of a short-run trade-off between inflation and output.

policy, lacking of which success would have to come at significant output and employment costs. The determinants of inflation discussed in this section underscore the relevance of the 'hybrid' New Keynesian Philips curve in addressing the hypotheses of this chapter.[61]

2.4 *Literature on Inflation Targeting and the Phillips Curve*

The New Keynesian Phillips Curve (NKPC) is a framework commonly used to understand how shifts in monetary policy affect inflation dynamics and relationships between inflation and the real economy. The reduced-form parameters of the NKPC model embed 'deep' parameters of preferences and technology, systematic dimensions of ways in which the central bank adjusts monetary policy instruments in response to changes in economic conditions, the public's understanding of the central bank reaction function and the credibility of its commitment to stick to its publicly-stated inflation targets. Two important sets of issues potentially complicate the use of a NKPC framework to examine how IT has affected dynamic interrelationships between macro variables in South Africa. The first concerns mixed empirical evidence on the validity of the basic NKPC model and on what variants are best suited to explaining the data. As reported by Roberts (2005), the basic NKPC model under rational expectations does not fit the U.S. data well unless modified with additional lags of inflation. Rotemberg and Woodford (1997) and Rotemberg and Woodford (1999) claim empirical support for the

[61] Figures 2.6-2.9 in Appendix 2.1 provides graphical representations of co-movements of inflation, nominal and real remuneration; inflation and labor productivity; labor productivity and unit labor costs; and labor productivity and nominal and real remuneration.

original New Keynesian sticky-price model under rational expectations only when they allow for a serially correlated error term. Gali and Gertler (1999) point out that conventional measures of the output gap may be poor approximations. They argue that if price dynamics are to be estimated conditional on labor costs, then the additional lags of inflation that are not predicted by the New Keynesian model under rational expectations are no longer needed. To address the possibility that it is an inappropriate rational expectations assumption that causes the lack of fit, they also estimate the hybrid NKPC finding that the explanatory power of the additional lag of inflation is statistically significant even though not quantitatively important.[62]

Second, standard NKPC models such as those of Gali and Gertler (1999) are based on closed economy assumptions, which may be fairly appropriate for large countries like the US, for which trade and capital flows are not large relative to the size of the economy. However, for countries like South Africa, which are small relative to the global economy yet have trade and capital flows that are relatively large compared to domestic output, failure to analyze domestic economic outcomes with regard to changes in global economic conditions may cause us to misconstrue how domestic monetary variables affect the real economy, where developments concerning the exchange rate are likely to be especially important.

[62] See Hornstein (2007) and Nason and Smith (2008) for a succinct account on the estimation of the NKPC and how well the NKPC and its various incarnations resonates with the data.

In previous work that estimates a NKPC model for South Africa, Du Plessis and Burger (2006) examine the importance of incorporating open-economy considerations.[63] The authors extend the methodologies of previous studies (mainly Gali and Gertler (1999) and Gali and Lopez-Salido (2001)) to the South African experience with the objective of examining whether the estimated basic NKPC and its extensions conform to the data. The authors report that the version of the hybrid NKPC with the cost variable augmented with import costs outperforms any other version in terms of fitting the data. They also indicate that the structural parameters they derive point toward inflation dynamics for South Africa that are not fundamentally at odds with those found in the USA and Europe. Thus, in the spirit of working with models shown to be valuable for explaining inflation-output dynamics, in this essay, we consider an open-economy extension to the hybrid NKPC model with the inflation estimate conditioned on both domestic and external marginal costs as a nuance for South Africa being a small open economy.

The literature on the impact of institutional reforms such as IT on the Phillips curve is fairly extensive (see, for example, Posen (1998), Baltensperger and Jordan (1998), Bernanke et al. (1999), Clarida et al. (1999), Andersen and Wascher (1999), Corbo et al. (2000), Clifton et al. (2001), and Ball and Sheridan (2005)). The core strand of the literature relates to empirical evidence on the effect of IT on the short-run trade-off between inflation and various measures of economic activity. Thus, what sets these

[63] While much of the focus of the literature has been predominantly to find a consistent fit between the basic NKPC and its extensions with empirical data for the USA and the euro area, recently there have been attempts by researchers to extend the debate about 'fitting' the NKPC to data beyond this block of countries.

studies apart from one another are the different assumptions used for the expectations formation process and for measuring activity variables in the versions of the Phillips curves that they estimate, most of which are a departure from the accelerationist model.[64] The results reported in these studies generally conclude that IT improves the output-inflation trade-off. For example, Clifton et al. (2001) estimate Phillips curves for seven OECD countries that adopted IT and nine OECD countries that did not do so.[65] The authors report that the unemployment-inflation trade-off improved significantly in countries that adopted IT relative to the non-IT countries, that is, a given reduction in inflation could be achieved with a smaller rise in unemployment. They also report that, for countries that adopted IT, inflation expectations for their sample were largely based on lagged inflation in the pre-IT period, and then on official inflation targets in the post-IT period. Clarida et al. (1999) arrive at a similar conclusion with regard to the trade-off. They show that if price-setting behavior depends on forward-looking expectations, then a central bank that can credibly commit to an inflation targeting rule faces an improved short -run tradeoff between inflation and unemployment.

While informative, these studies have not explicitly addressed the inquiry into causal effects of IT, as they make no effort to examine or explain how changes in the

[64] The "accelerationist" Phillips curve is so named because it implies that unemployment can only be kept low (or output high) at the expense of an increasing inflation rate, and thus an accelerating price level. Friedman (1968) assumes that inflation expectations evolve over time as a result of actual past experience. Simple formulations of this assumption of adaptive expectations assume that inflation expectations are determined by what happened last period. The accelerationist property becomes apparent when the relationship between inflation and output is presented in terms of the first differences.

[65] The model estimated by Clifton et al. includes inflation expectations and the rate of growth in labor productivity.

ways in which the central bank reacts to incoming information on prices, output, exchange rates and other variables in turn affect the behavior of these variables. They do not specifically investigate the role of inflation expectations in defining aggregate costs and therefore the inflation-marginal cost tradeoff. With the exception of Corbo et al. (2000), existing empirical work does not systematically link adoption of IT and shifts in inflation expectations to variation in aggregate costs. Therefore, the need to employ models that shed light on causal effects of IT makes the hybrid NKPC a good candidate model for addressing this gap in the literature since it is derived from an underlying structure of the economic environment.

The "hybrid" NKPC provides a valuable theoretical and empirical framework for capturing the implications of a regime change on wage-price-setting behavior. The hybrid model differs from the traditional NKPC model by allowing for a departure from the assumption of completely rational agents, by nesting a proportion of wage-price setters that follow a backward-looking "rule of thumb" along with a proportion that are forward-looking as in the standard NKPC. The hybrid model appears to have explanatory power that addresses observed inflation persistence in many countries (see, Fuhrer (1997), Gali and Gertler (1999), Gali et al. (2001), Du Plessis and Burger (2006)). Backward-looking pricing behavior is fairly endemic in emerging market countries, due to strong trade unions that tend to prefer wage indexation to forward-looking price indexation into wage contracts. The treatment of forward-looking expectations as endogenous is another ideal feature which makes the hybrid NKPC tractable because policy credibility, especially in emerging economies, builds over a period of time. Lastly, the hybrid NKPC's emphasis

on marginal cost as opposed to the output gap allows a logical link between costs and movements in fundamentals like real wages.

In our hybrid NKPC model, a shift to a credible monetary policy with a clear commitment to controlling inflation enhances the extent to which price and wage adjustments depend on beliefs about future economic conditions. This implies a macroeconomic and policy environment of lower inflation persistence and lower expected inflation, and as such, future output is not expected to contract excessively, giving rise to the improvement in the tradeoff. Therefore, a credible central bank is expected to pursue a disinflation policy with a relatively smaller inflation-marginal cost tradeoff because forward-looking expected inflation, which accounts for a larger weight relative to the weight on past inflation, will adjust downwards in line with the inflation target, thereby leaving policy to adjust just enough to meet the target. In contrast, when monetary policy lacks credibility, i.e., is not perceived as devoted to fighting inflation, inflation inertia may persist, perpetrating wage indexation and shorter wage contracts. This outcome makes the tradeoff less favorable, as any inflation not eliminated today would potentially require more output contraction in the future (higher marginal costs). In the next section, we discuss the proposed empirical approach.

2.5 *Key Theoretical and Methodological Frameworks*

The benchmark open-economy hybrid NKPC is the reduced form equation,

$$\pi_t = \gamma_b \pi_{t-1} + \gamma_f E_t[\pi_{t+1}] + \kappa x_t \qquad [1]$$

where π_t denotes the inflation rate, x_t denotes a measure of real marginal cost, $E_t[\pi_{t+1}]$ denotes the next period's expected inflation, γ_b and γ_f represent fractions of backward- and forward- looking agents, respectively, and κ is the inflation response to variation in marginal costs. The parameters γ_b, γ_f, and κ are functions of primitive structural parameters reflecting the extent of price rigidity, state of technology, elasticity of demand, and the discount factor.[66] Inflation is determined by expectations about future inflation and marginal cost (the measure of current economic activity). Because the degree of openness of the economy may affect inflation dynamics, we follow Gali and Lopez-Salido (2001) and treat real marginal cost as being proportional to real unit labor cost and also to the ratio of import prices to wages.

The open economy extension is important for analyzing the South African experience because the country is a small open economy in which imported intermediate inputs are likely to carry a significant weight in the production function. More so, with inflation targeting in place, along with trade and capital flows that are relatively large compared to domestic output, the volatility of the nominal exchange rate is likely to be important for inflation dynamics in South Africa. Episodes of currency depreciations and/or a rise in import prices could push up the cost of imported intermediate and final goods and generate an increase in domestic inflation. The counterpart to equation [1] for empirical estimation is given by

[66] where $\gamma_b = \omega\, \varphi^{-1}$ and $\gamma_f = \beta\theta\varphi^{-1}$, and $\kappa \equiv (1 - \omega)\,(1 - \theta)(1 - \beta\theta)\varphi^{-1}$ with $\varphi \equiv \theta + \omega[1 - \theta(1 - \beta)]$. For the detailed foundation of the model's derivation, see Gali and Gertler (1999), Gali and Lopez-Salido (2001) and Hornstein (2007).

$$\pi_t = \gamma_b \pi_{t-1} + \gamma_f \pi_{t+1} + \eta s_t + \phi(pm_t - w_t) + \xi_t \qquad [2]$$

where s_t is a log measure of real unit labor cost, pm_t is the log price of imported intermediate goods at time t, w_t is the log of remuneration per worker at time t, and ξ_t is an inflation disturbance with a mean of zero and variance σ_ξ (in the next section, we explain in detail how each of the variables in equation [2] is measured). The parameters η and ϕ determines how changes in the real unit labor costs and the ratio of the relative import price, respectively, would translate into movements in marginal costs and ultimately, inflation.

Equation [2] requires that shocks to wages, import prices and the exchange rate affect inflation by affecting the firm's marginal costs. Following Hornstein (2008), we make the implicit assumption that the random disturbance ξ_t is an exogenous shock to the firm's markup and so is propagated by shocks to productivity, global and domestic competition among others.

To recognize that the IT program could potentially lead to structural change, the empirical specification of equation [2] is modified to reflect dummy variables that multiply the regressors for the inflation targeting period.

$$\pi_t = \gamma_b \pi_{t-1} + \delta_b \text{Dum } \pi_{t-1} + \gamma_f \pi_{t+1} + \delta_f \text{Dum } \pi_{t+1} + \eta s_t + \eta_D \text{ Dum } s_t + \phi(pmt - wt) + \xi_t \qquad [3]^{67}$$

[67] The relative import price is not dummied due to the small open economy assumption.

The dummy variable takes the value one during the inflation targeting period and zero otherwise. Since the dummied regressors are not extra variables per se, but rather measure whether effects of lagged inflation, expected inflation, and marginal cost differ in the target period, the model remains consistent with the theoretical framework of the hybrid NKPC. However, the modification increases the number of parameters to be estimated and so obviously affect the standard errors of the coefficient estimates. The trade-off between the objective of measuring structural change and the need to achieve predictive accuracy is nonetheless noted.[68]

Estimation of equations [3] and [4] poses a challenge since expected inflation cannot be directly observed. If expected inflation is simply replaced with the observed value π_{t+1} and least squares is applied, the estimates of parameters would be inconsistent because π_{t+1} is correlated with the residual ξ_t. This endogeneity problem could be addressed by using an instrumental variable estimator such as Two-Stage Least Squares (TSLS) or Limited Information Maximum Likelihood (LIML). However, to estimate the NKPC many researchers have opted to use Generalized Method of Moments (GMM), of which TSLS is a special case, because of the tractability the method offers in exploiting properties of forecasts in models with rational expectations.[69] Suffice to say GMM is robust to heteroskedasticity while TSLS is not. Given sample data on the observable

[68] Minella et al. (2003b) estimate an aggregate supply curve by regressing inflation on its own two lags, one lag of the unemployment rate, one lag of the exchange rate and additional predictors constructed by multiplying dummy variables with the afore-mentioned primary regressors for the inflation targeting period.

[69] See Nason and Smith (2008) for a detailed account of the properties of forecasts that make GMM a preferred methodology for circumventing the challenge of measuring expected inflation in numerous studies of the NKPC.

variables, GMM finds values for the model parameters such that corresponding sample moment conditions are satisfied as closely as possible. In line with established literature (e.g., Gali and Gertler (1999) and Rudd and Whelan (2005)), we estimate equation [3] using GMM.[70]

Under rational expectations, the forecast error of π_{t+1} should be uncorrelated with information dated *t* and earlier. So equation [3] may be written as an orthogonality condition between the residuals and a set of *L* instruments z_t. The relevant population moment condition for estimating our set of parameters γ_b, γ_f, and κ is

$$E_t[\xi_t(\gamma_b , \gamma_f , \kappa) z_t] = E_t[(\pi_t - \gamma_b\pi_{t-1} - \gamma_f\pi_{t+1} - \kappa x_t) z_t] = 0 \qquad [4]$$

where the disturbance, ξ_t, is expressed as a linear combination of the variables in the model, z_t is a vector of potential predictor variables (instruments) observable at time *t* and earlier and thus orthogonal to the inflation surprise in period *t+1*. The parameters will be identified in terms of orthogonal counterpart sample moments. A set of instruments is needed to forecast the measure of expected future inflation, $E_t[\pi_{t+1}]$, which cannot be directly observed, but which enters the hybrid NKPC and influences the current inflation rate.

Equation [4] requires that in order for the estimates of the parameters in the hybrid-NKPC to capture all the systematic variation in inflation, π_t, there should be no predictable departures from the inflation dynamics implied by the hybrid NKPC or,

[70] We add a constant to the estimation to take account of the effect on the inflation environment of such factors as increase in domestic competition through globalization and domestic market liberalization and the inflation effects of productivity gains.

equivalently, the residuals, ξ_t, should have a mean of zero and be uncorrelated with predictor variables, z_t, which comprise our set of instruments. From equation [3], at most seven parameter values have to be estimated, including the constant. The system in [4] is expected to be over-identified as each instrument in the vector z_t will constitute an individual orthogonality condition and separate equation. The next section will explain in detail the variables that comprise the instrument set. Further, the postestimation test for over-identification will be Hansen's J-statistic for over-identifying moment conditions. Evidence against the null that over-identifying restrictions are valid implies that the moment conditions used are redundant.

The expected change in the response of inflation between the pre- and the post-IT periods in the hybrid NKPC should be consistent with firms setting prices on the basis of their expectations about the future evolution of demand and cost factors. With an inflation target in place, firms will tend to discount steeply the output ambitions of the central bank and they will also expect the central bank to be more aggressive in dealing with supply side shocks. So the role of IT in the wage-price setting environment should be to provide certainty about how policy will handle demand and cost disturbances. This implies that when agents recognize the credibility of the IT regime, their inflation expectations would be delinked from the dynamics of actual inflation and would instead anchor on the announced target. Once this occurs, the effect of shocks to wages and import prices on inflation will be weakened. The combination of central bank actions and the responses of wage-price setters should result in the expected structural change to the relationship between inflation and inflation persistence, inflation expectations and marginal cost to reflect price stability as the primary objective of policy. Nevertheless,

price movements will still be predicated on the dynamics of real marginal costs in line with theory.

In the hybrid NKPC, marginal costs which are subject to inertial effects arising from frictions in the labor market play a central role as a source of inflation changes (Gali and Lopez-Salido, 2001). Since IT, when credible, is likely to induce and enhance these inertial effects toward lower and stable growth in marginal costs, the result is an improvement of the tradeoff between inflation and real marginal costs.[71]

Following from the above, the key points to be investigated are whether there has been a measurable change in the relationship between inflation and its main explanatory variables. That is, whether there is a change in the composite values of GMM estimates of γ_b, γ_f, and κ between the pre-targeting period and the post-targeting period and whether this shift is statistically significant. The key comparison involves the expected shift in the shares of backward and forward-looking firms and the potential change in the tradeoff between inflation and real marginal cost ($\kappa_{post} < \kappa_{pre}$). With a credible IT program, wage-price setting behavior in the post-targeting period should become more forward-looking with much extended or longer employment and goods contracts anchored around the pre-announced inflation target. The shift in wage-price-setting behavior should result in a smaller fraction of backward-looking agents (lower γ_b) and a larger fraction of forward-looking agents (larger γ_f). As a result, IT should lead to relatively lower inflation persistence. Furthermore, a central bank that has established its credibility is expected to pursue a disinflation/inflation stabilization policy with a smaller inflation-marginal cost

[71] See Gali and Lopez-Salido (2001) for a discussion of inertial effects on marginal cost dynamics and labor market frictions.

tradeoff because the expected rate of inflation, which is anticipated to have a larger weight relative to past inflation in the NKPC will be either on target or very close if agents believe the central bank has credibility to stand by its inflation target objectives in the future.

For purposes of assessing robustness of the results to specification, the model in equation [3] is also estimated using an alternative specification which requires that the two subsamples (pre and post) be estimated jointly as a system of non-panel equations. The estimation method still remains GMM and all the orthogonality conditions apply. The model is estimated with and without coefficient restrictions on the backward- and forward-looking elements of the model. The constraint requires that the coefficients add up to unity, i.e., $\gamma_b + \gamma_f = 1$.[72] While this restriction is implied through the assumption which calibrates the firm's discount factor to unity in the structural model of the hybrid NKPC, researchers have suggested placing the constraint on the reduced-form parameters without taking recourse to this assumption, but simply on the basis of the 'share' interpretation (see, for example, Henry and Pagan (2004) and Rudd and Whelan (2006). The motivation notwithstanding, this particular robustness check has become an integral procedure in estimated hybrid NKPC (Gali and Gertler (1999), Gali, Gertler and Lopez-Salido (2005) Du Plessis and Burger (2006)).

The above notwithstanding, other writers have repudiated the idea of restricting the reduced-form parameters to $\gamma_b + \gamma_f = 1$ in the hybrid NKPC as being problematic. Nason and Smith (2008) argue that the purpose of estimation is to test hypotheses about

[72] The constraint $\gamma_b + \gamma_f = 1$ is implied when the discount factor, β, in the standard hybrid NKPC is restricted to unity (see, for example, Gali and Gertler (1999)).

all relevant values of parameters. They claim the restriction in the hybrid NKPC causes the model to break ranks with the underlying Calvo-type staggered pricing mechanism, which in turn has implications for the marginal costs in the hybrid NKPC. Hornstein (2007) explains that the slack is relevant as it implies accommodating a discount factor in the structural model that reflects stylized fundamentals such as consumption and investment habits.

The third and final variant to equation [3] follows from the specification by Guender (2006), which introduces the real exchange rate directly into equation [2] to substitute for the relative import price. Guender reasons that there exists a benchmark price that firms face in world markets and that this price affects the optimal price charged by firms, i.e., domestic firms adjust their prices in line with the price charged by their foreign competitors on the final goods in domestic currency price equivalency.

The first post-estimation exercise assesses the stability of inflation expectations under the IT program. Since the inflation targeting regime is supposed to affect the formation of inflation expectations, assessment of the degree of stability, overtime, of forward-looking influences relative to backward influences (i.e., degree of 'anchor') could provide useful information about the credibility of the inflation target. For this purpose, a more detailed nonlinear analysis estimates the relationship in equation [4] recursively to map the dynamics of the γ_b and γ_f coefficients over the targeting period. In terms of the mechanics, the sample size for the base equation (pre-targeting sample) is successively extended one quarter at a time up until the end point of the post-targeting sample so as to re-estimate the coefficients at each interval.

The second post-estimation exercise will assess graphically the shift in inflation dynamics between the pre- and post-targeting period. Equation [4] estimated for the pre-targeting period will be used to predict a series of one-step ahead forecasts of inflation over the targeting period and these series will be compared with actual inflation realizations. The graphical relationship provides a useful tool for assessing the structural change even though its conclusions may only be qualitatively important. The indicator of structural change is when the out-of-sample forecasts of key model factors appear not to systematically explain the observed inflation during the post-targeting period.

2.6 *Data and Descriptive Statistics*

The analysis uses seasonally adjusted quarterly time series data for South Africa on annual change in the log of the consumer price index (π_t), real GDP growth rate, log of worker compensation as percent of GDP (s_t)[73], real unit labor costs, yield on treasury bills (T-Bill rate), yield on government bonds (Bond-rate), log of commodity price index, log of import price index (pm_t), log of worker remuneration index (w_t) and the real effective exchange rate (q_t) from 1990: Q1 to 2010: Q4.[74] Table 2.3 reports variable definitions and data sources. Table 2.4 shows descriptive statistics.[75]

[73] Our use of the log of labor share in national income as our measure of aggregate marginal cost, x_t, follows from Gali and Gertler (1999).

[74] The sample data for Chapters two and three continue through to 2010 because South Africa does not appear to have significant macroeconomic shifts during the first two years of the financial crisis. The model estimated up to 2010 appears to be consistent with that for up to 2008, albeit with improved fit to the data so we go up to 2010 to take advantage of 8 additional degrees of freedom for each variable.

[75] For reference, Appendix 2.1 presents correlation coefficients for the key variables.

TABLE 2.3
DEFINITIONS AND DATA SOURCES FOR KEY VARIABLES
Sample: 1990:1-2010:4

Variables	Quantity	Unit of measurement (Percent Change of index)	Equation Variable	Source
Inflation rate[a]	Consumer price index	Over Corresponding Period of Previous Year	π	IFS
Real GDP growth rate[b]	Real GDP growth index	Over Corresponding Period of Previous Year		IFS
Real Appreciation[c]	REER index	Over Corresponding Period of Previous Year	App	IFS
Output gap†	Real GDP growth index	Hodrick-Prescott filter	GAP	IFS
Marginal cost	Worker compensation/GDP	End of period	s_t	SARB
Marginal cost	Real unit labor cost	Ratio of nominal unit labor cost/GDP deflator	s_t	SARB
Marginal cost	Relative import price		pm_t-w_t	SSA
Yield on T- bills	91-day T-Bill	End of period (annualized)		SARB
Yield on government bonds	10-year bond or more	End of period (annualized)		SARB
Commodity price inflation	Commodity price index	Over Corresponding Period of Previous Year	π^c	IFS
Import price change	Import price index††	Over Corresponding Period of Previous Year	π^{imp}	SARB
wage inflation	Worker remuneration index	Over Corresponding Period of Previous Year	π^w	SARB
Yield spread†††			*Spread*	

Note: International Monetary Fund's International Financial Statistics (IFS), South African Reserve Bank (SARB), Statistics South Africa (SSA). All data is measured at a quarterly frequency. - a, b and c are measured as annualized rates: log(index)-log(index(-4)), where (index(-4)) is the fourth lag of the index. - REER refers to the Real Effective Exchange Rate. †To measure the output gap, we use the Hodrick-Prescott filter to detrend real GDP growth rate into its aggregate cyclical variation (λ=1600), i.e., the difference between the real GDP growth series and the recovered trend. †† Is measured by price index for merchandise imports, excluding fuels and lubricants. †††The Yield spread is the difference between the Bond rate and the T-Bill rate. - The Treasury bill rate is the tender rate on 91-day treasury bills in national currency and the yield on government bonds is the average of the yield on bonds with maturities of ten years and longer.

TABLE 2.4

DESCRIPTIVE STATISTICS: MEANS AND STANDARD DEVIATIONS (percent)

Sample: 1990:1-2010:4

	Whole sample		Pre-IT Period		Post-IT Period	
Variables	Mean	Std Dev	Mean	Std Dev	Mean	Std Dev
Inflation rate	7.8	3.9	9.7	3.7	6.0	3.2
Real Appreciation	-0.7	11.8	-2.0	6.9	0.4	14.8
Output gap†	0.0	1.6	0.0	1.6	0.0	1.6
Worker compensation/GDP	53.5	2.9	56.3	0.9	50.9	1.2
Commodity price inflation	5.1	31.6	-3.5	11.6	12.5	40.5
Import price change	7.6	8.9	8.3	4.0	7.0	11.6
wage inflation	10.4	3.8	12.2	3.8	8.8	3.0
Yield spread	0.9	1.9	1.0	2.1	0.7	1.7
Domestic real GDP growth rate	2.8	2.2	1.9	2.3	3.5	2.0

Data source: South African Reserve Bank's interactive data base, IMF's International Financial Statistics (IFS), and Statistics South Africa (SSA).Whole sample period: 1990:1-2010:4 ;Pre-IT period: 1990:1-2000:1;Post-IT period: 2000:3-2010:4.† Derived using the Hodrick-Prescott filter (λ=1600).

The Treasury bill rate is the tender rate on ninety-one-day treasury bills in national currency and the yield on government bonds is the average of the yield on bonds with maturities of ten years and longer. Our instrument set, z_t, is composed of four lags each of inflation, the log of labor share in income, the output gap (HP filtered), the yield spread, wage inflation, commodity price inflation and the real exchange appreciation. We estimate the output gap using a Hodrick-Prescott filter on quarterly real output data and we set the value of the smoothing parameter λ to the recommended level for quarterly data of 1600. We expect the instruments to be relevant and valid, since conceptually, each one of them seems to be a viable predictor of CPI inflation, conditional on its impact

on expected inflation, or at least each instrument's movements seem to anticipate movements in CPI inflation.[76]

The start date for the sample period, 1990:1, is intentionally chosen to coincide with the start date for the panel sample in the previous chapter so as to maintain a consistent pre-targeting sample. To determine the breakpoint between the pre-targeting and post-targeting periods, we follow previous literature such as Corbo et al. (2001) and Mishkin and Schmidt-Hebbel (2007), which prescribes a post-targeting dating convention based on the start of fully-fledged inflation targeting. This implies using the first full calendar quarter of IT implementation as the break-point between the pre-targeting and the post-targeting sub-periods. Since fully-fledged inflation targeting in South Africa began in February 2000, we delimit the post-targeting period as having commenced at the beginning of April, 2000.

Table 2.4 shows that inflation in South Africa declined between the two subsample periods from an average of 9.7 percent during the pre-targeting period to an average of 6.0 percent in the post-targeting period. The average volatility of inflation also declined from 3.7 percent to 3.2 percent. The observed reduction in the level of inflation and its volatility after adoption of IT is in line with other results reported for other inflation targeting countries (see, for example, Neumann and von Hagen (2002)). While the real exchange rate had, on average, depreciated during the entire decade of the 1990s, it has, on average exhibited appreciation during the targeting period (2000:2-2010:4). Its volatility has gone up from 6.9 percent in the pre-targeting period to 14.8 percent in the

[76] Du Plessis and Burger (2006) report no weak instrument problem in their estimates of parameters for the hybrid NKPC for South Africa using the same list of instruments.

post-targeting period. Surprisingly, the level of the output gap and its volatility seem on average to have remained unchanged between the subsamples. This observation is at odds with the common notion that targeting could potentially engender increased output volatility. The levels of worker compensation as a percent of GDP and wage inflation, together with their volatilities, have both declined between the two sample periods. In Figure 2.10 below, we plot the evolution of inflation based on the CPI index against the share of compensation in GDP, which is our key measure of real marginal costs. Inflation appears to closely track the movement of the marginal cost variable reasonably well.

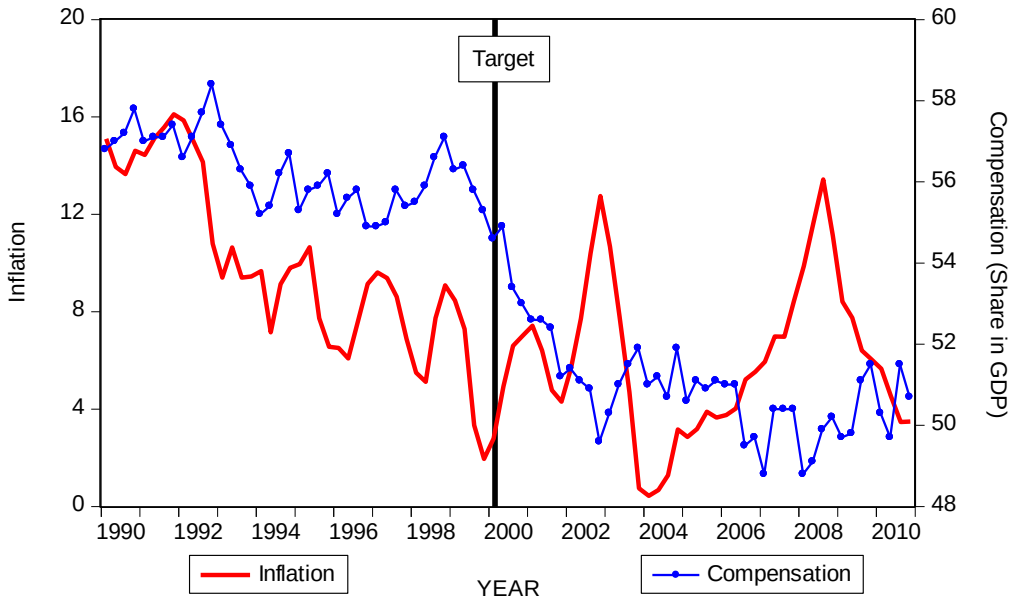


Figure 2.10

Worker Compensation (share in GDP) and Inflation

The relation in Figure 2.10 appears to hold strong, particularly in the early phase of the sample. The correlation coefficients suggest reasonably plausible relationships between the key variables (see Appendix 2.2). In the next section, we proceed to provide formal

reduced form evidence of the existence of the NKPC for South Africa for the pre-and post-targeting periods.

2.7 *Results of the Estimations*

2.7.1 GMM Estimation Results - The Hybrid NKPC with Targeting Dummy Variables

Table 2.5 reports single-equation GMM estimation results for the specification of equation [3] which includes dummy variables where coefficients on the lag of inflation and the lead of inflation are allowed to differ during the targeting period. The model is estimated using two alternative measures of real activity – compensation as percent of GDP (A 1) and real unit labor cost (A 2). The estimates suggest a good fit to the data for the two alternative measures of real activity. The adjusted R-squared value for each equation is at least 94 percent. As anticipated, the coefficient estimates, γ_b and γ_f are significant, positive fractions for both measures of real activity. Further, there is evidence of a statistically significant structural shift in both backward- and forward-looking influences during the targeting period. For example, estimation alternative 1.a suggests a significant structural shift in both the backward- and forward-looking influence at the standard 5 percent level as suggested by the estimates of δ_b and δ_f.

Alternative 2.a also presents significant structural shift for the forward-looking component at the standard 5 percent level even though it only does so at the 10 percent level for the backward-looking component.[77] A comparison of the magnitude of the structural change for inflation persistence and inflation expectations, respectively, across

[77] Nason and Smith note that the NKPC that uses the labor share to represent Real Unit Labor Costs has been relatively successful empirically.

TABLE 2.5

HYBRID NEW KEYNESIAN PHILLIPS CURVE: SOUTH AFRICA

Sample: 1990:1-2010:4, $E[\pi_t - \Upsilon_b\pi_{t-1} - \delta_b Dum\pi_{t-1} - \Upsilon_f\pi_{t+1} - \delta_f Dum\pi_{t+1} - \kappa x_t \backslash z_t] = 0$

Measure of marginal cost		Υ_b	Υ_f	δ_b	δ_f	η	η_d	ϕ
1. Labor income share:	A 1.a	0.57*	0.49*	-0.12*	0.15*	0.14*		0.004
		(0.04)	(0.05)	(0.06)	(0.07)	(0.04)		(0.007)
	A 1.b	0.58*	0.49*	-0.12*	0.14*	0.14*	-0.03	0.004
		(0.05)	(0.05)	(0.06)	(0.07)	(0.04)	(0.12)	(0.007)
2. Real unit labor cost:	A 2.a	0.55*	0.50*	-0.09+	0.14*	0.11*		0.009
		(0.04)	(0.06)	(0.06)	(0.06)	(0.04)		(0.007)
	A 2.b	0.62*	0.58*	-0.17*	0.04	0.12*	-0.04	0.005
		(0.04)	(0.07)	(0.07)	(0.08)	(0.04)	(0.13)	(0.008)

		J-statistic	Prob (j)	Adjusted R-squared
Labor income share:	A 1.a	15.84	(0.72)	0.94
	A 1.b	15.89	(0.66)	0.94
Real unit labor cost:	A 2.a	15.94	(0.72)	0.94
	A 2.b	15.96	(0.67)	0.94

Notes: π is the year-over-year rate of inflation, $Dum\pi_{t-1}$ and $Dum\pi_{t+1}$ are Dummy variables for the lag and lead of inflation, respectively, during the targeting period; Standard errors in parentheses; * and + denote coefficient significance at the 5 and 10 percent levels, respectively. A 1 and A 2 reports estimates for the alternatives using the ratio of compensation to GDP and the real unit labor cost, respectively. A i.b is the alternative that includes a dummy variable for domestic marginal costs for i = 1, 2. The instrument specification for A 1 comprise four lags each of: inflation, log of the ratio of compensation to GDP, the output gap, the spread, wage inflation, commodity price inflation, and the real exchange rate appreciation. For A 2, the same set of instruments apply, except that log of the ratio of compensation to GDP is replaced by the log of the real unit labor cost. The estimation closely reflects the instrument list used by Gali and Gertler (1999), Du Plessis and Burger (2006), Nason and Smith (2008) among others in their estimation of the NKPC. The J-statistic reports the test of over-identifying moment conditions where the null has valid over-identifying restrictions. The activity variable x(t) = const + ηs(t) + ϕ(pm(t) - w(t)). The parameter η refers to inflation response to domestic marginal costs, s(t), η_d is the estimate of η during the targeting period and ϕ refers to response to the relative import price.

alternative 1.a and 1.b indicates that with the adoption of an inflation target, there is a shift from backward-looking price-setting to forward-looking. For instance, alternative 1.a shows that the share of forward-looking price setting has increased to 0.64 (0.49 + 0.15) while the share of backward-looking price-setting has reduced to 0.45(0.57 – 0.12). The estimates are consistent with the theory that the hybrid NKPC predicts inflation by both backward- and forward-looking influences. In this regard, the observed structural changes are as anticipated under the theory in the presence of a credible inflation target. In particular, the shift confirms the hypothesis that IT, due to its forward-looking feature, encourages more forward-looking wage-price setting behavior relative to backward. In the hybrid NKPC, this is typified by a significant switch during the post-targeting period with the weight on expected future inflation, γ_f (0.64) being relatively larger than that on inflation persistence, γ_b (0.45) (see alternative 1.a). The converse is true during the pre-targeting period, where the weight on inflation persistence, γ_b (0.57) is relatively larger than the weight on expected future inflation, γ_f (0.49).

The estimates of the slope coefficients for the marginal cost, η and ϕ, are positive as implied by theory. The impacts of labor income share and real unit labor cost on current inflation are statistically significant.[78] However, ϕ, the response to the relative import price appears not to have significant predictive content for inflation. Further, alternatives 1.b and 2.b, which include a dummy variable for the labor income share and the real unit labor cost for the targeting period, show a quantitative shift in the coefficient η between the pre- and post-subsamples. The value of η reduces from 0.14 and 0.12 in

[78] This finding is consistent with previous results, such as those of Gali and Gertler (1999), Du Plessis and Burger (2006) and Nason and Smith (2008).

the pre-targeting period to 0.11 and 0.08 in the post-targeting period, respectively, albeit, the change is not statistically significant. The prediction by theory that the effect of real activity on price changes can be explained by variation in real marginal costs is borne out in these estimates. The IT program appears to induce a quantitative improvement in the tradeoff between inflation and real marginal costs. As expected, the quantitative impact on inflation of marginal costs is smaller during the post-targeting sub-period than during the pre-targeting sub-period. Such a key monetary policy result of substantial reduction in the degree of inflation persistence and marked improvement in the inflation-marginal cost tradeoff after adoption of an inflation target implies that the central bank can pursue disinflation and maintain low and stable inflation at lower costs to output.

A number of diagnostic tests were conducted to evaluate the regression. The estimates of parameters for the hybrid NKPC, γ_b, γ_f, and η appear to be valid and can be said to 'fit' the data reasonably well. The test statistic for the model's over-identifying restrictions, the *J-statistic*, is generally small with a large *p*-value and hence supports the null hypothesis that over-identifying restrictions hold for the instrument set used (we do not reject the null hypothesis), i.e., the same parameters apply for any set of instruments.[79] Equivalently, the departures in equation [3] are close to zero, even when we use a longer list of instruments. Next, to check for potential weaknesses of the instruments, we performed the Anderson-Rubin (A-R) test and then checked the Kleibergen (2001) statistic. Both tests suggest that the instruments used are relevant (A-R

[79] Larger values of the *J-statistic* would yield smaller *p*-values which may indicate that the residual is predictable and thus constitutes a rejection of the relevant version of the NKPC.

= 4.70, with p-value = 0.001; K-statistic = 18.6, with p-value = 0.00). The above diagnostic tests are consistent with the model being reasonably representative of the underlying data.

2.7.2 GMM Estimation Results – Joint Sub-sample Estimation without and with Coefficient Restrictions

To gauge the robustness of the estimates in Table 2.5 to sub-sample properties, the hybrid-NKPC was estimated jointly for the pre-IT and post -IT sub-periods as a system of two non-panel equations. The relevant comparison is to test whether γ_f(post-IT) > γ_f(pre-IT) and γ_b(post-IT) < γ_b(pre-IT). Table 2.6 reports the GMM results of the joint estimates without and with coefficient restrictions alongside the results for individual sub-samples. The results suggest a good fit of the model to the data with the adjusted R squared value being at least 90 percent for both joint and sub-sample estimates. Like in Table 2.5 the estimates of γ_b, γ_f, η, and ϕ are statistically significant. The general conclusions that we reached with the estimates in the previous section also show up in the unrestricted joint and sub-sample estimates. As conjectured, forward-looking price-setting behavior becomes relatively more prominent with the IT regime.

As a further robustness check, given that γ_b and γ_f are shares of backward and forward-looking influences on inflation dynamics, Table 2.6 also reports estimates of coefficients for the restricted model, $\gamma_b + \gamma_f = 1$, for the joint estimation and for subsample estimation, respectively. The estimates of the restricted model show reasonable consistency, with their unrestricted counterpart specification. However, the precise estimate of the weight on backward/forward price-setting influence appears to be

somewhat sensitive to the restriction. The results are consistent with forward-looking influences becoming relatively more important with inflation targeting.

TABLE 2.6

GMM ESTIMATES OF THE HYBRID-NKPC FOR SOUTH AFRICA

Comparison of unrestricted and restricted coefficient estimates: $\Upsilon_b + \Upsilon_f \neq 1$ or $\Upsilon_b + \Upsilon_f = 1$

Dep Var: Current Inflation (π_t): (Sample: pre-1990:1-2000:1; post 2000:2-2010:4)

Coefficients	Υ_b	Υ_f	η	ϕ	J-stat
Unrestricted	(se)	(se)	(se)	(se)	(p)
Joint estimates					
Pre	0.53*	0.49*	0.22*	0.05*	11.2
	(0.02)	(0.03)	(0.06)	(0.01)	(0.67)
Post	0.47*	0.63*	0.11*	0.02*	11.2
	(0.01)	(0.01)	(0.02)	(0.002)	(0.67)
Sub-sample estimates					
Pre	0.60*	0.47*	0.20*	0.03*	8.19
	(0.02)	(0.02)	(0.04)	(0.005)	(0.99)
Post	0.52*	0.57*	0.14*	0.006*	9.8
	(0.01)	(0.01)	(0.01)	(0.002)	(0.98)
Restricted					
Joint estimates					
pre	0.53*	0.47	0.16*	0.02*	7.65
	(0.03)	-	(0.06)	(0.08)	(0.24)
Post	0.45*	0.55	0.13*	0.005*	7.65
	(0.01)	-	(0.04)	(0.002)	(0.24)
Sub-sample estimates					
Pre	0.54*	0.46	0.24*	0.02*	8.5
	(0.02)	-	(0.05)	(0.006)	(0.99)
Post	0.48*	0.52	0.11*	0.0001	9.3
	(0.01)	-	(0.02)	(0.003)	(0.99)

Notes: The instrument set, z_t is composed of four lags each of inflation, the log of labor share in income, the output gap (HP filtered), the yield spread, wage inflation, commodity price inflation, and the real exchange appreciation. The parameter η refers to inflation response to domestic marginal costs and ϕ refers to inflation response to the relative import price. The implied value for Υ_f for the restricted estimations is the difference $\Upsilon_f = 1 - \Upsilon_b$. * denotes significance at 5% confidence level. The instrument list is similar to that of Du Plessis and Burger (2006) for their estimates of the hybrid-NKPC for South Africa. J-Stat refers to the J-statistic; the J-statistic reports the test of over-identifying moment conditions where the null has valid over-identifying restrictions.

It is clear that before IT adoption, backward-looking price setting is > 50 percent and after adoption, forward-influences are > 50 percent. The results in Table 2.6 are supported by diagnostic tests (*J*-statistic, K-statistic and AR tests) which are consistent with the model being reasonably representative of the underlying data. Since the results of the joint estimation technique are not materially different from those obtained in the previous section, we can conclude that inflation targeting leads to significantly more forward-looking price-setting behavior relative to back-ward.

In general, the estimates reported in Tables 2.6 are broadly similar to those reported in other studies that use the GMM technique to estimate the hybrid NKPC. For example, Gali and Gertler (1999) report no significant difference between the unrestricted and restricted models. They also report no significant impact of the constraint on the estimates of the other parameters of the model. Gali, Gertler and Lopez-Salido (2005) report the sum of the backward and forward shares which is greater than 1, i.e., $\gamma_b + \gamma_f > 1$ for the unrestricted model. These previous findings suggest that some slack in the constraint is plausible, within some range depending on the underlying data, without having a significant impact on the results. Du Plessis and Burger (2006) report that the restricted model of the hybrid NKPC is the version that best fits their data.

The results of the exercise that estimates equation [3] with the real exchange rate in place of the relative import price are not reported as the estimates with the relative import price out-performs those with the real exchange rate mainly on the basis of the size of the standard errors of the coefficients and on the R – square values of the regression.

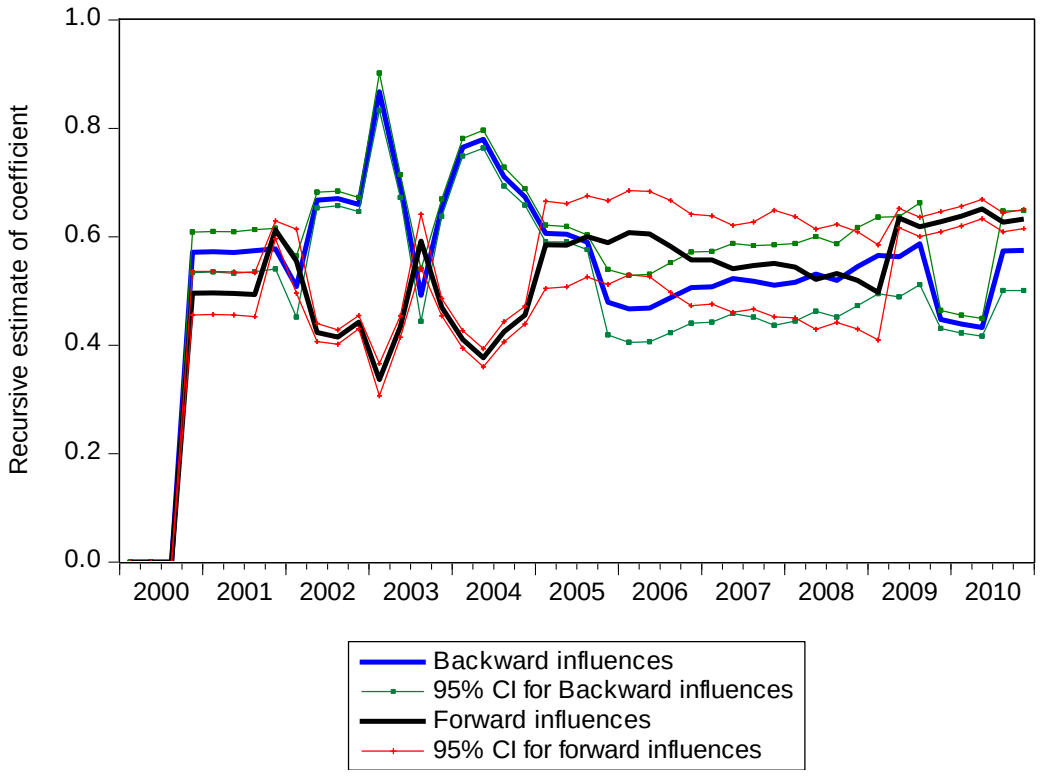
2.7.3 Recursive Estimates and Credibility of the Inflation Target

Figure 2.11, below, displays recursive estimates of forward- and backward-looking components in price adjustment (γ_f and γ_b).[80] Also shown are two 95 percent standard error bands around the estimated coefficients.[81] The estimates of both coefficients display significant variation during the initial 4 years of IT implementation. The initial volatile dynamics appear to be consistent with inflation expectations not having been credibly anchored in the formative years. In fact, this period in time is characterized by high inflation volatility. Beyond the fourth year of IT implementation, forward influences suggest relative stability and relative significance, except at end of 2008 when there is an indication of relative instability in both components (γ_f momentarily fell below γ_b). Further, the difference between γ_f and γ_b appear to be consistently significant beyond 2004 as shown by the likely values of γ_f that lie outside the confidence band of γ_b. This result reinforces the earlier conclusions on the prominence of forward-looking behavior relative to backward- in an inflation targeting regime. Furthermore, the estimated forward component on price adjustment has an upward trend. This suggests, when we take into account the numerous price shocks

[80] Note that the feasible recursive estimation begins in q4 of 2000. This is forced by the constraint of estimating extra (dummy) parameters vis-a-vis the post-targeting size of the sample. So, in essence, at least two observations are required beyond the pre-sample period to estimate the initial set of recursive dummy coefficients for inflation persistence and inflation expectations making q4 of 2000 the feasible quarter.

[81] The 'pooled' standard errors for the coefficients that exhibit significant change between the pre-targeting and post targeting periods were computed using the Satterthwaite (1946) approximation to take account of the potential difference in the variances of the pre- and post-sub-samples.

experienced in the short sample span under which South Africa has had an inflation target, that belief in the target is growing and the credibility of policy is on the rise.



Note: CI ≡ Confidence Interval

Figure 2.11

Recursive estimates: Forward and Backward Influences

In particular, the sharp depreciation of the rand currency in 2001 and 2007 resulted in actual inflation moving beyond the upper limit of the target band. The severity of the shocks to inflation appear to have impacted the credibility of the inflation target to the extent of inducing the component of price adjustment that looks backwards to respond. However, the reaction during 2008-2009 appears to be not as sharp as the

noticeably substantial peak in γ_b in 2002.[82] [83] It is conceivable that the anchoring effects of IT have become more durable overtime.

2.7.4 Actual vs. Forecast Inflation –Post-Targeting Period

Figure 2.12a displays actual and fitted values of inflation during the pre-targeting period. The fitted values suggest a reasonable fit to the pre-targeting sample. Figure 2.12b displays actual and forecast values during the post-targeting period.

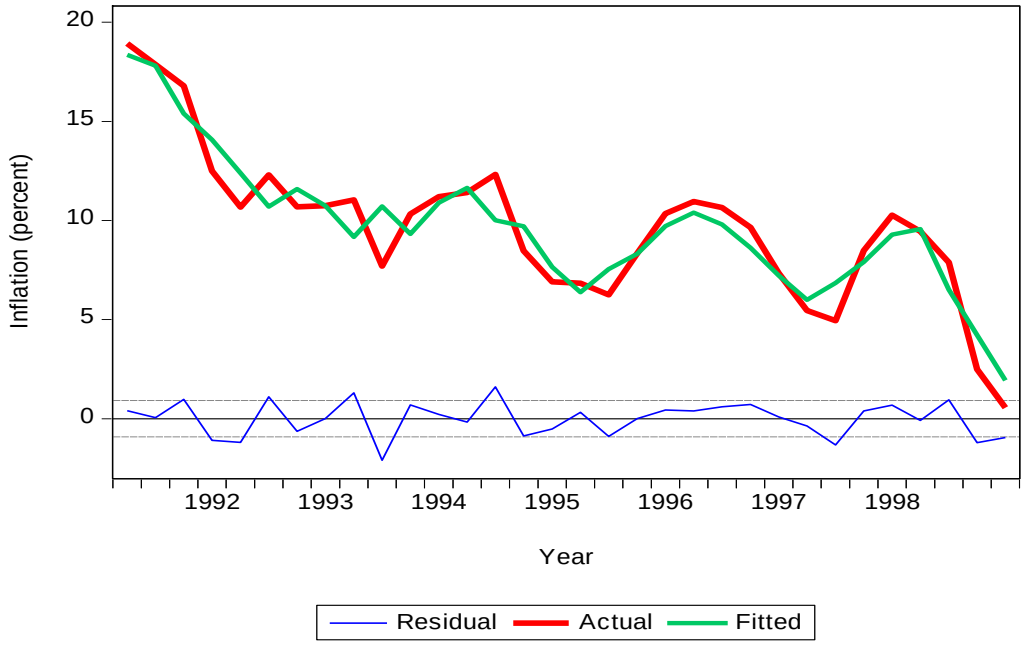


Figure 2.12a

Actual and Fitted Inflation: Pre-targeting Period

[82] The instability observed during 2004 appears to be linked to the low inflation episode when actual inflation fell below the lower bound of target band.

[83] The episodes of relative instability in both components appear to be well anticipated from Figure 2.1 of section 2.3.3. The 2-year ahead inflation expectations during the two episodes were above the target band suggesting a de-anchoring of inflation expectations from the target.

The forecast of inflation for the post-targeting period, based on the pre-sample, appears to be systematically above realized inflation, generally confirming the existence of a structural break in the relationship between inflation, inflation expectations, and marginal cost during the post-targeting period. In essence, the persistent over-prediction in recent years could be ascribed to growing credibility of the SARB.

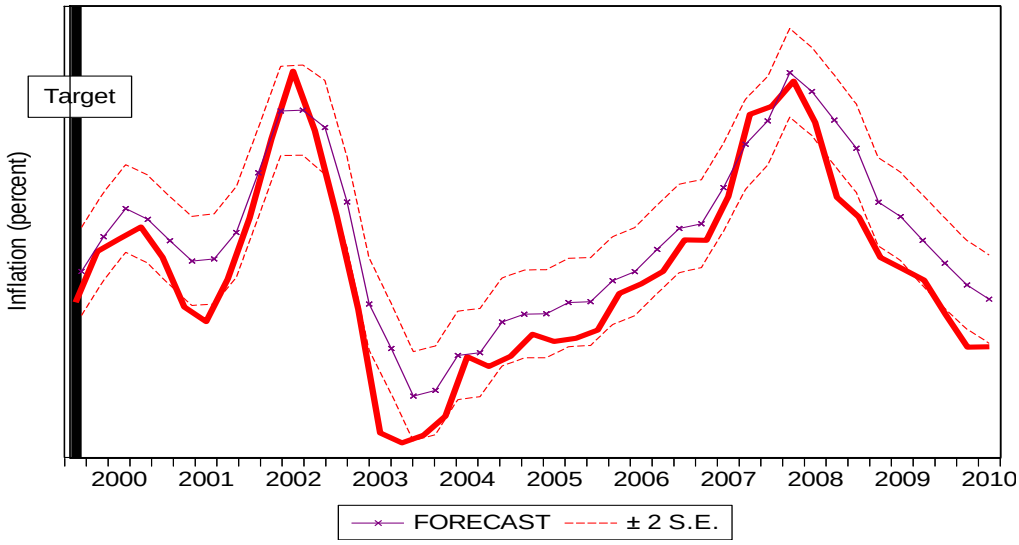


Figure 2.12b

Actual and Forecast Inflation: Post-targeting Period

The recent period of the sample indicates that the central bank has been making substantial headways in reigning in inflation pressures.

2.8 *Recent Developments and Challenges in Implementing Monetary and Fiscal Policies in South Africa*

South Africa is still adjusting from the impact of the global slowdown of 2008-2009. The IMF staff report for 2012 estimate a slower GDP recovery over the medium

term than earlier projected. The output gap is expected to be negative until sometime in 2014. This means inflation and fiscal revenues are also expected to be lower than earlier anticipated. Thus far, the response of fiscal policy has been to delay the pace of fiscal consolidation and to increase spending over the medium term, reflecting the need to erase the negative output gap under a lower-than-envisaged fiscal revenue base. South African authorities have been able to mitigate the impact of the global financial crisis and deal with the anemic pace of recovery through a strong counter-cyclical fiscal policy because of prudent fiscal management in the last decade which provided significant fiscal space. The fiscal deficit has provided further stimulus in the face of weak external demand and a negative output gap. In December 2011, the cyclically-adjusted fiscal deficit was around 4 percent of GDP, while the gross national government debt reached just below 40 percent of GDP. However, in 2012 the fiscal position had worsened and lowered significantly the fiscal space available for countercyclical fiscal policy. The dip in the fiscal position notwithstanding, public debt levels are still moderate and the composition bears little exchange rate or maturity risk. Moreover, other non-public external debts also remain moderate and about half of them are Rand denominated (hence low risk of "original sin").

Going forward post-crisis, the South African government looks set to keep the policy of fiscal stimulus for longer than initially envisaged. This stance will likely induce even higher fiscal deficits and higher public debt levels for the years 2013-2014 than originally envisioned.[84] Fiscal space for facing any future stress will likely diminish as

[84] In view of the anticipated fiscal deficit over the medium term, rating agencies have lowered South Africa's outlook. This could have implications for the exchange rate

the government debts continue to grow. Nonetheless, in its medium term budget framework, the government has emphasized gradual fiscal consolidation to rebuild fiscal space where by 2017, the fiscal deficit is programed to be at 1 percent of GDP and the debt at about 35 percent of GDP.

The IMF's recent assessment of non-fiscal vulnerabilities was that they are on the low side. The Financial Sector Assessment Program (FSAP) update of 2008 found that South Africa's financial system is sound, well capitalized, and is underpinned by a well-established legal and financial infrastructure and a generally effective regulatory framework. Even in 2012, financial soundness indicators have stabilized at comfortable levels since 2010, having partially recovered from the effects of the global financial crisis. Banks' capital and liquidity cushions have shored up again, while credit growth and bank profitability have started to pick up from a low base. The main risks remain banks' dependence on domestic short-term wholesale funding and heavy exposure to home mortgages. Broad regulatory reforms to further enhance financial sector resilience are underway.

The main risks, according to the IMF, are external. These include concerns about the euro area and signs of a slowdown in China which could impact adversely on external demand, slowing demand for South African exports and affecting the real sector and, indirectly, the domestic financial sector. South Africa's reliance on mineral exports makes it sensitive to movements in international commodity prices. So far, large portfolio flows have helped fund the significant external current account and fiscal deficits after

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going forward with depreciation possible and potentially induce upside inflationary pressures through an increase in marginal costs due to higher import price mark-ups.

the 2008 financial crisis. The continued inflows of capital will depend on factors such as the degree of aversion to risk, currency depreciation, and interest rates. So, any instability in these factors could further complicate both fiscal and monetary policy. Therefore, a fiscal and monetary policy supported by sufficient flexibility of the rand and adequate international reserve coverage is crucial to providing buffers against external risks. Despite a volatile external environment, South Africa appears to have sufficient macroeconomic and financial stability to enable it to borrow abroad in its own currency at interest rates that are reflective of its investment grade rating.

Monetary policy through the inflation targeting framework has been crucial in South Africa's resilience to the large shifts in the global external environment (IMF Staff report, 2012). IT has allowed an accommodative monetary policy stance, especially given the recent limited fiscal space, geared to provide the much needed stimulus to erase the output gap while keeping inflation expectations well anchored. The SARB has kept the policy rate unchanged at 5.5 percent since November 2010, which has worked to erode real interest rates. Moreover, with well-contained core inflation expectations and inflation risks on the downside, monetary policy space is slowly being created to erase the negative output gap.

To support fiscal and monetary policies, structural reforms in labor and product markets are critical for improving productivity and employment growth in South Africa. Labor and product market competition still requires additional strengthening by lowering administrative and regulatory burdens. Real wage growth has not been consistent with growth in labor productivity. In 2010, public sector wage settlements, were on average, higher than inflation and productivity gains. This distorted wage negotiations in other

sectors (IMF Staff report, 2010). The IMF has recommended labor reforms aimed at increasing labor and wage flexibility, arguing removing rigidities in the labor market could contribute to reducing unemployment. However, the relevant rigidity to remove may be the arbitrary price-setting processes because the rigidity borne of anchoring effects of the inflation target are necessary for low and stable inflation as we have shown in the hybrid NKPC that we estimate in this chapter.

2.9 *Summary and Conclusions*

In this chapter, we provide evidence on the hybrid New Keynesian Phillips curve for South Africa over two distinct policy episodes spanning the recent period, i.e., pre-targeting period and post-targeting period (1990:1-2000:1 and 2000:2-2010:4). We have shown that the relative stability of inflation in South Africa post-IT adoption in February 2000 is attributable to factors other than productivity improvements and structural improvements in domestic market competitiveness. Productivity gains actually declined over the period and so could not be responsible for the price stability exhibited. Similarly, the previous chapter reported a positive relationship between openness and inflation in South Africa, suggesting that globalization may have exposed the country to net-positive price shocks.

The formal investigation of inflation dynamics in South Africa in the context of a hybrid New Keynesian Phillips Curve (NKPC) suggests that there is evidence of a structural break in the behavior of inflation after adoption of inflation targets. The evidence from the data indicates that during the inflation targeting period, wage-price setting behavior appears to be getting in stride with the inflation targeting environment.

Wage developments during the targeting period suggest inertial behavior of real marginal costs induced by the inflation target. The dynamics of inflation are suggestive of ever becoming depend on expectations of inflation.

The foregoing has ensured that realized inflation during the post-targeting period is, on average, relatively lower and stable. Out-of-sample forecast values based on the pre-targeting subsample indicate that South Africa has achieved inflation rates in the IT period that are considerably lower than what would have been expected had the pre-IT relationships between macro variables continued to hold in the IT period. Since labor market frictions play a key role in shaping the behavior of marginal costs, the important policy lesson to draw from our findings is that the IT regime plays a crucial role in harnessing labor market frictions by anchoring wage developments in a beneficial way, which improves the trade-off between inflation and marginal costs. Through this mechanism, IT helps deliver lower and stable inflation.

The findings in this chapter invite two important propositions about the labor market conditions in South Africa. First, that labor costs primarily play a crucial role in accounting for inflation pressures. Second, structural characteristics in the labor market, perhaps induced by government empowerment and equity programs that followed the introduction of democracy in 1994, could be responsible for some of the inflation persistence observed in the pre-targeting period. Invariably, programs and policies that advocate living wages/compensation imply pay structures based on indexing to inflation.

There are several interesting dimensions this research can take in the future. For a longer sample, it will be interesting to test the response of backward- and forward-looking influences to massive inflation shocks. Another interesting extension would be to

empirically link the relation between survey inflation expectations such as those in Figure 1 to the estimated ratio of forward-backward influences on inflation for a panel of IT countries. It would be interesting to see whether the gap between expected inflation (from survey) and the official target inflation would be decreasing with this ratio.

APPENDIX 2.1: LABOR PRODUCTIVITY AND INFLATION

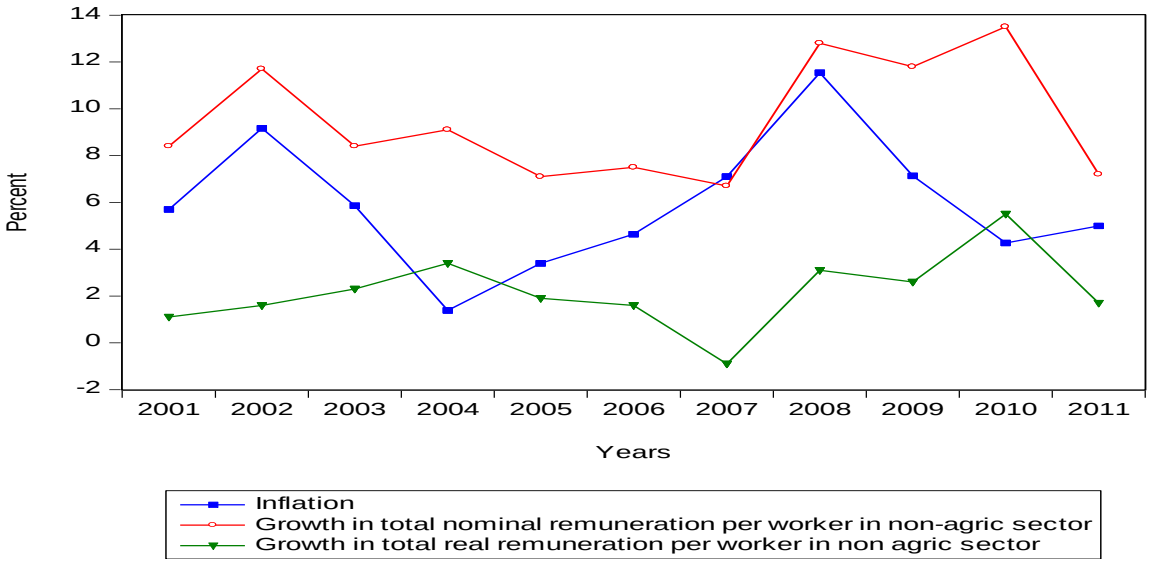

Figure 2.6

Remuneration per Worker and Inflation

Figure 2.7

Labor Productivity and Inflation

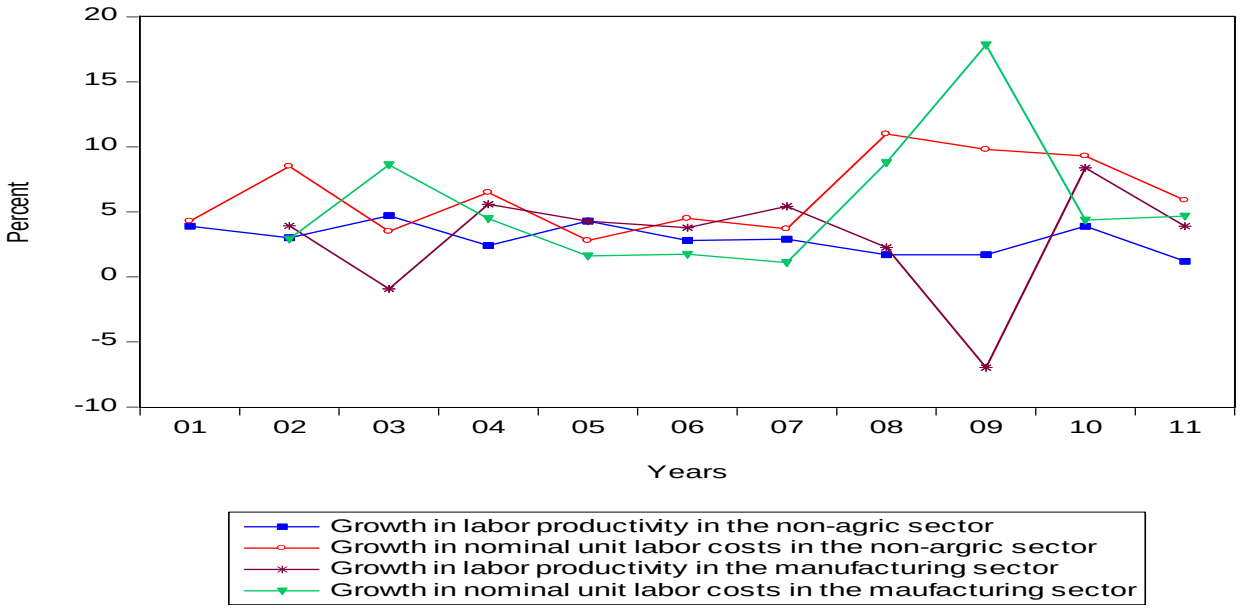

Figure 2.8

Labor Productivity and Unit Labor costs

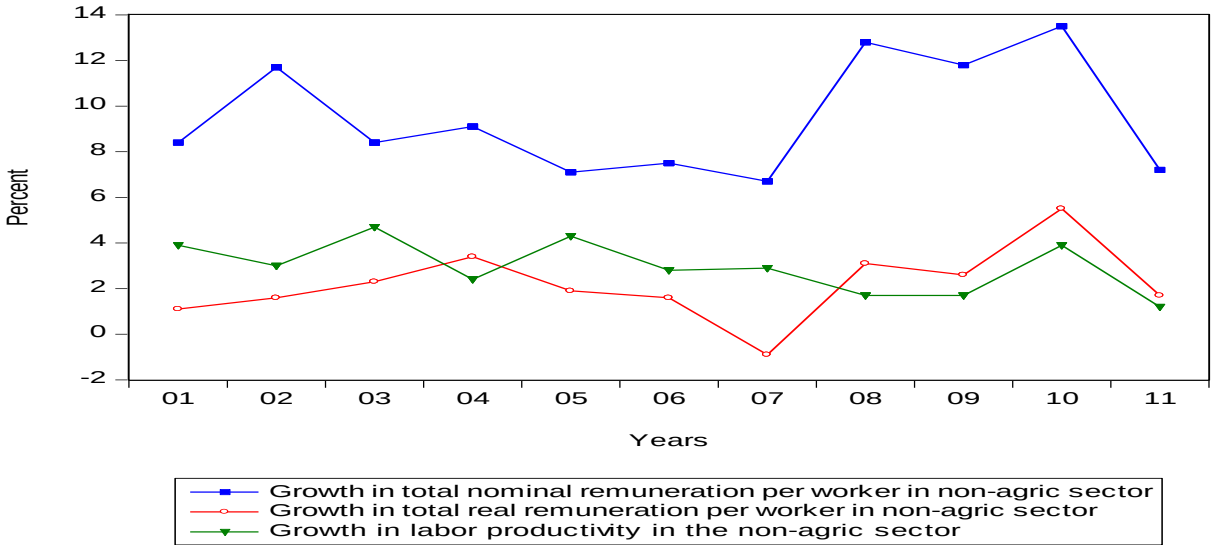

Figure 2.9

Labor Productivity and Remuneration

APPENDIX 2.2

CORRELATION MATRIX

Sample: 1990:1-2010:4

	Infln rate	**Real App**	**Output gap**	**W'k cp/GDP**	**Com pr infln**	**Import price change**	**GDP Deflator**	**wage inflation**	**Y'ld sp'd**
Infln rate	1 -----								
Real App	-0.12 (-1.07)	1 -----							
Output gap	-0.13 (-1.18)	-0.17 (-1.54)	1 -----						
W'k Cp/GDP	0.42 (4.10)	-0.08 (-0.67)	-0.16 (-1.42)	1 -----					
Com pr infln	-0.14 (-1.23)	0.08 (0.67)	0.47 (4.65)	-0.26 (-2.34)	1 -----				
Imp pr ch'ge	0.28 (2.60)	-0.84 (-13.76)	0.36 (3.45)	0.05 (0.45)	0.18 (1.60)	1 -----			
GDP Deflator	0.75 (9.95)	-0.14 (-1.26)	-0.03 (-0.23)	0.51 (5.25)	-0.13 (-1.18)	0.26 (2.38)	1 -----		
wage infln	0.56 (5.99)	-0.05 (-0.43)	-0.22 (-1.95)	0.46 (4.52)	0.00 (0.01)	0.08 (0.68)	0.56 (6.04)	1 -----	
Yield spread	-0.29 (-2.66)	0.03 (0.23)	0.18 (1.65)	0.27 (2.52)	0.01 (0.09)	-0.05 (-0.46)	0.06 (0.57)	0.07 (0.65)	1 -----

Note: t-statistics in parenthesis. Infln rate ≡ Inflation rate, Real App ≡ Real Appreciation, W'k cp/GDP ≡ Worker compensation/GDP, Com pr infln ≡ Commodity price inflation, imp pr ch'ge ≡ Import price change, y'ld sp'd≡ yield spread.

APPENDIX 2.3

GMM ESTIMATES OF THE HYBRID-NKPC FOR SOUTH AFRICA

PANEL A: PRE-TARGETING PERIOD 1990:1-2000:1 (Dep Var: Current Inflation (π_t))

Instruments	Υ_b	Υ_f	η	ϕ	**J-stat**
	(se)	(se)	(se)	(se)	(p)
1. π_{t-1}, s_{t-1},s_{t-2}, s_{t-3}, App_{t-1}, App_{t-2}, App_{t-3}	0.87*	0.18	0.22*	0.085	1.92
	(0.09)	(0.11)	(0.10)	(0.02)	(0.38)
2. π_{t-1},s_{t-1}, s_{t-2}, s_{t-3}, GAP_{t-1}, GAP_{t-2}, App_{t-1}, App_{t-2}, App_{t-3}	0.74*	0.36*	0.30*	0.064*	4.82
	(0.06)	(0.07)	(0.09)	(0.02)	(0.30)
3. π_{t-1},s_{t-1}, s_{t-2}, s_{t-3}, $Spread_{t-1}$, $Spread_{t-2}$, App_{t-1}, App_{t-2}, App_{t-3}	0.84*	0.21*	0.21*	0.08*	2.60
	(0.08)	(0.09)	(0.09)	(0.02)	(0.62)
4. π_{t-1},s_{t-1}, s_{t-2}, s_{t-3}, π^w_{t-1}, π^w_{t-2}, App_{t-1}, App_{t-2}, App_{t-3}	0.71*	0.38*	0.29*	0.07*	4.91
	(0.08)	(0.10)	(0.09)	(0.02)	(0.30)
5. π_{t-1},s_{t-1}, s_{t-2}, s_{t-3}, π^c_{t-1}, π^c_{t-2}, App_{t-1}, App_{t-2}, App_{t-3}	0.76*	0.35*	0.30*	0.07*	4.65
	(0.09)	(0.10)	(0.08)	(0.02)	(0.33)
6. $(\pi, s, GAP, Spd, \pi^w, \pi^c, App)_{t-1}(\pi, s, GAP, Spd, \pi^w, \pi^c, App)_{t-4}$	0.60*	0.47*	0.20*	0.03*	8.19
	(0.02)	(0.02)	(0.04)	(0.005)	(0.99)

PANEL B: POST-TARGETING PERIOD 2000:3-2010:4

Instruments	Υ_b	Υ_f	η	ϕ	**J-stat**
	(se)	(se)	(se)	(se)	(p)
1. π_{t-1}, s_{t-1},s_{t-2}, s_{t-3}, App_{t-1}, App_{t-2}, App_{t-3}	0.52*	0.57*	0.12	0.006	0.62
	(0.05)	(0.08)	(0.07)	(0.01)	(0.73)
2. π_{t-1},s_{t-1}, s_{t-2}, s_{t-3}, GAP_{t-1}, GAP_{t-2}, App_{t-1},..,App_{t-3}	0.47*	0.65*	0.18*	0.01*	5.81
	(0.04)	(0.05)	(0.05)	(0.007)	(0.21)
3. π_{t-1},s_{t-1}, s_{t-2}, s_{t-3}, $Spread_{t-1}$, $Spread_{t-2}$,…,App_{t-3}	0.50*	0.59*	0.12*	0.008	5.00
	(0.039)	(0.07)	(0.07)	(0.008)	(0.29)
4. π_{t-1},s_{t-1}, s_{t-2}, s_{t-3}, π^w_{t-1}, π^w_{t-2}, App_{t-1},……..,App_{t-3}	0.51*	0.56*	0.10*	0.004*	1.68
	(0.05)	(0.07)	(0.06)	(0.01)	(0.79)
5. π_{t-1},s_{t-1}, s_{t-2}, s_{t-3}, π^c_{t-1}, π^c_{t-2}, App_{t-1}, App_{t-2}, App_{t-3}	0.51*	0.57*	0.12*	0.005*	3.67
	(0.04)	(0.07)	(0.07)	(0.01)	(0.45)
6. $(\pi, s, GAP, Spd, \pi^w, \pi^c, App)_{t-1}(\pi, s, GAP, Spd, \pi^w, \pi^c, App)_{t-4}$	0.52*	0.57*	0.14	0.006*	9.80
	(0.01)	(0.01)	(0.01)	(0.002)	(0.98)

Notes: Our instrument list is similar to that of Du Plessis and Burger (2006) for their estimate of the hybrid-NKPC for South Africa. The parameter η refers to inflation response to domestic marginal costs and ϕ refers to inflation response to the relative import price. * denotes significance at 5% confidence level. Spd refers to Spread, J-Stat refers to the J-statistic.

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CHAPTER 3

TARGETING, AGGREGATE SHOCKS AND MACROECONOMIC PERFORMANCE: EMPIRICAL EVIDENCE FROM SOUTH AFRICA

3.1 *Introduction*

This chapter's theme closely complements chapter two. We address the question of whether the change in the inflation environment has altered the propagation of shocks in the South African economy in a way that reinforces price stability. We look at how monetary policy under inflation targeting in South Africa has influenced the dynamic responses of macroeconomic variables to aggregate shocks. This should imply that some types of shocks that previously had a conspicuous influence on inflation should appear to have much less influence with targeting in place. Alternatively, inflation and output should become more resilient in the face of larger aggregate shocks. In particular, we are interested in examining the character of short-run responses of inflation, output and the short-term interest rate to aggregate shocks before and after the adoption of inflation targeting and by implication the long-run variances of these macro variables. We care about understanding dynamic profiles of responses to aggregate shocks because if the objective of the central bank is to stabilize inflation around its target and output around its natural rate, we need to see whether IT delivers comparably more superior macroeconomic outcomes (in terms of increased resilience/reduced volatility) than previous monetary policy strategies by changing the way shocks to inflation and output are propagated.

South Africa presents a particularly interesting case for studying the dynamic impact of aggregate shocks on macroeconomic variables and the response by the central

bank to these shocks. First, being an emerging market country implies prevalence of a different set of economic conditions and policy options relative to those of industrial countries. As a result, macroeconomic effects arising from the impact of aggregate shocks are likely to be more pronounced due to factors such as a shallow foreign exchange market, volatile capital flows, segmented domestic financial markets and macroeconomic policy vacillations. Second, the South African Reserve Bank (SARB) has been implementing inflation targeting for 12 years now, so it would be interesting to examine whether the regime change has brought with it a 'calming effect' on the volatilities of inflation, output and the policy interest rate, reflecting a new equilibrium where the central bank is reacting differently to incoming news about inflation and output and the public has taken recognition of this change in behavior.

The hypotheses that we examine in this chapter address the predictive ability of models based on New Keynesian perspectives in explaining the resilience in the character of short-run macroeconomic responses under inflation targeting observed in the data. If targeting is effective, we expect to see evidence of enhanced resilience of price changes and output volatility with respect to aggregate shocks that should have a bearing on inflation performance. Therefore, we hypothesize that the IT regime should entail quantitative and qualitative differences in the magnitude of short-run responses of inflation, output, and the short-run interest rate between the pre-and post-targeting periods. Due to the special stabilizing role of this monetary policy strategy, macroeconomic variables should become resilient to amplified effects of aggregate shocks and the general variance of these macro variables will be lower relative to the composite shock. We expect the effect of both demand and supply shocks to become

much more transitory so that persistence of inflation shocks will decline as a result. We also hypothesize that targeting should facilitate the conduct of monetary policy relative to a counterfactual case of non-targeting. Intuitively, we expect the level and the volatility of the short-term interest rate in the post-targeting period to be lower relative to the pre-targeting period because of reduced costs of disinflation and the desire to control inflation at longer horizons. That is, inflation expectations should play a heightened role in guidance of policy and in disinflations under the IT regime.

We hypothesize that the adoption of IT should reflect a shift in the degree of relative importance of demand and supply shocks in accounting for variation in inflation, output, and interest rates over the forecasting horizon. The IT strategy implies that the central bank's preferences would be skewed toward limiting inflation volatility relative to output stabilization. So, the central bank will systematically use its policy interest rate to counter inflation shocks and try to maintain inflation within the target range over the long-run. Due to increased policy tenacity to countering inflation shocks, we expect the degree of importance of supply shocks in accounting for variation in inflation over the post-targeting forecasting horizon to diminish relative to the pre-targeting horizon. In this regard, supply shocks should exhibit a larger degree of importance in accounting for interest variation during the post-targeting period relative to the pre-targeting period.[85] However, when agents accept that a targeted low inflation program is credible, their inflation expectations are more likely to rapidly and durably anchor around the target point or band. The agents' conjecture of the inflation model will be consistent with policy

[85] The central bank is assumed to place a larger weight in the Taylor rule on stabilizing inflation relative to output.

making directed toward an inflation target achievable over some given future time horizon in line with inflation forecast targeting. If the shift in the agents' behavior and expectations vs. the shift in policy-making could together more than compensate the effect on interest variation due to the larger weight placed on controlling inflation in the Taylor rule, supply shocks could exhibit a lower degree of importance in accounting for the forecast-error variance of the policy interest rate in the longer term of the post-targeting period. Since IT requires the central bank to tolerate recessionary gaps/booms, which are implied by policy interest rate responses toward controlling inflation, we expect demand shocks to become more prominent in accounting for output variation over the post-targeting forecasting horizon relative to the pre-targeting period.[86]

To examine the preceding hypotheses, this essay estimates a structural Vector Autoregression (SVAR) system for South Africa for two sub-samples (pre- and post-targeting periods) informed by a small New Keynesian-type model of inflation targeting. The key analysis compares impulse response functions (IRFs) and variance decomposition schemes across the samples for consistency with the conceptual framework's predictions. We test whether responses of inflation, output, and the short-term interest rate to shocks are consistent with the stabilizing properties of IT. By examining the dynamic adjustment of these variables in response to supply and demand shocks, we can indirectly address the normative question of whether IT is more beneficial

[86] To the extent that the effect of demand shocks on output can be assumed to be transitory in sticky wage-price models, the central bank will rationally tolerate output gaps/booms implied by demand shocks. We assume that the central bank balances output gaps against the risks of deflation/overheating and as such, when necessary, will use policy to complement real wage (marginal cost) adjustment to offset a limited set of aggregate demand shocks.

than previous monetary policy strategies, namely by seeing whether it accelerates adjustments following shocks and/or tends to dampen their effects. Thus, a dampening of volatility, reduction of inflation bias, and a reduction of the odds of non-transitory negative output gaps in the post-targeting period would be consistent with improvements in social welfare.

The conceptual and empirical approach in this essay attempts to bridge the gap that exists between the standard theoretical framework and the current strand of the empirical literature on IT. The empirical literature, which investigates macroeconomic outcomes under IT, is fairly extensive. Yet it is apparent that various studies in this line of research have relied heavily on estimating reduced-form empirical models, which are not backed by structural foundations.[87] The few studies that have attempted to invoke a structural model of the macroeconomy have also met with criticisms of either conceptual or empirical limitations. Because the key features of the macroeconomic relationships that are estimated tend to be ad hoc, these empirical studies usually eschew the theoretical motivation for the expected behavior of inflation, output and the short-term interest rate under the regime of inflation targeting (the study by Kuttner and Posen (1999) being an exception). This atheoetical approach is unsatisfactory since it fails to isolate the key channels and determinants implied in standard conceptual models, which are relevant for explaining how and why policy may affect macroeconomic variables and vice versa. Among the key contributions in this essay is the attempt to place the

[87] See, for example, Aizenman and Hutchison (2011), Akyurek et al. (2011), Mollick et al. (2011), Goncalves and Salles (2008) Ball and Sheridan (2005), Corbo et al. (2000), Fraga et al. (2003), Kaseeram and Contogiannis (2011), Johnson (2002), Ammer and Freeman (1995)).

discussion of the effects of IT in the context of a structural model and, using only those variables from the model, to assess the empirical efficacy of targeting. We intend to address the positive question of whether IT has impacted macroeconomic responses to aggregate shocks using data on South Africa.

The chapter is organized as follows. Section 3.2 discusses the developments in output, prices and interest rates in South Africa since the 1990s. Section 3.3 highlights the mechanisms through which nominal rigidities and volatilities of inflation, output and the short-term interest rate could be jointly determined. In section 3.4, we describe the primary benefits associated with inflation targeting and review some notable criticisms on the methodological approaches to modelling the effects of IT. In section 3.5, we formalize the aspects of the story from the previous sections through a conceptual model articulated via a small open-economy structural model with New-Keynesian influences and we explain our empirical approach. Section 3.6 discusses the data, selected descriptive statistics and the economic specification of external variables. Section 3.7 reports the results of the estimations. Section 3.8 discusses recent experiences of implementing IT in South Africa and challenges going forward and section 3.9 summarizes and concludes the chapter.

3.2 *Recent Trends in Output, Prices and Interest Rates in South Africa*

Most, if not all, emerging market economies are subject to pronounced commodity price volatilities. This is especially apparent during periods of acute stress on global demand and downturns in production. For example, during the 2008 global financial crisis, the magnitude of commodity price changes and volatility rose to

unprecedented levels for many major commodities (see Table 3.1 below). A comparison of columns 4 and 6 reveals that adverse shocks to the world financial system increased the volatility of commodity prices from the pre-crisis average levels by a factor of two or more for each of the respective commodities itemized. With gold and other base metals as major exports and crude oil as a key import, the South African economy was certainly exposed to the unusual developments in world commodity markets. However, despite the volatilities in the global markets, the country's macroeconomic responses during the period in question appear not to have amplified.[88] The connections between fluctuations in prices of commodity exports, availability of foreign exchange, and the external value of the domestic currency are well established in the context of the domestic macro-economy. However, fluctuations of prices of commodity imports are expected to influence domestic macroeconomic performance via two key channels, direct and indirect through commodity exports. That is, exogenous shocks to prices of imported commodities directly affect the domestic price level; in addition, fluctuations in world prices of commodity exports may cause changes in the availability of foreign exchange and the external value of the currency, which in turn may filter through to fluctuations in import prices.

The developments in output, prices and interest rates in South Africa since the 1990s suggest a combination of the effect of shifts in the policy regime and changes in the nature and character of shocks that have impacted these variables. Since the early 2000s, data suggest that there has been an apparent increase in resilience to foreign and

[88] In 2008, South Africa's imports of mineral fuels, oils and products of their distillation were 22.3 percent of the country's total value of merchandise imports (United Nations Statistics Division Commodity Trade Statistics Database (COMTRADE)).

domestic shocks. In Figure 3.1, we plot the evolution of consumer price inflation and domestic real GDP growth rate for the period 1990:1-2010:4.

TABLE 3.1
MEASURES OF COMMODITY PRICE VOLATILITY

	Six-Month % Changes		Standard Deviations of week-to-week % changes in prices		
COMMODITY	Largest six-month % decline in 2008	Largest six-month decline during 1970-2007	2008	Highest year during 1970-2007	Average year during 1970-2007
Crude oil (WTI)	-76.8	-60.1	18.4	16.1	8.5
Aluminum	-52.9	-33.4	12.1	8.9	5.6
Copper	-54.8	-52.6	12.2	13.0	6.7
Nickel	-68.0	-49.0	23.6	17.7	9.2
Corn	-52.4	-51.8	13.9	13.6	7.6
Wheat	-45.2	-38.0	16.0	12.9	6.4
Soybeans	-44.1	-51.3	12.8	15.5	6.3
Gold	-25.4	-30.1	8.7	13.3	5.1

Source: IMF's World Economic Outlook (2009). WTI = West Texas Intermediate.

The series for inflation does not obviously indicate a marked change in the dynamics of inflation over the observation period. Average inflation in the 1990s appears not to be generally higher than outcomes in the 2000s. The absolute effect of aggregate shocks on inflation variability does not necessarily appear to be smaller in the past decade than during the 1990s; however, the run-ups in domestic inflation in 2002-03 and the longer run-up from 2004 through 2008 in part appear to reflect increases in global commodity prices during these periods, making it difficult to detect whether the shift to IT has reduced the volatility of inflation relative to what it would have been under an alternative policy regime.

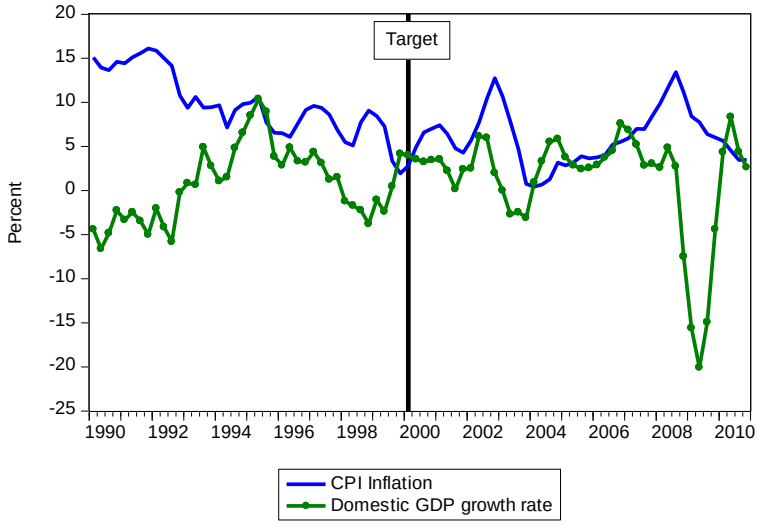

Figure 3.1

Inflation and Real Growth in Gross Domestic Product[89]

In Table 3.2, we present a simple comparison for South Africa of the variability of inflation with the variability of import prices and real growth. The table shows that while the standard deviation of import prices increased by a factor of more than two, the standard deviation of inflation decreased by a factor of less than one after 2000 compared to the value in the 1990s. The table indicates an increase in the ratio of import price volatility to the inflation volatility. The ratio of the output gap volatility to inflation volatility remained unchanged after adoption of the inflation target by South Africa. These indicators suggest a prima facie case for an increase in resilience of the inflation environment to aggregate shocks possibly due to the inflation targeting monetary program. Similarly, output growth appears to be relatively resilient in the period after

[89] CPI is Headline CPI as reported by Statistics South Africa.

adoption of IT, save for the effect of the 2001 sharp depreciation of the rand and the effect of the 2008 global financial crisis.

TABLE 3.2
VARIABILITY OF INFLATION, IMPORT PRICES AND REAL GROWTH
Sample: 1990:1-2010:4

	Pre-2000	2000s
Standard deviation of quarterly changes (in percent)		
CPI inflation	3.7	3.2
Import price index	10.4	24.1
Output gap	2.3	2.0
Standard deviation relative to standard deviation of inflation		
Import price index	2.8	7.5
Output gap	0.6	0.6

Author's calculations; Data source: South African Reserve Bank's interactive data base (SARB), IMF's International Financial Statistics (IFS), and Statistics South Africa (SSA). All data is measured at a quarterly frequency. "Output gap" is the cyclical component of real GDP growth obtained using the Hodrick-Prescott Filter.

In Figure 3.2, we report the movement of the SARB discount rate (repo), which is the key monetary policy variable for the central bank. Before 2000 and, in particular, between the periods 1994-1998, the repo appears to exhibit considerable volatility. Prior to the adoption of inflation targeting, monetary policy responses appear to be characterized by aggressive and frequent adjustment of the discount rate so as to attack inflation inertia and address inflation concerns at the shortest possible horizon. After adoption of IT, the dynamics of the discount rate appear to have changed noticeably, tending toward a lower stable equilibrium, save for the responses to the 2001 sharp depreciation of the rand and the 2008 global financial crisis.

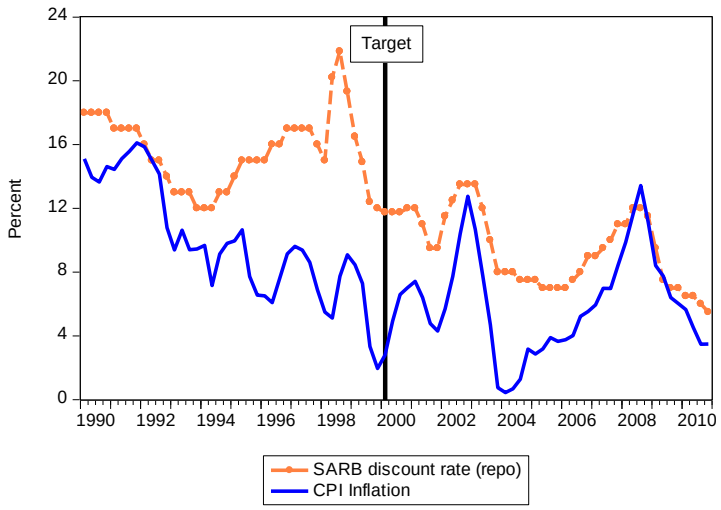

Figure 3.2

Inflation and the SARB Discount Rate

The post-targeting behavior of the discount rate reflects a monetary policy stance geared toward controlling inflation at a longer horizon as required under an IT regime when the inflation forecast over some horizon is the intermediate target of policy. Finally, Figure 3.3 below shows that the movements of the SARB discount rate is reasonably in tandem with other key rates on the short, medium and long ends of the yield curve reflecting a judicious monetary transmission mechanism through the interest, money and credit, and asset price channels, respectively.

The preceding discussions convey a picture where the inflation rate and output gap look approximately as variable in the second period as in the first. Since import prices seem to be more volatile during the post-targeting period, IT may have been offsetting the effects of swings in import prices to ensure volatility in inflation and output remained relatively unchanged.

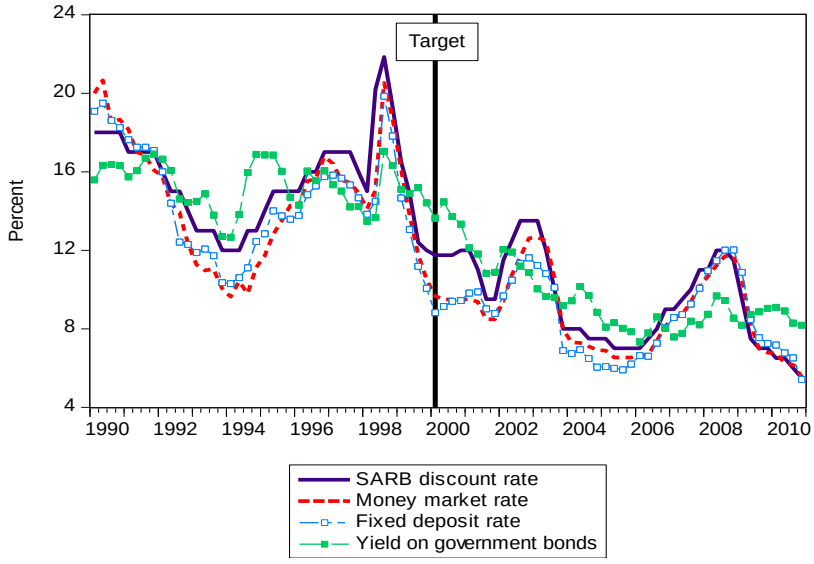

Figure 3.3

SARB Discount, Money Market, Fixed Deposit, and Bond Rates

In the next section, we discuss the mechanism through which inflation targeting could result in the macroeconomic stability and/or resilience that is suggested by the behavior of inflation, real GDP growth, and the short-term interest rate.

3.3 *Price Stability and the Volatility of Inflation, Output and the Short-Term Interest Rate*

In chapter two, we discussed the mechanism through which reduced volatility in prices, which arise due to durably anchored inflation expectations under IT, could lead to lower inflation. In this chapter, we extend the argument that the same propagation mechanism is expected to lead to a reduction in volatility of inflation. First, we assume that a central bank pursuing IT will place a relatively larger weight on controlling

inflation around its target in its objective function. Thus, wage-price setters will discern this change in the central bank's response toward aggregate shocks and at the same time will take account of the forward-looking character of monetary policy under IT. Second, with sufficient credibility, agents' inflation expectations will be anchored around the target, putting a damper on persistence and volatility of inflation.

Despite the central bank placing a smaller weight on the output gap relative to inflation stabilization in the loss function, output volatility is still expected to fall under IT.[90] Under the New-Keynesian framework, when agents settle their goods and wage contracts in advance, wages and prices may not be fully flexible in the short-run. With the reduction in the responsiveness of wages and prices, IT could induce demand and supply side effects that could diminish the volatility of output via improving the Phillips curve's output-inflation trade-off. The higher the extent and the larger the fraction of sticky wage-price-setting behavior, the less inflation will move about and the less need for demand contraction to control inflation.[91] So the slope of the Phillips curve is a positive function of the degree of sticky wage-price setting behavior. A steeper slope leads to an improvement in the output-inflation trade-off and therefore a reduction in both output volatility induced from supply side shocks and disinflation costs and vice versa for a flatter slope. If the reduction in output volatility could more than compensate for the increased volatility arising from the lower relative importance attached to stabilizing the

[90] For a standard presentation of the positive link between IT and inflation volatility, see Walsh (2002) and Bofinger, et al (2006).

[91] If a large proportion of agents have expectations locked in with the inflation target and hence settled into long-term goods and wage contracts, then actual inflation will not fluctuate as much in response to aggregate shocks because only a minority of agents can adjust their prices.

output gap in the central bank's loss function and interest rate rule, then a long-run reduction in output volatility is possible.[92]

Following Bofinger et al. (2006), we assume that in the post-targeting period the central bank seeks to satisfy a systematic monetary policy rule in the form of an optimal IT rule derived from a model with nominal rigidities. The central bank systematically adjusts its policy instrument to movements in inflation and output to restore inflation stability in line with the IT rule and the inflation target. Intuitively, we expect the volatility of the short-term interest rate in the post-targeting period to be lower because of the reduced costs of disinflation (improved trade-off) and the heightened role played by expectations in disinflations under the IT regime. Since monetary policy under IT is forward-looking, to achieve the inflation objective following a shock, policy needs to adjust just enough to a level that allows the prospect of a slack or boom in output to marshal inflation expectations around the target and drive dynamic adjustment of inflation toward long-run equilibrium. Based on the implications suggested in the above discussion, the relationship between movements in the inflation rate, output and the short-term interest rate and aggregate shocks in South Africa under IT is investigated in the following sections. We begin, in the next section, by describing the primary benefits associated with inflation targeting and reviewing some notable criticisms on the methodological approaches to modeling the effects of IT.

[92] See Posen (1998), Baltensperger and Jordan (1998) and Clifton (2001) for evidence on the effect of IT on the Phillips curve trade-off.

3.4 *Evaluating the Benefits of Inflation Targeting: Some Criticisms on Conceptual and Empirical Approaches*

Proponents of IT have put across several arguments regarding benefits of targeting. Svensson (1997) argues that IT reduces inflation variability and if "flexible" can stabilize output as well. Bernanke et al. (1999) argue that targeting locks in expectations of low inflation, which reduces the inflationary impact of macroeconomic shocks, i.e. shocks to inflation die away more quickly and inflation is less persistent.[93] Siklos (1999) argues that introduction of IT should change the persistence of inflation rates, as central banks no longer tolerate lasting movements of actual inflation rate outside the target range. These observations are consistent with theoretical predictions in models with IT as the monetary strategy, particularly those in the New-Keynesian tradition.[94] The key distinguishing feature in these models is that IT changes how the central bank reacts to incoming information and how, in turn, this affects the behavior of macroeconomic variables, the central bank's own behavior and the behavior of the public. Thus, IT influences both the behavioral relationships between policy and macroeconomic variables and the expectant conjectures of agents.

Since IT is simply an alternative monetary policy strategy, it should be convenient to characterize its macroeconomic effects and empirical regularities in the context of established theoretical macroeconomic models. Yet it is not uncommon for the current

[93] This observation is consistent with the finding we reported in chapter two that inflation persistence is decreasing in the ratio and extent of forward-looking wage-price setting influences.

[94] The modeling approach by Benigno (2009) is one such example.

strand of the empirical literature to examine the effects of IT outside the context of established theoretical macroeconomic models.[95] For example, a number of important studies analyze the effects of IT using statistical and Box-Jenkins/time-series estimation methods (see, for example, Goncalves and Salles (2008), Johnson (2002), Kaseeram and Contogiannis (2011) and Mollick et al. (2001)).

Recently, the trend has been toward enriching earlier statistical models with an additional menu of predictor variables for various heterogeneous economic characteristics, so as to get estimates of the impact of targeting on inflation and output that are more efficient (see Mollick, et al. (2011)). The empirical methods are usually employed without giving ample focus to the underlying structural model of the macroeconomy, which should imply a set of results for comparison with those observed from the data. An exception is Kuttner and Posen (1999) who employ a standard theoretical model (based on King (1997) and Svensson (1997)) to assess the response of three central banks to movements in inflation and Enders and Hurn (2007), who evaluate the variability of inflation and output under IT in response to aggregate shocks using a small AS-AD framework. While the results of previous studies have been insightful, they do not usually explain the causal effects of IT, as they hardly address the aspect of how changes in the ways in which the central bank reacts to incoming information on prices, output, exchange rates, business and consumer sentiments and other variables in turn affect the behavior of these variables and the central bank's own behavior with regard to

[95] The literature on effects of inflation targeting on macroeconomic outcomes is extensive and still very active. Most of the previous debate primarily centers on comparing average inflation, average growth and their respective degrees of variability before and after the adoption of inflation targeting and between countries that had and had not adopted IT (see, for example, Ammer and Freeman (1995) and Ball and Sheridan (2005)).

the settings of its key policy variable. In this regard, we argue that the current filament of empirical results, mainly in favor of IT having significant favorable macroeconomic influences, particularly on inflation and its volatility, is lacking in motivation on the aspect of how and why IT might lead to desirable causal effects alluded to at the beginning of this section.

The recent study by Enders and Hurn (2007) is particularly interesting because it makes a key step toward entrenching the empirical discussion of IT effects in the context of a theoretical model, the AS-AD model.[96] However, following notable criticisms of the standard IS-LM-AS/AD framework by, among others, Romer (2000), Walsh (2002) and Benigno (2009), the Enders-Hurn approach appears to be inherently inappropriate for analyzing IT as a strategy for monetary policy. Romer shows that the AS-AD model is unable to deal with a monetary policy that uses the interest rate as its operating target. He argues that the traditional model is weak in this respect, as its monetary policy is based on adjustments in money supply and demand (real money balances). Walsh observes that the key limitation of the standard AS-AD framework is that it fails to make explicit the policy objectives of the central bank and the role of monetary policy and hence is not well suited for an analysis of inflation targeting. Benigno observes that using a model with an AS curve has a weakness since it does not explicitly provide for forward-looking behavior such as in the New-Keynesian approach. Thus, the standard AS-AD model cannot properly analyze inflation dynamics and disinflation. The AS-AD framework also misses the dynamic aspect of the stabilizing role of monetary policy.

[96] In the same paper, the authors introduce an alternative method to the Blanchard and Quah (1989) procedure for orthogonalizing structural disturbances in identifying SVAR systems.

Conversely, conventional conceptual models of IT set in the New-Keynesian tradition do attempt to explicitly invoke policy objectives and preferences of the central bank in order to determine the dynamics of aggregate demand in the output-inflation space. In addition, they bring to the literature two attractive features: the use of the short-term interest rate as the instrument of monetary policy and the explicit role given to forward-looking wage-price setting behavior. These characteristics allow for a tractable analysis of the effects of concepts such as inflation targeting on macroeconomic performance, more so that modern central banking targets short-term nominal interest rates instead of money supply aggregates.

In this chapter, we set out a theoretical framework in the context of a small model of the open economy with New-Keynesian features on the basis of which we estimate a structural vector autoregressive (SVAR) model. The SVAR requires that identifying restrictions from theory are imposed on reduced-form estimates of parameters in order to recover structural estimates of a relevant stylized model that can be tested for theoretical consistency. Hence the SVAR framework provides helpful insights in gaining a sense of the range of dynamics of variables given a set of data. With regard to testing the macroeconomic effects of IT implied in a New-Keynesian type model, the SVAR framework provides a natural empirical template for characterizing the causal relationships among the set of endogenous and exogenous variables.

Since the seminal contribution by Sims (1980), analyses of the effects of monetary policy have to a large extent been addressed in terms of vector autoregressive models. For example, Ammer and Freeman (1995) compare counterfactual inflation forecasts implied by VARs without an IT program with actual inflation outcomes under

IT. Kuttner and Posen (1999) report impulse responses of interest rates to inflation shocks for subsamples of pre-targeting and post-targeting periods and Mishkin and Posen (1997) estimate VARs for counterfactual levels of inflation and interest rates for four countries after the introduction of IT. We estimate an SVAR system, as opposed to an unrestricted VAR used in previous studies, because the approach will allow for structural interpretation of responses of variables to aggregate shocks. The response of inflation, output, and the short-term interest rate, under two different monetary policy strategy episodes, will be evaluated in the context of their response to identified structural shocks. In the next section, we present the conceptual and empirical framework, which formalizes the investigation of the causal relationships and hypotheses discussed in the preceding sections.

3.5 *Conceptual and Empirical Framework*

In this section, we describe an equilibrium model of inflation targeting and analyze the dynamic adjustment of inflation and output toward equilibrium and how monetary policy reacts to restore stability in prices and the output gap in response to different shocks. We also describe the SVAR approach and the identification procedure.

3.5.1 The Conceptual Framework

Our conceptual framework of the monetary transmission under IT addresses the aspect of how and why IT might lead to the desirable causal effects of lower volatility of inflation, output, and the short-term interest rate. The model mainly draws on Walsh (2002) and Bofinger et al. (2006) and so follows New Keynesian influences. We envisage

a model of a small open economy, described through long-run equilibrium relationships: (i) an IS curve, (ii) an expectations-augmented Phillips curve, and (iii) a quadratic loss function for the central bank.[97] The following is a detailed exposition of the model and its dynamic adjustment process.

3.5.1.1 The Model

The IS curve is of the form

$$y = y_0 - a_1 r + u_1 \qquad [1]$$

where y is the output gap measured as the deviation of the log of aggregate output from its potential level, y_0 captures autonomous demand components associated with the external sector such as effects of real exchange rate variation on aggregate demand, $r = [i - \pi^e]$ is the real interest rate, i is the nominal interest rate, π^e is expected inflation, and u_1 is a demand shock. The parameter a_1 is non-zero with $a_1 > 0$. The aggregate supply side is represented by an expectations-augmented Phillips curve of the form

$$\pi = \pi^e + b_1 y + u_2 \qquad [2]$$

where π is the inflation rate, π^e is expected inflation, y is the output gap, u_2 is an inflation shock that captures any other factors affecting inflation and $b_1 > 0$. To reflect the potential structural heterogeneity that South Africa may have in its dynamic macroeconomic responses to aggregate external shocks, which are likely to be more

[97] Since the instrument of monetary policy is the nominal interest rate and not money supply, this framework dispenses with the requirement for an LM equation.

pronounced than they are for advanced industrial countries, we specify the inflation shock u_2 as a composite of two supply-side shocks, domestic and foreign,

$$u_2 = \delta_1 + \delta_2 \qquad [3]$$

where δ_1 and δ_2 are the domestic and foreign supply shocks, respectively.[98] The ratio of the variances of the shocks is given by the constant, *rho* = $\sigma^2(\delta_2)/\sigma^2(\delta_1)$. As is customary in models with New-Keynesian persuasions, we assume that the supply-side shocks are invariably markup costs, hence they may affect inflation variability. Following Benigno, we interpret the foreign markup shock as coming from variation in the prices of imported commodities that are inelastically demanded as factors of production. Such commodities usually exhibit excessive price volatility in response to shifts in monopoly power. Under an IT regime with high credibility, equation [2] implies that π^e tends toward the inflation target, π^T such that $\pi^e \approx \pi^T$ so that the Phillips curve can be written as

$$\pi = \pi^T + b_1 y + u_2 \qquad [4]$$

Intuitively, a steeper Phillips curve implies that the output loss from a permanent inflation shock is smaller under IT because there is less need for demand contraction to control inflation. This is consistent with Wells (2010), who observes that for a steeper Philips

[98] This additional insight is a slight departure from the specifications by Walsh (2002) and Bofinger, et al. (2006).

curve, long-run changes in output, interest rate and inflation should be smaller than the flatter case.

Following Svensson (2007), we assume that the central bank determines the optimal policy on the basis of a quadratic loss function that constitutes preferences toward inflation and output objectives, i.e.,

$$L = k(\pi - \pi^T)^2 + \lambda y^2 \quad \text{where } k, \lambda \geq 0 \qquad [5]^{99}$$

Equation [5] says the objective of the central bank is to stabilize the deviation of inflation from its target rate, π^T, and also to minimize the output gap. Monetary policy adjusts systematically to movements in inflation and output (shifts in the IS curve and the Phillips curve due to demand and supply shocks, respectively) to achieve this objective. Optimal policy implies minimization of the loss function and simplifies to a curve (optimal targeting rule or IT curve) along which the trade-off between the two objectives can be optimally exploited. From equations [4] and [5], we derive an optimal targeting rule (IT rule) of the form

$$\pi = \pi^T - (\lambda / kb_1)\, y \qquad [6]$$

[99] Svensson (1999) observes that if $\lambda > 0$, then a central bank prefers a policy of flexible inflation targeting. However, if $\lambda = 0$, the bank can be defined as a strict inflation targeter.

The IT rule describes the optimal choice of inflation and output that minimizes the central bank's loss function and provides a guideline of how to set the interest rate instrument.[100] The slope of the targeting rule (MPR) in [6] depends on the relative importance to the monetary authority of output and inflation objectives, λ/k in its loss function. The slope of the rule affects the relative volatility of the economy as it experiences inflation shocks. A central bank that is mainly worried about output stability (large λ/k) would have a steeper curve in output-inflation space. In the face of an inflation shock, such a central bank acts to limit fluctuations in output, allowing the shock to affect inflation more, instead (Walsh, 2002). Conversely, a central bank with great concern for price stability (small λ/k) would have a flatter IT curve. Under a flatter curve, reminiscent of IT, in the face of the same positive shock, the central bank will try to limit the rise in inflation. It will contract output to offset most of the impact of the shock on inflation. This result implies that attempting to achieve greater inflation stability may come at the cost of increased variability in real economic activity around the natural rate. John Taylor (1993) called this role played by the slope of the monetary policy rule in determining the volatility of inflation and the output gap as reflecting "the new policy trade-off". In this paper, we argue that since there is empirical evidence that IT could improve the output-inflation trade-off in the Phillips curve (see, for example, Siklos, 1999), then under a credible IT program, the new trade-off between inflation and output volatility could disappear. The steeper Phillips curve could more than compensate the increased output

[100] Bofinger, et al. (2006) observes that targeting rules are an important device to describe actual central banks in terms of the institutional changes that commit central banks to specifying a concrete inflation target.

volatility from the flatter IT line with long-run volatility of inflation and output declining during the post-targeting period.

In line with the standard New-Keynesian approach, we assume that monetary policy is conducted via optimal control of the output gap. The central bank uses its nominal interest rate policy to indirectly control forecasted inflation via aggregate demand management.[101] Adjustments in the nominal interest rate are aimed at achieving optimal short-run and long-run equilibria of inflation-output combinations. The central bank reaches the optimal locus for inflation and output combinations at the point where the IT curve is consistent with the Phillips curve. However, it would be fortuitous to manipulate the interest rate to achieve the optimal solution for all circumstances because the central bank does not control perfectly the output gap.[102]As the central bank adjusts the policy rate to stabilize inflation toward the target, the output gap adjusts along with it and variation in the rate and the gap depends on whether the shock is demand-side or supply-side. Following Benigno (2009), we assume that an inflation targeting central bank achieves a minimum target for its loss function by specifying a rule for its interest rate instrument in the form of a simple Taylor-type rule

$$i = i_0 + g_1(\pi - \pi^T) + g_2 y + \xi \qquad [7]$$

[101] The instrument of monetary policy is the real interest rate and the central bank controls this rate indirectly through its direct control of the nominal interest rate on the money market.

[102] Walsh (2002) observes that the central bank cannot control the output gap perfectly because of factors such as instability in the MPR or Phillips curves, the central bank's uncertainty about the position of the Phillips curve, uncertainty about the linkages between its policy instrument and aggregate demand, or uncertainties over the appropriate objectives of monetary policy.

where i_0 is the equilibrium nominal interest rate and g_1 and g_2 are non-negative parameters while ξ is an idiosyncratic shock to the monetary policy instrument. The central bank chooses the parameters g_1 and g_2 so that the equilibrium outcomes of its policy actions should aim to minimize the loss function and ensure that inflation is kept on or around its target value. In line with equation 3, the central bank's response to a cost shock emanating from the foreign sector should give rise to a value of g_1 higher/lower by a factor of *rho* over the value required to manage cost shocks from the domestic sector, all the while taking into account the Taylor principle.[103]

The way the central bank manipulates its policy instrument and in effect the behavior of the economy depends on its policy objectives. So this means a shift from one regime to another should have implications for the structure of the policy instrument and for macroeconomic behavior. The long-run volatility of short-term interest responses to demand and supply shocks is expected to be lower with IT because of the expected reduction in inflation persistence due to the anchoring effects of the target and the lesser need for demand contraction to control inflation due to the improved trade-off. The impact of supply shocks should become more important for interest rate variation during the post-targeting period.

By inserting the Taylor rule (equations [7]) into the IS curve (equation [1]), we can derive an aggregate demand-inflation curve (the AD curve) of the form

[103] The Taylor principle requires that in order to achieve a determinate price level the central bank should adjust nominal interest rates more than one for one in response to any change in inflation (see for example Gali, 2008).

$$\pi = \pi^T + u_1/a_1g_1 - (1 + a_1g_2)y/a_1g_2 \qquad [8]$$

Monetary policy works through influencing movements in the AD curve since inflation can only be indirectly controlled by the central bank via aggregate demand management.

3.5.1.2 Equilibrium and Dynamic Adjustment

In this model, long-run equilibrium is reached when both expected and actual inflation are equal to the central bank's inflation target rate and the output gap is zero. Perturbation from this equilibrium is caused by shifts in the aggregate demand curve, the Phillips curve and the IT rule itself, which arise due to short-run realizations of fiscal policy shocks, trade shocks and shocks to the real exchange rate. When there is a perturbation from long-run equilibrium, monetary policy has to restore inflation stability in line with the inflation target and to close the output gap. The adjustment of inflation expectations plays a critical role in moving the economy from a point of disequilibrium to a long-run equilibrium. For example, a negative supply shock increases the inflation rate for any given output gap. In response to an increase in inflation, the Taylor rule requires a higher interest rate that leads to a short-run equilibrium with a negative output gap and inflation higher than the target. The reduced economic activity then counteracts the increase in the inflation rate. With actual inflation above target but below the level expected by households and firms, and the economy in recession, overtime, agents revise their inflation expectations downwards. The reduction in expected inflation pulls the Phillips curve downwards, so actual inflation declines for each value of the output gap until long-run equilibrium with inflation equal to its target and the output gap equal to

zero is attained. A flatter Phillips curve implies more rapid convergence to equilibrium (Wells, 2010).

Conversely, a negative demand shock results in a negative output gap. The negative output gap puts a damper on aggregate demand, thus also restricting wages and marginal costs. The proportion of firms that can adjust prices downwards do so and inflation declines. In response, the Taylor rule requires that the central bank lowers the interest rate. This action results in a short-run equilibrium of inflation below the target rate and a negative but smaller output gap than would have been the case if policy had not responded according to the Taylor rule.

The magnitude of the coefficients that guide the response of the interest rate to inflation and output in the Taylor rule has important implications for the slope of the aggregate demand curve, the conduit for monetary policy on and off the IT locus. The slope of the AD curve determines the variability of inflation and output occasioning from aggregate shocks and policy responses when policy is off the optimal IT locus. For example, an increasing weight (g_1) on inflation in the Taylor rule relative to the output gap requires a flatter AD curve and results in smaller inflation gaps ($\pi - \pi^T$) and therefore lesser inflation variability but higher output variability. However, in this essay, we argue instead that with adequate amounts of credibility, the volatility of output under the IT regime could decline because of potential improvement in the output-inflation trade-off (steeper Phillips curve). So if the improvement in the PC trade-off more than compensates the flatter AD curve, the variability of output could go down under targeting. Conversely, a relatively larger weight on the output gap steepens the AD curve

and leads to smaller output gaps and smaller output variability and higher inflation gaps and variability.

3.5.1.3 Assumptions on Central Bank Behavior Before and After Adoption of IT

As a base case for our conceptual framework, we assume that in the pre-targeting period the central bank could either follow a discretionary policy or a systematic monetary policy rule (MPR) directly derived from its monetary policy strategy. Under the discretionary policy, the central bank may elect to respond to inflation shocks discriminately. They may allow shocks to inflation and could also choose expansionary policy. For a central bank with a systematic rule, but not yet a targeter, we assume this simply means that they do not place a large weight on stabilizing inflation compared to that on output in their loss function, i.e., the loss function does not reflect price stability as the primary goal of monetary policy. Adoption of IT for such a bank implies revising the weights in the loss function to reflect inflation as the overriding goal of monetary policy. For the discretionary bank, adopting IT implies adopting a systematic monetary policy rule with inflation and output combinations reflecting the primacy of the goal of price stability.

We assume that in the post-targeting period the central bank systematically adjusts its policy instrument to movements in inflation and output to restore inflation stability in line with the IT rule and the inflation target. For example, initially, a positive inflation shock would create a positive output gap, but the central bank's policy move to offset this shock would intend to bring output down below the natural level. Thus, a positive inflation shock leads to a negative output gap as the higher interest rate response contracts demand. The central bank adjusts its interest rate instrument to achieve a short-

run equilibrium in which a recessionary output gap is just sufficient to offset the ongoing effect of the inflation shock.[104] The adjustment of inflation expectations plays a critical role in moving the economy toward long-run equilibrium. We assume that the IT rule for the post-targeting period is structurally different in terms of position and slope with respect to inflation and output objectives from the MPR for the pre-targeting period, but is consistent with the MPR for the post-targeting period. We assume that the position and slope of the MPR is distinguishable under different monetary policy regimes with respect to inflation and output objectives.

3.5.2 The Empirical Approach

Our empirical methodology involves decomposing inflation and output fluctuations into dynamic effects of aggregate demand and aggregate supply shocks. We estimate an SVAR system for the period before and after the adoption of inflation targeting in South Africa and analyze impulse responses and variance decomposition schemes.[105] We use the SVAR estimation to assess the pass-through effects associated with external shocks to aggregate demand and supply (y_o and δ_2 in equations 1 and 2 respectively) and the importance of aggregate shocks to inflation rate and output variability. The SVAR's four variables are the price of imports of commodities (assumed to be the source of exogenous markup shocks to producers), the real domestic output, the

[104] The monetary policy-maker is willing to tolerate short-run price inflation insofar as it coincides with a contraction in output, and vice versa.

[105] The two regimes are treated separately pursuant to an F-test for variance equality test (Conover, *et al.* (1981)).

domestic inflation rate and the discount rate (policy variable for the central bank).[106] The structural foundation of our SVAR is the simple New-Keynesian model for a small open economy as presented in the last section. The SVAR empirical counterpart for the conceptual model is:

$$cp^*_t = \sum_{i=1,k} a_{11i}\, cp^*_{t-i} + \sum_{i=1,k} a_{12i}\, y_{t-i} + \sum_{i=1,k} a_{13i}\, \pi_{t-i} + \sum_{i=1,k} a_{14i}\, i_{t-i} + e_{1t}$$

$$y_t = \sum_{i=1,k} a_{21i}\, cp^*_{t-i} + \sum_{i=1,k} a_{22i}\, y_{t-i} + \sum_{i=1,k} a_{23i}\, \pi_{t-i} + \sum_{i=1,k} a_{24i}\, i_{t-i} + e_{2t}$$

$$\pi_t = \sum_{i=1,k} a_{31i}\, cp^*_{t-i} + \sum_{i=1,k} a_{32i}\, y_{t-i} + \sum_{i=1,k} a_{33i}\, \pi_{t-i} + \sum_{i=1,k} a_{34i}\, i_{t-i} + e_{3t}$$

$$i_t = \sum_{i=1,k} a_{41i}\, cp^*_{t-i} + \sum_{i=1,k} a_{42i}\, y_{t-i} + \sum_{i=1,k} a_{43i}\, \pi_{t-i} + \sum_{i=1,k} a_{44i}\, i_{t-i} + e_{4t}$$

where cp^*_t, y_t, π_t, and i_t denote the price of imported commodities, the real domestic output, the domestic inflation rate and the policy interest rate, respectively. We assume that perturbations to cp* are propagated through exogenous external shocks only. In line with the conventional invertibility assumption of the unrestricted VAR, the regression residuals e_{1t}, e_{2t}, e_{3t}, and e_{4t} from the unrestricted VAR are assumed to be related to the unobserved realizations of structural innovations u_1, δ_1, δ_2 and ξ from the conceptual model by the relation:

$$\begin{bmatrix} e_{1t} \\ e_{2t} \\ e_{3t} \\ e_{4t} \end{bmatrix} = \begin{bmatrix} D_{11} & D_{12} & D_{13} & D_{14} \\ D_{21} & D_{22} & D_{23} & D_{24} \\ D_{31} & D_{32} & D_{33} & D_{34} \\ D_{41} & D_{42} & D_{43} & D_{44} \end{bmatrix} \begin{bmatrix} \delta_2 \\ u_1 \\ \delta_1 \\ \xi \end{bmatrix} \qquad [9]$$

[106] Detailed description of the measurement criteria of the variables is given in the next section.

where δ_2 is the current shock to foreign supply (i.e. via shocks to global commodity markets), δ_1, is a domestic supply shock and u_1 is a domestic demand shock, while ξ is an idiosyncratic shock to the monetary policy instrument. Equation [9] is represented in compact form by equation [3] in Annex I, where we present a complete derivation of our identification procedure of unobserved structural innovations from observable reduced form residuals obtained from estimates of an unrestricted VAR.

To identify aggregate demand and aggregate supply shocks in the system above, we follow established standard open-economy literature (e.g., Christiano, et al. (2005)) in setting the SVAR system's decomposition in a manner that reflects the qualitative properties of a monetary policy shock in a model with nominal rigidities or staggered nominal wage-price contracts. This implies using a combination of sign, recursive, short-run and long-run restrictions on the variables in the system and on impulse response multipliers. First, we assume that while there is a contemporaneous response of the policy rate to movements in macroeconomic variables, there is no contemporaneous response of macroeconomic variables to policy variation ($D_{24} = D_{34} = 0$). Second, we impose three short-run restrictions motivated by the small country open economy assumption. In order for the SVAR system to reflect the structure of a small open economy, the external variable ought to evolve independently of domestic variables. Hence, we assume that domestic shocks (u_1, δ_1 and ξ) have no effect on the rest of the world ($D_{12} = D_{13} = D_{14} = 0$). The block exogeneity Wald test did not reject the hypothesis that the measure of the external variable we use in the estimation is independent of real domestic output, inflation and the short-term interest rate variables (details of the measurement of

variables are in the next section). Finally, we impose one long-run restriction using the standard assumption that aggregate demand shocks have no long-run effects on output.[107] This assumption distinguishes the effect of supply and demand shocks on aggregate output as permanent and cyclical, respectively. Despite the appeal and tractability of the "long-run neutrality restriction" assumption in the identification of SVARS, the approach appears not to be without challenges of reliability. At the forefront may be problems with structural inference of the estimated parameters.[108] Notwithstanding the challenges, structural inference under the long-run scheme will be reliable if the underlying structure being approximated by the VAR satisfies strong dynamic restrictions.[109]

With these six restrictions, orthogonalization of the structural disturbances is complete and the SVAR system is exactly identified (see Annex I). Depending on the global business cycle, the D_{ij} coefficients are allowed to be different for the pre-and post-sub-sample. This comes about because while the typical foreign innovation in each sub-period may be similar in size in terms of variance, the innovation may have an amplified

[107] Studies that impose the long-run neutrality restriction of aggregate demand shocks include Enders and Hurn (2006), Cover et al. (2006), Jacobson et al. (2001), Kim (2000), Lastrapes and Selgin (1995), Bayoumi and Eichengreen (1994). Others are Rogers and Wang (1993), Hutchison and Walsh (1992), Blanchard and Quah (1989), Shapiro and Watson (1988).

[108] Faust and Leeper (1997) report that the long-run effect of shocks is imprecisely estimated in finite samples leading to uncertainty in the estimates of other parameters of the model. Ramayandi (2006) provides empirical evidence of the problem of commingling of the underlying demand and supply shocks in both of the estimated innovations for the case of five countries in the Southeast Asian bloc.

[109] Suggestions to improve estimate reliability by using valid shock aggregation strategies, higher dimension models and higher frequency data in estimating structural shocks have been made by among others Faust and Leeper (1997), Blanchard and Quah (1989), and Ramayandi (2006)).

impact multiplier attributable to a special economic event or episode. A rejection of the null hypothesis that the variances in both subgroups are equal at the standard 0.05 percent level of significance is the basis for estimating and treating D_{ij} as different for each sub-sample (see for example, Conover, *et al.* (1981)). The impact multipliers to structural innovations to inflation and output, D_{ij} are expected to be larger in the post-period due to the global financial crisis and huge run-up in commodity prices that preceded it.

As mentioned earlier, exogenous shocks to prices of imported commodities have a direct influence on the domestic price level. Additionally, fluctuations in world prices of South Africa's commodity exports may cause changes in the availability of foreign exchange and the external value of the rand, which in turn may filter through to fluctuations in import prices. Therefore, foreign cost shocks enter into the policy function via the shocks to inflation emanating from import-price volatility. The exchange rate is assumed not to have foreign cost influences by itself, but rather via import prices. As established in Chapter 1, South Africa does not exhibit statistically significant pass-through from the exchange rate to inflation. However, as a mixed strategy targeter, South Africa was typically using the exchange rate in its policy function as a second companion policy target to optimally react to deviations in output caused by the exchange stimulus. This assumption is consistent with the formulation of equation 1, the IS curve, in the previous section, which include effects of real exchange rate variation on aggregate demand, and the absence of an independent real exchange rate effect in equation 2, respectively.

As hypothesized above, we expect the influence of inflation targeting as a monetary policy strategy to be quantitatively important. We expect to show through

standard innovation accounting exercises (impulse responses and variance decompositions) a subdued response of inflation, output and the policy interest rate to relatively larger aggregate shocks during the post-targeting period compared to the pre-targeting period. We also expect to observe a quantitative shift in the relative importance of demand and supply shocks in predicting variation in inflation, output and the policy interest rate across the forecasting horizon of the two sub-periods. Since IT implies a shift in preferences, the central bank will place a relatively larger weight on inflation control in its loss function as output and real exchange rate stabilization become secondary objectives. Therefore, we expect supply shocks to become relatively less important for inflation variation over the post-targeting forecasting horizon compared to the pre-targeting forecasting horizon. Conversely, we expect demand shocks to be relatively more important in accounting for output variation over the post-targeting forecasting horizon compared to their effects during the pre-targeting period given that monetary policy is conducted through optimal control of the output gap.[110]

3.6 *Data Sources, Descriptive Statistics and Economic Specification*

3.6.1 Data and Descriptive Statistics

The analysis uses seasonally-adjusted quarterly data for South Africa on the log of the import price, domestic real GDP, log of consumer prices and the interest rate,

[110] The importance of demand shocks for output volatility is further bolstered by the argument that having an inflation targeting strategy in place could mitigate the dynamic inconsistency problem such that monetary policy actions (demand shocks) meant for maintaining the target rate could have quantitatively significant real effects.

covering the period 1990:01 to 2010:04.[111] Included for expositional purposes of our economic specification are the real effective exchange rate, commodity price index (fuel and non-fuel products) and the commodity price index for fuel products only, where detailed information on variable definitions, data sources and descriptive statistics is given in Table 3.3 and 3.4. The import price index is the price index for merchandise imports, including fuels and lubricants. The starting date of 1990:01 is deliberately chosen to avoid modeling structural breaks in the data.[112] Our data source for CPI inflation is the Statistics South Africa's interactive database. Except for the import price index, which comes from the South African Reserve Bank's interactive database, all other data is sourced from the IMF's International Financial Statistics (IFS) database, as described in Table 3.3. Table 3.4 indicates that the average volatility of inflation declined from 3.7 percent in the pre-targeting period to 3.2 percent in the post-targeting period. Similarly, the volatilities of the domestic real GDP growth rate and the discount rate declined during the post-targeting period from their levels in the pre-targeting period. The domestic real GDP growth rate fell by 30 basis points and the discount rate by 10 basis points from 2.3 percentage points and 2.4 percentage points, respectively, in the pre-targeting period.

[111] Real GDP is measured in terms of the output gap or the detrended/cyclical component of GDP growth rate. Consumer prices is Headline CPI as reported by Statistics South Africa. The interest rate is the SARB discount (repo) rate, the basic interest rate in the economy, controlled by the Central Bank.

[112] Toward the end of the 1980s and in the early 1990s, South Africa began the process of dismantling the apartheid system. As a result, many important structural shifts that took place in the economy required fundamental domestic reforms in monetary and financial policies (e.g. lifting of controls on international trade and finance).

TABLE 3.3
DEFINITIONS AND DATA SOURCES FOR KEY VARIABLES
Sample: 1990:1-2010:4

Variables	Quantity	Unit of measurement	Equation Variable	Source
Inflation	Consumer price index	End of period (annualized)	π	SSA
Real GDP growth rate	Real GDP growth index	End of period (annualized)	y_t	IFS
Interest rate	Repo rate	End of period (annualized)	i_t	IFS
Import price	Import price index	End of period (annualized)	cp*	SARB
Real Effective Exchange Rate	REER index	End of period (annualized)		IFS
Commodity price_all	Commodity price index	End of period (annualized)		IFS
Commodity price_fuel	Commodity price index for fuel	End of period (annualized)		IFS

Note: International Monetary Fund's International Financial Statistics (IFS), South African Reserve Bank (SARB), Statistics South Africa (SSA). All data is measured at a quarterly frequency. — Real GDP is measured in terms of the output gap or the detrended/cyclical component of GDP growth rate. — Consumer prices are Headline CPI, as reported by Statistics South Africa. — Import price index is the price index for merchandise imports, including fuels and lubricants. — The interest rate is the SARB discount (repo) rate. — REER refers to the Real Effective Exchange Rate. — Commodity price_all refers to commodity price index for fuel and non-fuel products. — We use the log of the import price index to proxy the dynamics of markup shocks coming from external sources.

Conversely, the data suggests that the volatility of prices of imports increased between the pre-targeting and post-targeting periods. As one may expect, the standard errors of both inflation rate and output gap are highest before 2000, which is the pre-inflation targeting period. It is also apparent that the standard errors of both the inflation rate and the output gap take their lowest values during the post-2000 period, which suggests a role for the inflation targeting regime toward the substantial reduction in the volatility of these variables.

TABLE 3.4

DESCRIPTIVE STATISTICS: MEANS AND STANDARD DEVIATIONS (percent)

Sample: 1990:1-2010:4

	Whole sample		Pre-IT Period		Post-IT Period	
Variables	Mean	Std Dev	Mean	Std Dev	Mean	Std Dev
Domestic real GDP growth rate[a]	2.8	2.2	1.9	2.3	3.5	2.0
Inflation rate[b]	7.8	3.9	9.7	3.7	6	3.2
Consumer Price Index (CPI) †	85.8	28.3	59.4	10.7	106.0	19.4
Interest rate	11.8	3.7	15.0	2.4	9.4	2.3
Import price index ††	85.2	37.4	48.9	10.4	113.0	24.1
REER Index	99.3	14.8	111.3	10.5	90.1	10.4
Commodity price index	82.4	39.2	55.2	5.4	103.3	41.1
Commodity price index_fuel	71.3	47.8	35.2	5.7	98.9	47.4

Data source: South African Reserve Bank's interactive data base (SARB), IMF's International Financial Statistics (IFS), and Statistics South Africa (SSA). — All data is measured at a quarterly frequency. — Whole sample period: 1990:1-2010:4; Pre-IT period: 1990:1-2000:1; Post-IT period: 2000:2-2010:4. — *a* and *b* are measured as annualized rates: log(index)-log(index(-4)), where (index(-4)) is the fourth lag of the relevant index. †CPI is Headline CPI as reported by Statistics South Africa. ††Import price index is the price index for merchandise imports, including fuels and lubricants. — REER refers to the Real Effective Exchange Rate. — We use the log of the import price index to proxy the dynamics of markup shocks coming from external sources.

3.6.2 Specification of External Cost Shocks

The conceptual model discussed in section 3.5 implies two aggregate structural shocks, namely demand and supply shocks. While the specification of the demand shock is straightforward from the IS curve, the nature and character of cost shocks specified in the expectations-augmented Phillips curve, particularly the external markup shock, require further elaboration for the benefit of the empirical framework.[113] We use the log of the import price index as our key external sector variable to decompose the dynamics

[113] See section 3.5 for our theoretical characterization of the external mark-up shock, which draws on Benigno (2009). Foreign supply shocks are characterized as foreign markup shocks coming from variation in the prices of imported commodities that are inelastically demanded as factors of production.

of external markup shocks. The prices of imported commodities are assumed to transmit cost shocks through shifts in global market conditions for these commodities. Also, volatility in export prices impacts availability of foreign exchange causing changes in the external value of the rand and as such filters through to fluctuations in import prices. The volatility in the world price of oil appears to be an important source of foreign cost shocks to the inflation process in South Africa. That is, variation in world oil prices accounts for approximately one-fifth of the foreign cost shocks in the import price index.[114] Nonetheless, the broader import price index seems to represent a reasonable source of a wider range of external markup shocks to the CPI including shocks to food prices that the central bank needs to worry about.

The alternative specification would have been to assume that external markup shocks affect domestic inflation through the real exchange rate. However, as established in Chapter 1, South Africa does not exhibit statistically significant pass-through from the exchange rate to inflation. For this reason, South Africa as a mixed strategy targeter was typically using the exchange rate in its policy function as a second companion real activity variable to optimally react to deviations in output caused by the exchange stimulus. So, the exchange shock appears to be more consistent in the short run with a

[114] The statistical release by the Statistics Bureau (Statistics South Africa, June 2012) indicates that fuel imports accounted for nearly 20 per cent of the value of all merchandise imports in South Africa in 2010. During the same period, imported crude petroleum and natural gas accounted for about 15 percent of the total weight in the producer price index (PPI) for imports. Between June 2011 and June 2012, the variation of 20.7 percent in the price of the crude petroleum and natural gas sub-component of the PPI was the highest contributor to the annual percentage change in the overall PPI for imported commodities. The proportion of fuel imports in the merchandise bill has been trending upwards over the past decade from 14.3 percent in 2000 to an average of 20 percent during the period 2007-2009 (statistics from WDI).

demand shock than with a foreign cost mark-up shock. Notwithstanding, the exchange rate is linked to foreign cost shocks through its influence on the cost of intermediate imports. The changes in the external value of the currency arising due to volatility in prices of commodity exports or independent changes in the foreign-exchange market make the exchange rate an important latent variable.

Figure 3.4 shows domestic inflation, import prices and the real exchange rate before and after the adoption of IT in South Africa. The graph suggests reasonable compliance between changes in the prices of imports and domestic inflation in South Africa during the pre-targeting period. In the post-targeting period, the import price schedule appears to exhibit greater volatility relative to the CPI schedule. Despite the higher import price volatility, the volatility of CPI appears to be similar to the previous period suggesting marked resilience of domestic prices to pass-through of external markup shocks during the IT regime.

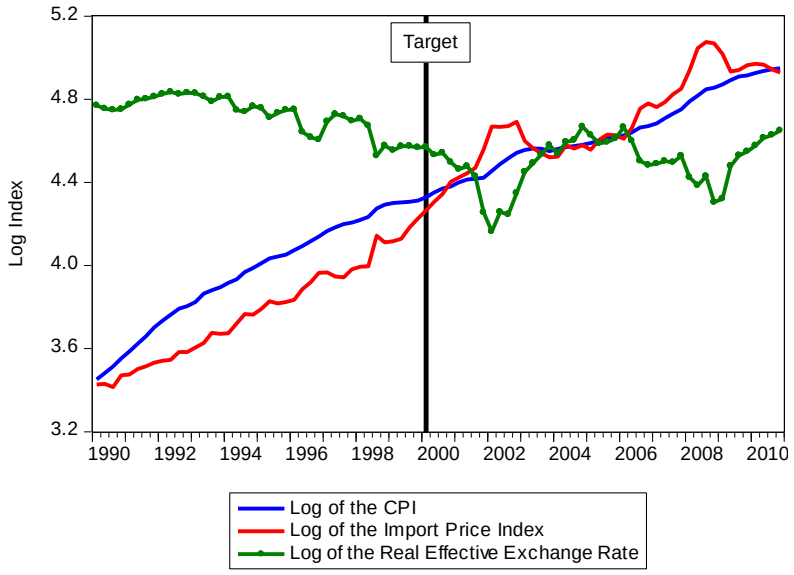

Figure 3.4

Import Prices and Inflation

As already established in Chapter 2, Fig 3.4 suggests a recognizable feature of IT where the ability of mark-up-shocks-to-intermediate import prices to fully influence unit cost mark-ups is partially buffered by anchored inflation expectations creating an improvement in the trade-off between inflation and imports costs that reduces the sensitivity of inflation to foreign cost shocks. The assumption of markup pricing in the simple new-Keynesian model appears to be consistent with the observed co-movement of import prices and domestic inflation in South Africa before and after IT so that a shock to the import price is a reasonable proxy for an external markup shock.

3.7 *Results of the Estimations*

This section reports the results of the SVAR estimations. First, as is standard in the literature, to ensure that our data conform to VAR estimation properties, we ran Augmented Dickey-Fuller unit root tests, with an intercept and a linear time trend, on the log levels of the import price index, domestic real GDP index, the consumer price index and the discount rate. We failed to reject the null of the presence of a unit root in all four variables. However, we reject the presence of a unit root for the quarterly change of those variables. Therefore, we estimate the SVAR system in first differences: log approximations to the import price inflation, real growth rate, inflation, and the first-difference of the short-term interest rate. The measure of real GDP growth rate is the detrended aggregate cyclical variation obtained using the Hodrick Prescott filter with λ=1600. Second, we checked for statistical evidence of cointegration between the four variables in the SVAR system and found none.

In general, the results point toward the model being a good fit to the data. Table 3.5, below, reports VAR coefficient estimates in cp^*_t, y_t, π_t and Δi_t for the pre-targeting subsample (Panel A) and the post-targeting subsample (Panel B). The two regimes are treated separately on the basis of the results of an F-test for variance equality (Conover, *et al.* (1981)). The standard error of each regression which is a summary measure based on the estimated variance of the residuals is used for the variance equality test. The null hypothesis that the variances in both subgroups are equal was rejected at the standard 0.05 percent level of significance. The heterogeneity of the two subsamples was also confirmed via the structural shift in the coefficients in the New-Keynesian Phillips Curve estimated in Chapter 2. The lag length of the VAR estimations was chosen according to the Schwarz criterion.

We test for the presence of serial correlation of the residuals and we have used two lags for both specifications to obtain no significant serially-correlated residuals. The LM tests of the residuals from the SVAR estimates indicate that inflation persistence has declined in the post targeting period compared to the period before the adoption of the IT program (see Appendix 3.1). The sample autocorrelations, as a simple measure of persistence of inflation for the period 1990-2010, suggest that in the period up to February 2000, inflation exhibited significant serial correlation, particularly for lags beyond the second. However, after the adoption of the inflation targeting regime, there is a significant attenuation of autocorrelations. The hypothesis of no serial correlation could not be rejected for the post-targeting sample at all lags.

TABLE 3.5
COEFFICIENT ESTIMATES FROM THE UNRESTRICTED VAR

Panel A: Pre-targeting period; 1990:1-2000:1

LHS Variable	c	cp^*_{t-1}	cp^*_{t-2}	y_{t-1}	y_{t-2}	π_{t-1}	π_{t-2}	Δi_{t-1}	Δi_{t-2}
cp^*_t	1.21*	1.25*	-0.51*	0.04	0.08	-0.03	-0.02	1.3*	-1.05*
	[2.05]	[6.63]	[-2.30]	[0.44]	[0.85]	[-0.56]	[-0.30]	[3.84]	[-2.77]
y_t	2.96*	-0.08	-0.59	0.44*	-0.19	-0.09	-0.01	-0.08	0.06
	[2.40]	[-0.20]	[-1.26]	[2.25]	[-0.96]	[-0.77]	[-0.13]	[-1.13]	[0.82]
π_t	1.13	-1.47*	1.68*	0.52	-0.22	1.17*	-0.41*	0.35*	-0.16
	[0.55]	[-2.25]	[2.18]	[1.59]	[-0.67]	[6.28]	[-2.26]	[2.90]	[-1.17]
Δi_t	0.44	-0.13*	0.04	0.26	-0.06	0.19*	-0.39	0.36*	-0.14
	[0.64]	[-1.96]	[0.58]	[0.68]	[-0.16]	[2.80]	[-1.55]	[2.12]	[-0.74]

Panel B: Post-targeting period; 2000:2-2010:4

LHS Variable	c	cp^*_{t-1}	cp^*_{t-2}	y_{t-1}	y_{t-2}	π_{t-1}	π_{t-2}	Δi_{t-1}	Δi_{t-2}
cp^*_t	0.46	0.91*	-0.23	0.73	-0.5	-0.32	0.34	-1.64	-1.05
	[0.44]	[4.92]	[-1.28]	[1.01]	[-0.74]	[-1.05]	[1.03]	[-0.52]	[-0.27]
y_t	0.57*	-0.02	0.02	0.78*	-0.40*	-0.05	-0.04	0.51*	0.32
	[2.18]	[-0.45]	[0.35]	[4.26]	[-2.33]	[-0.68]	[-0.51]	[1.96]	[1.03]
π_t	1.09*	-0.04	0.1	0.37	-0.60*	1.53*	-0.74*	0.27	0.53*
	[2.59]	[-0.50]	[1.34]	[1.24]	[-2.18]	[12.30]	[-5.49]	[0.63]	[2.02]
Δi_t	-0.07	0.04	0.05*	-0.02	-0.07	0.41*	-0.32	-0.02	0.17
	[-0.08]	[0.77]	[1.99]	[-0.06]	[-0.22]	[2.55]	[-0.86]	[-0.07]	[0.47]

Notes:
t-statistics in parentheses, average R-squared: 0.63 for panel A and 0.69 for panel B. Lag-length of two was chosen according to the Schwarz criterion. * Statistically significant at 5 percent level. Except for the discount rate, the rest of the variables are the first difference of the log level of the respective index as defined in Appendix 3.1.

The estimates generally indicate a statistically significant dynamic relationship among the four variables in the system. The changes anticipated in sections 3.1, 3.3 and 3.5 indeed show up in the comparison of the pre- and post-IT results. First, despite the higher volatility displayed during the targeting period, the VAR estimation with quarterly data indicates that the pass-through of aggregate shocks to inflation, output and the short-term policy interest rate has become more resilient in the post-targeting period compared

to the period before the adoption of the IT program. Table 3.6 shows the estimates of impact multipliers for the pre and post targeting period for decomposed innovations to inflation and output. That is, the structural relationship between the residuals e_{2t} and e_{3t} and aggregate innovations (equation 9). The coefficient estimate on the foreign cost innovation suggest an impact multiplier which is relatively larger in the post-targeting period than in the pre-targeting period. The multipliers for the domestic cost shock and the domestic demand shock are also larger during the post-period. The structural differences between the impact multipliers for the two sub-periods imply post-targeting period inflation which is subject to "amplified shocks" relative to the pre-targeting period.

TABLE 3.6
ESTIMATES OF STRUCTURAL COEFFICIENTS OF DECOMPOSED INNOVATIONS (Equation 9)

INFLATION	δ_2	δ_1	u_1
Pre-targeting period	0.47*	0.31*	0.43*
	(0.17)	(0.14)	(0.20)
Post-targeting period	0.75*	0.48*	0.35*
	(0.32)	(0.21)	(0.18)
OUTPUT GAP	δ_2	δ_1	u_1
Pre-targeting period	0.12*	0.15*	0.21*
	(0.03)	(0.03)	(0.06)
Post-targeting period	0.07*	0.23*	0.46*
	(0.02)	(0.12)	(0.12)

Note: Standard errors are in parenthesis. * Statistically significant at 5 percent level.

Second, Figures 3.5a, 3.5b and 3.5c, show impulse responses of the discount rate, inflation, and output to innovations in foreign supply $\{\delta_2\}$, domestic supply $\{\delta_1\}$ and domestic demand $\{u_1\}$ for the pre-targeting and the post-targeting subsamples,

respectively.[115] Despite the results not suggesting clear systematic differences in responses to aggregate shocks between the pre-and post-periods, the IRFs suggest important quantitative and qualitative differences between the two periods. The impulse response functions generally convey the expected results. Looking at Figures 3.5a and 3.5b, the initial interest response in the pre-targeting period to a one-standard-deviation positive foreign supply shock appears to be countering inflation one-to-one. The pass-through of the foreign shock to inflation for the pre-period of 40 percent is met with an immediate interest response of a similar magnitude.

The change in the discount rate suggest a concern for immediate inflation pressures and a strategy of addressing inflation at a short horizon. However, the interest response in the post-targeting period to a foreign cost shock does not suggest a concern for the immediate 20 percent pass-through to inflation. Instead, the interest response appears to be consistent with a strategy of addressing inflation at a longer horizon especially given that foreign cost shocks to inflation in the post-targeting period appear to be transitory. The response of the discount rate to a domestic cost shock is fundamentally similar to that observed for the foreign cost shock for the two periods. However, despite the 80 percent pass-through to inflation in the pre-targeting period, the discount rate adjustment was half the level of pass-through. The discount rate is gradually adjusted upwards until the shock dissipates. The domestic cost shock to the discount rate in the pre-targeting period appear to be relatively more persistent.

[115] The impulse responses represent point estimates and two-standard-error bands.

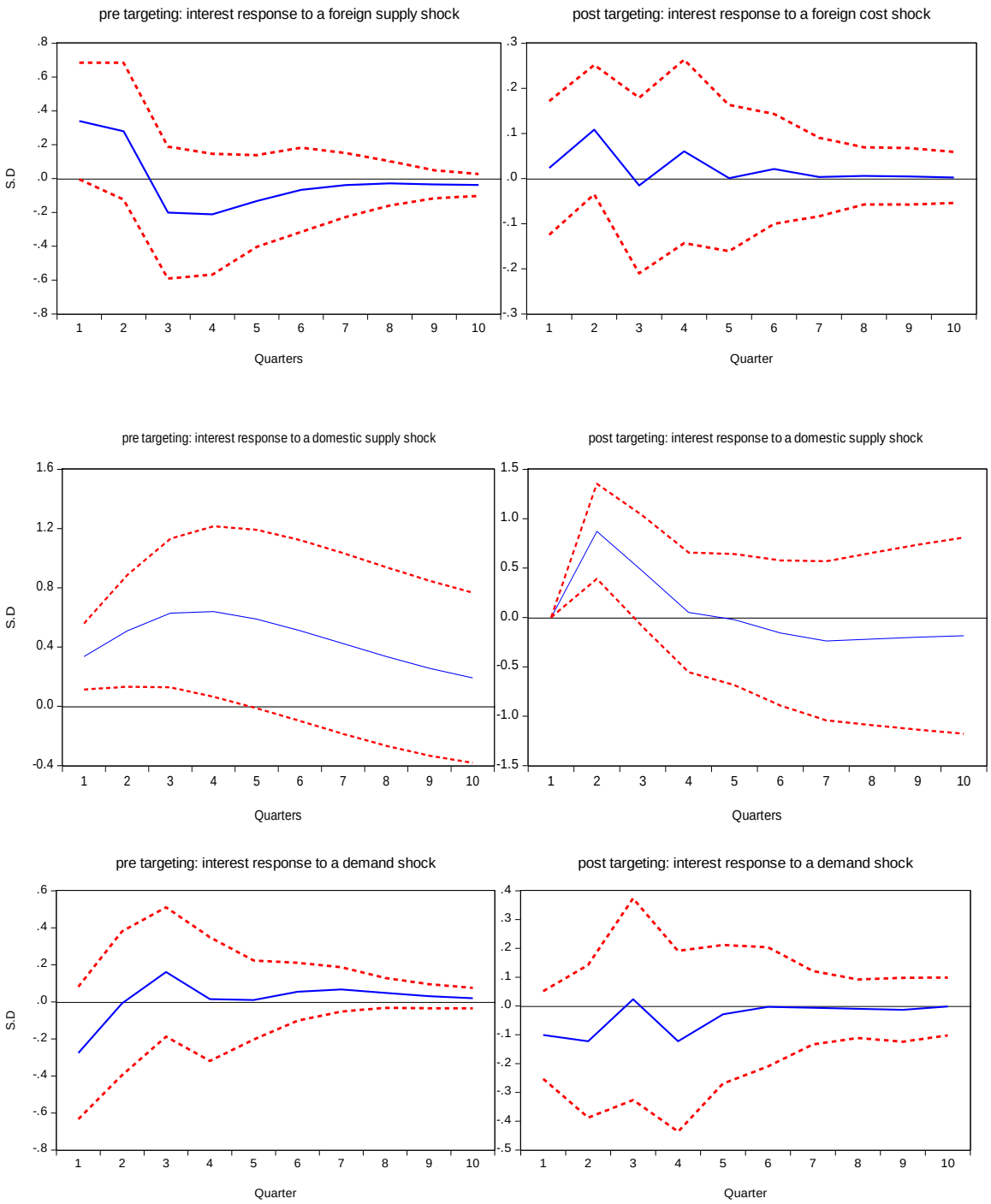

Figure 3.5a

Standardized Responses of the Change in the Discount Rate, Δi_t, to Structural Shocks: Foreign Supply Shock, $\{\delta_2\}$, Domestic Supply Shock, $\{\delta_1\}$, and Domestic Demand Shock, $\{u_1\}$: Pre-targeting Period (1990:1-2000:1); Post-targeting Period (2000:2-2010:4).

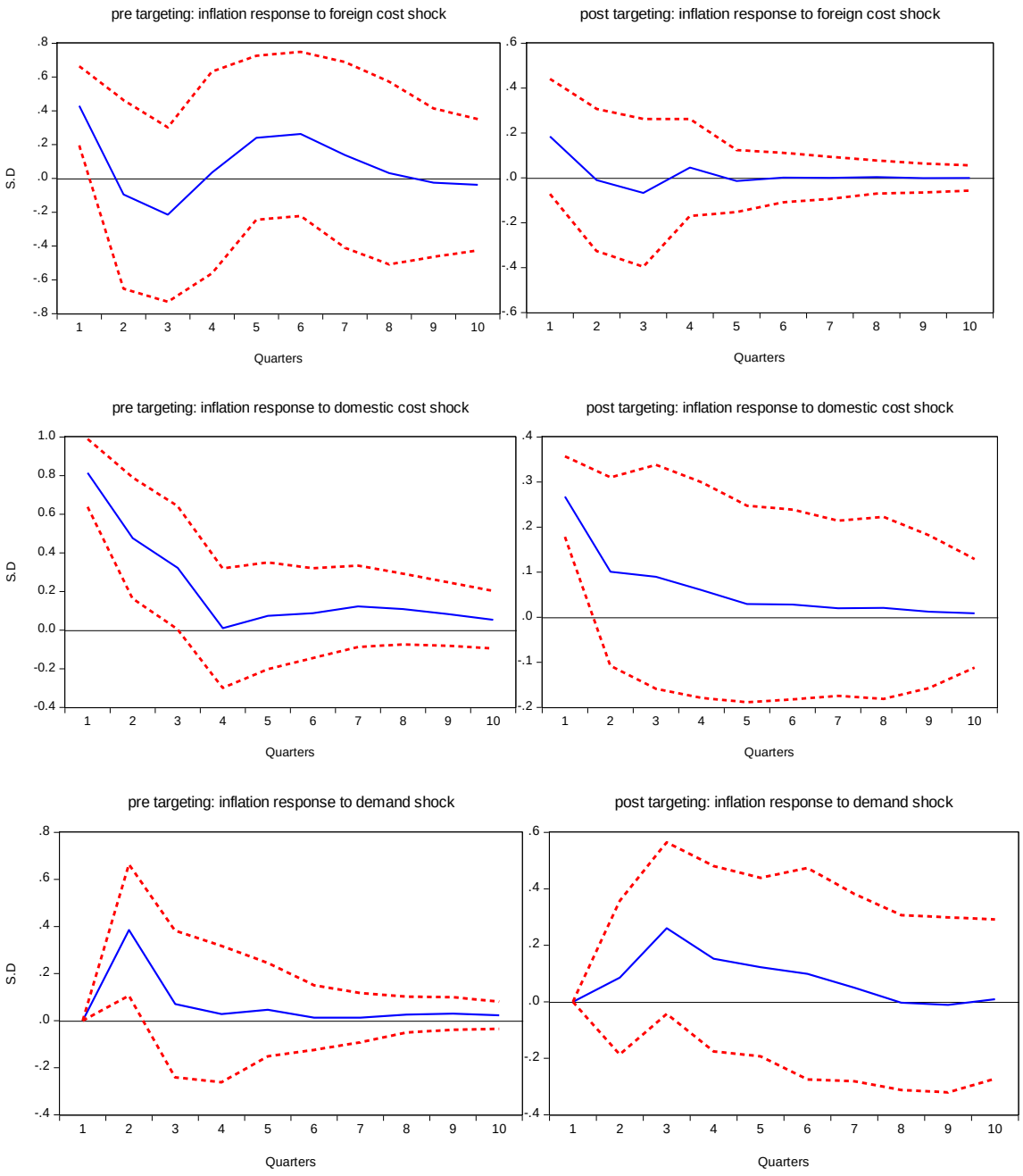

Figure 3.5b

Standardized Responses of Inflation, π_t, to Structural Shocks: Foreign Supply Shock,$\{\delta_2\}$, Domestic Supply Shock, $\{\delta_1\}$, and Domestic Demand Shock, $\{u_1\}$: Pre-targeting Period (1990:1-2000:1); Post-targeting Period (2000:2-2010:4).

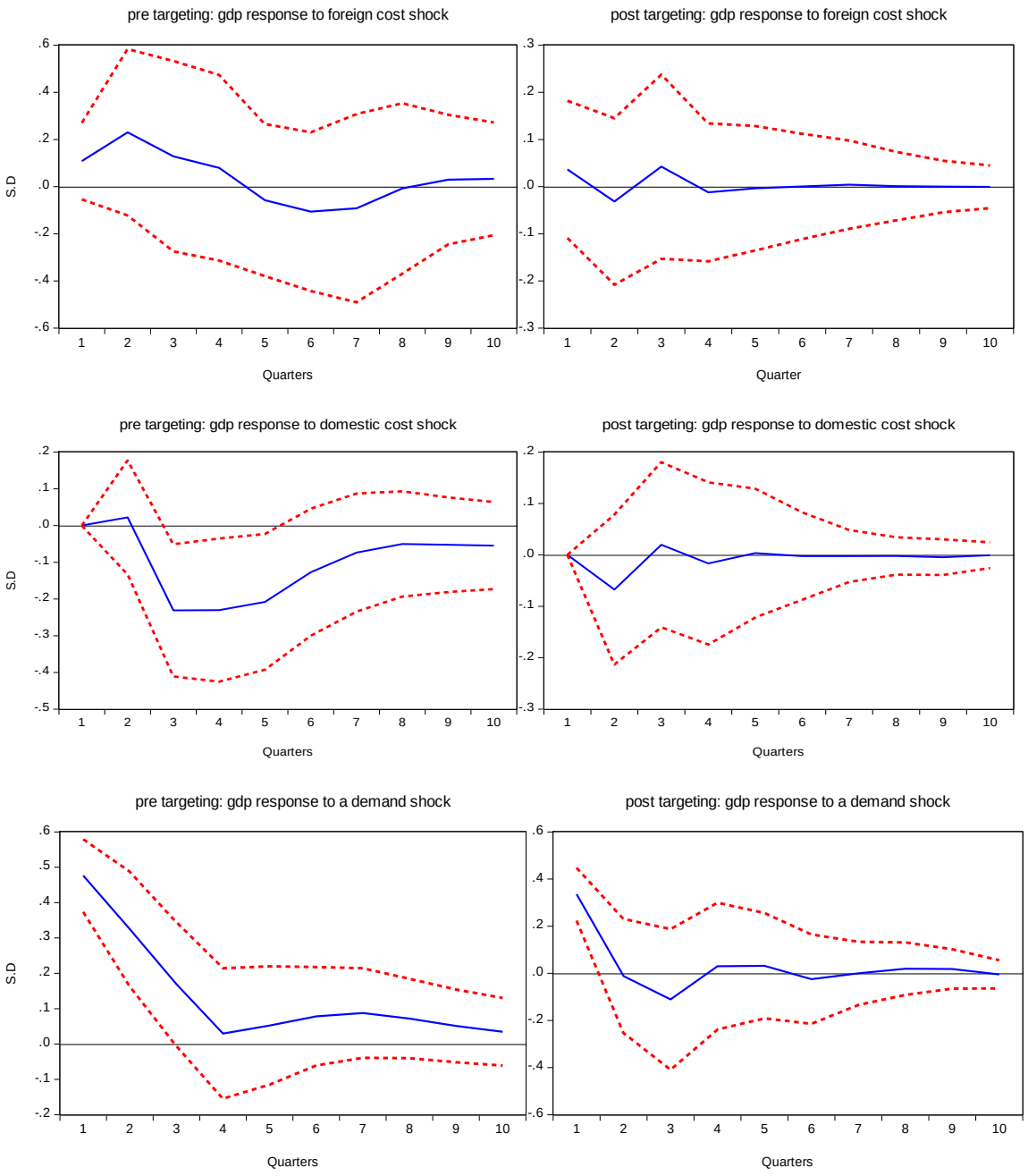

Figure 3.5c

Standardized Responses of Real GDP Growth Rate, y_t, to Structural Shocks: Foreign Supply Shock, $\{\delta_2\}$, Domestic Supply Shock, $\{\delta_1\}$, and Domestic Demand Shock, $\{u_1\}$: Pre-targeting Period (1990:1-2000:1); Post-targeting Period (2000:2-2010:4).

Conversely, the interest response to a positive domestic supply shock in the post-targeting period suggest scope and urgency to counter domestic cost shocks at the short-end. The sharp rise in the discount rate conveys a sense of urgency in dealing with domestic second-round effects such as wage mark-up demands, essential in keeping headline CPI in check. The lower panel of Figure 3.5a shows the interest response to a negative demand shock. The initial reaction in the discount rate of 22 percent in the pre-targeting period is larger compared to 10 percent in the post-targeting period. This shift is consistent with placing a larger weight on controlling inflation relative to output stabilization. The responses of the discount rate in Figure 3.5a in the post-targeting period relative to the pre-targeting period suggest that the central bank has been making policy differently in the two periods. The character of the responses of the discount rate in the post-period are consistent with a monetary policy framework under inflation targeting.

Figure 3.5b shows that the inflation response to a one-standard-deviation foreign supply shock is resilient in the post-targeting period when compared to the pre-period, under the condition of amplified impact multipliers of structural shocks. Table 3.6 suggested that the impact multipliers to inflation in the post period are quantitatively larger than those for the pre-period. In the pre-targeting period, a one-standard-deviation foreign cost shock leads to an immediate positive and statistically significant inflation response of 43 percent. The effect of the shock eventually dissipates in the ninth period. Conversely, a one-standard-deviation foreign cost shock in the post-targeting period leads to an immediate positive but not significant inflation response of only 18 percent. Apart from the transition path being less volatile than in the post-targeting period, the shock effect completely dissipates in the fifth period. Foreign cost shocks to inflation appear

quantitatively less persistent, and more transitory in the post period relative to the pre-adoption period.

The effect of domestic supply shocks on inflation in the pre- and post-targeting periods tells a similar story to that of foreign supply shocks. In the pre-subsample, the initial impact of the shock is absorbed substantially at 81 percent. Although the initial effect of the shock dies out in the fourth period second round effects remain marginally active over the entire forecasting horizon. The response of inflation to a domestic supply shock in the post-subsample is relatively subdued. A one-standard-deviation domestic supply shock results in an immediate and significant positive realization of inflation of 27 percent. We saw that the discount rate over-reacts in the second period to this shock so as to counteract the initial effect and possible second round effects. As anticipated, the inflation response in the pre-targeting subsample is quantitatively more pronounced than that of the post-targeting subsample. The effect of a demand shock appears to dissipate quicker in the pre-targeting sample relative to the post-targeting sample. While the pre-targeting response of inflation to a typical demand shock is statistically significant in the initial two periods, the post-targeting response is within the 95 percent confidence interval throughout the forecasting horizon suggesting features of resilience to demand shocks.[116] Overall, the IRFs suggest that inflation in the post-period has clearly been resilient in the wake of higher volatility. Further, the results support the propositions by Bernanke (1999) and Siklos (1999) that introduction of IT should reduce the persistence of inflation rates.

[116] This observation also applies to the inflation response to a foreign cost shock in the post-targeting period.

The impulse responses for output exhibit relative resilience in the post-period when assessed under the condition of amplified impact multipliers. Figure 3.5c shows that output remained essentially as volatile in the post-period as in the pre-period despite a shift in the magnitude of impact multipliers on the aggregate innovations between the two periods. However, the IRFs suggest important quantitative and qualitative differences between the two periods. A one-standard-deviation foreign supply shock (adverse markup shock) in the pre-targeting subsample provokes an immediate positive output growth rate realization of 11 percent. Conversely, a one-standard-deviation positive foreign supply shock in the post-targeting subsample, results in an immediate positive realization of output of 4 percent. This comparison suggests that output costs are more resilient to foreign supply shocks during the post-targeting period than during the pre-targeting period. The response of output to a one-standard-deviation positive domestic supply shock is also skewed in favor of the post-targeting subsample. The induced cost to output dissipates quicker during the IT period. The recovery time of output to a positive demand shock is shorter in the post-targeting subsample than in the pre-targeting subsample. The response of output to the three identified shocks suggests that the IT regime in South Africa has been stabilizing for output rather than the opposite. The resilience of inflation to aggregate shocks in the post-period suggest is consistent with a policy environment of entrenched and durably anchored inflation expectations as implied under the IT regime. The resilience of output may suggest, as earlier anticipated, that the Phillips curve is relatively steeper during the targeting period.

Further, the importance of aggregate shocks to variability of the variables has changed between the two periods. Table 3.7, below, reports forecast error variance

decompositions for domestic inflation, π_t and domestic real GDP growth rate, y_t, for the pre-targeting and the post-targeting subsamples. The variance decomposition gives the percentage of the forecast error variance of a variable that can be attributed to a specific structural shock. The results of the decomposition analysis closely reflect the evidence presented through IRFs.

First, the standard errors of the inflation rate and the output gap are relatively lower for the post-targeting period compared to the pre-targeting period. With regard to forecast-error variation in inflation, supply-side shocks are responsible for explaining most of the variation in inflation at all horizons in both subsamples. However, in the post-period, inflation is more resilient to the influence of an aggregate supply shock, foreign or domestic, despite the shock having a larger impact multiplier. For example, considering a forecast horizon of 8 periods ahead, foreign supply shocks explain, on average, 48 percent of the forecast error variance of inflation in the post-targeting period, as opposed to 58 percent of the variance in the pre-targeting period.

Moreover, while supply shocks are important for explaining over 83 percent of the variation in inflation at shorter forecasting horizons of the pre-targeting subsample, they only explain about 75 percent of the variation at shorter horizons of the post-targeting subsample. As expected, supply shocks exhibit decreased prominence in accounting for inflation variation over the forecasting horizon during the post-targeting period relative to the pre-targeting period. Conversely, demand shocks appear to be more prominent for inflation variation in the post-targeting period relative to the pre-targeting. While it is trivial to note that the importance of demand shocks should increase when that of supply shocks is on the wane, we attribute some of the enhanced effects of demand

shocks on inflation variation to the improved monetary transmission mechanism via output gap management by the monetary authorities using the interest rate instrument.

TABLE 3.7

FORECAST-ERROR VARIANCE DECOMPOSITION OF STRUCTURAL SHOCKS

(% variance due to innovation)

Decomposition of π_t

Period	Pre-targeting period; 1990:1-2000:1				Post-targeting period; 2000:2-2010:4			
	S.E.	δ_2	δ_1	u_1	S.E.	δ_2	δ_1	u_1
1	1.05	61.6	24.7	13.7	1.26	54.4	21.1	24.5
2	1.88	60.8	23.1	16.1	1.93	52.1	22.1	25.8
3	2.50	60.1	23.1	16.8	2.31	43.6	16.3	40.1
4	2.88	58.3	23.2	18.5	2.49	40.7	15.8	43.5
5	3.08	56.0	23.1	20.9	2.55	44.8	14.1	41.1
6	3.17	55.6	23.1	21.3	2.59	49.2	12.7	38.1
7	3.23	55.7	23.0	21.3	2.64	49.9	12.3	37.8
8	3.26	55.8	23.0	21.2	2.70	49.8	12.3	37.9

Decomposition of y_t

Period	Pre-targeting period; 1990:1-2000:1				Post-targeting period; 2000:2-2010:4			
	S.E.	δ_2	δ_1	u_1	S.E.	δ_2	δ_1	u_1
1	0.76	21.4	22.0	56.6	0.65	18.6	18.0	63.4
2	0.85	21.1	24.6	54.3	0.81	20.8	17.1	62.1
3	0.90	24.2	23.1	52.7	0.84	21.0	19.6	59.4
4	0.98	24.2	26.5	49.3	0.89	20.7	19.2	60.1
5	1.04	24.6	27.0	48.4	0.93	21.0	25.3	53.7
6	1.07	27.1	26.4	46.5	0.96	21.5	26.9	51.6
7	1.10	29.0	25.9	45.1	0.97	21.7	27.0	51.3
8	1.12	29.0	25.8	45.2	0.98	21.7	27.1	51.2

Notes: Foreign supply shock, δ_2, domestic supply shock, δ_1, and domestic demand shock, u_1; S.E is standard error which is the forecast error of the variable at the given forecast horizon. Source of the forecast error is the variation in the current and future values of the innovations to each endogenous variable.

The importance of supply shocks to domestic output variation is, on average, lower during the post-targeting period across the forecasting horizon relative to the pre-targeting period. In terms of output variance decomposition, aggregate supply shocks explain about 40 percent of the forecast error variance in output in the pre-targeting period and 34 percent in post-targeting period in an 8-period forecasting horizon. Therefore, the estimation results suggest that the contribution of supply shocks to output variation is less during the post-targeting period than during the pre-targeting period. This result supports the hypothesis that IT is consistent with a steeper Phillips curve, which leads to an improvement in the output-inflation trade-off and, therefore, a reduction in output volatility induced from supply side-shocks. The result suggests that inflation targeting as a strategy for monetary policy could actually work to reduce the volatility of output over the longer term. Demand shocks appear to have become more prominent for output variation across the forecasting horizon.

Finally, the IRFs of the SVAR showed little to no evidence of differences in macroeconomic dynamics between the pre- and post-periods. This is plausible because impact multipliers to foreign supply and demand shocks have been bigger in the post-IT period. The potency of the IT regime appear to be confounded with the issue that the central bank has had to cope with larger multipliers to aggregate shocks in the post-period. The post-IT period contained a really difficult episode related to global turbulence of the global financial crisis and huge run-up in commodity prices that preceded it. Despite the macro environment susceptible to magnified shocks, the standard deviations of shocks to inflation and the output gap managed to stay the same and even tapered down in some cases. The observed resilience in volatility of inflation and the output gap

is remarkable and suggest an improvement in policy credibility on the part of the SARB which did well in making sure these shocks do not cause important macroeconomic instability.

The estimation results discussed here were supported with diagnostic tests on the data and the SVAR estimates, which comprise specification tests for lag length selection, autocorrelation, heteroscedasticity, normality and parameter stability. All the tests point to the estimation model being a good fit to the data. The results in this chapter parallel those reported by other authors. For example, Goncalves and Salles (2008) report a significant reduction in the volatility of GDP in 15 emerging-market IT countries and Neumann and von Hagen (2002) report a decline in central bank overnight rates for IT banks in 5 OECD countries.

3.8 *Implementing Inflation Targeting in South Africa: Recent Practical Experience and Challenges*

The operational elements of IT in South Africa have undergone a number of changes since inception in February, 2000. Aron and Muellbauer (2007) report that the SARB appeared to practice a stricter version of IT in the early years partly to establish initial inflation control credibility. More recently, the SARB seems to have gained traction in influencing inflation expectations. The inertia in inflation seems to have dissipated and this has allowed the SARB to move toward a more flexible approach. With this approach, the SARB appears to focus on controlling inflation at a longer horizon of two to three years rather than at the shortest possible horizon, as was the case initially. Since 2004, the movement of the repurchase, or 'repo,' interest rate, which is the key

policy variable, has not been as aggressive and volatile, save for the response to the global downturn of 2008, an indication that SARB policy is consistent with stabilizing not only output but also the business cycle.

Monetary policy in South Africa is challenging in general, given that the country's economic mainstay is heavily reliant on exports of gold, platinum and other minerals. This dependency manifests via unique shocks to South Africa's export base as a result of fluctuations in commodity demand, as happened during the Asian Financial crisis of 1997-1998 and more recently during the global financial meltdown of 2008-2009. The fact that South Africa is not self-sufficient regarding its energy requirements also presents serious challenges for monetary policy, particularly now with inflation targeting in place. In 2008, the IMF observed that inflation in South Africa had taken a strong upward swing, owing in part to global shocks to fuel and food prices. The Fund's assessments, such as this one, have suggested a challenging environment for meeting the inflation target in South Africa since the direct first-round effects from such shocks have been large, given that food represents a sizable proportion of the consumption basket and world oil price changes are fully and quickly passed through to domestic prices. Second round effects which manifest through settlement of wage markup demands and sharp rises in inflation expectations are also a source of concern for the monetary authorities.

So far, with the advent of IT and a more transparent monetary policy stance, evidence points toward the SARB ensuring that policy actions are essentially limited to dealing with second round effects of external shocks, unless for exceptional periods, as observed during the sharp depreciation that occurred in the fourth quarter of 2001, when

the domestic currency, the rand, depreciated by 42 percent against the US dollar and during the period 2008-2009 of the global financial crisis.

3.9 *Summary and Conclusion*

This essay exemplifies the structural understanding of causal effects of IT and also affirms the empirical regularities associated with the conduct of monetary policy under the IT regime. In this chapter, we have attempted to place the empirical discussion of IT effects in the context of a theoretical model of the New-Keynesian persuasion, a dimension that has been lacking in the current strand of the literature. We have used the SVAR estimation method, which is an empirical methodology explicitly driven by the conceptual framework to extract aggregate demand and supply shocks. The responses of inflation, output and interest rates to decomposed structural shocks observed in the data are consistent with dynamic adjustment under the IT regime. We have demonstrated that inflation targeting is relevant for the determination of the magnitude of the responses of macroeconomic variables to aggregate shocks in the post-targeting period. The response of inflation and output to shocks is highly resilient during the post-targeting period relative to the pre-targeting period. Similarly, the duration of the impact of shocks on inflation and output during the post-targeting period is markedly shorter and thus more transitory than in the period before the adoption of the IT regime. We also demonstrate that targeting does affect policy behavior by supporting conduct of easier policy than would otherwise be possible under a counterfactual scenario of non-targeting.

So, since IT can be described as a rule-based, albeit flexible, policy, rather than a discretionary policy, the relatively high resilience achieved with targeting should imply

that a rule-based policy, when credible, can deliver macroeconomic stability. As long as agents believe that the central bank is committed to attaining the inflation target, they will not take account of the effect of aggregate shocks in their model of inflation in setting contracts for wages and prices, even in the face of volatile macroeconomic shocks and the absence of strict performance by the central bank in meeting the inflation target. We have in this chapter demonstrated that the key empirical regularities exhibited by macroeconomic and policy variables under inflation targeting are generally consistent with the theoretical predictions of the New-Keynesian framework.

There are several dimensions in which our research can be extended in the future. The obvious one would be to compare the predictive capacity of a New-Keynesian model such as ours under the IT strategy with some model from, say, the new Monetarist school of thought or a monetary business cycle model. The less obvious would be to calibrate the dynamics of inflation and output under a more complex New-Keynesian type model with richer dynamics. While in this chapter we use an equilibrium model, a model with more primitive parameters would also be interesting to explore, as it would address questions such as the extent of forward-looking wage-price-setting behavior and the degree of intertemporal substitution of consumption.

ANNEX I

A discussion on the Identification Framework

(Based on Sarte (1997) and Bjornland (2000))

First, We define $Z_t = [cp^*_t,\ y_t,\ \pi_t,\ i_t]'$ as a (4×1) vector of stationary macroeconomic and policy variables comprising our data as discussed in section 3.4 above, where cp^*_t is the price of imported commodities, Δy_t is the first difference of domestic real GDP, π_t is the inflation rate and i_t is the discount rate.

Our k-lag reduced form VAR can be modeled as follows;

$$\Phi(L)Z_t = \upsilon_t \qquad [1]$$

where:

$\Phi(L)$ is a kth-order matrix polynomial in the lag operator and υ_t is a (4×1) vector of reduced-form residuals assumed to be identically and independently distributed, $\upsilon_t \sim$ iid $(0,\Omega)$ with covariance matrix Ω_υ. The covariance matrix Ω_υ is also assumed positive definite. To go from the reduced form in [1] to the structural model, we impose a set of identifying restrictions.

We assume that the var in [1] is stable (covariance stationary process). Inverting [1] and rewriting it in its moving average (MA) representation (ignoring any deterministic terms), we get:

$$Z_t = B(L)\upsilon_t \qquad [2]$$

where:

$\Phi(L) = B(L)^{-1}$

B(L) is a (4 × 4) convergent matrix polynomial in the lag operator L, i.e., $B(L) = \sum^{\infty}_{j=0} B_j L^j$. The B_j matrix refers to the moving average coefficient at lag j.

We assume that the reduced form residuals υ_t are composites of the underlying structural disturbances ε_t, which are themselves orthogonal to each other. We further assume that υ_t can be written as linear combinations of the innovations, i.e,

$$\upsilon_t = D_0 \varepsilon_t \qquad [3]$$

where D_0 is the (4 × 4) contemporaneous matrix.

This means equation [3] can be written as;

$$Z_t = C(L)\varepsilon_t \qquad [4]$$

where $B(L)\ D_0 = C(L)$ [5]

C(L) in equation [5] is the matrix in the lag polynomial that contains the impulse response functions of our macroeconomic variables (Z_t) to the structural innovations (ε_t). So the coefficient c_{23} in the matrix C(L) represent the impulse response of change in

output growth, y_t, to an aggregate domestic demand shock. The variance-covariance matrix of the structural disturbances can also be represented by

$$\Omega_{\varepsilon} = \sigma_{ij}^2 I \qquad [6]$$

The covariance $\sigma_{ij} = 0$, where $i \neq j$. For convenience, we normalize the variance of the structural disturbances to unity. If D_0 can be identified, we can derive the MA representation in [4]. From the normalization of cov $(\varepsilon_t) = 1$, it follows that

$$D_0 D_0' = \Omega_{\upsilon t} \qquad [7]$$

There are $n(n + 1)/2$ distinct covariances (due to symmetry) in $\Omega_{\upsilon t}$. In our four variable system, this imposes ten restrictions on the elements in D_0. We need six more restrictions to identify D_0. This is where we impose two recursive, three short-run and one long-run restriction(s), as mentioned in the text. The recursive restrictions define the contemporaneous relationships between the policy variable and domestic variables. The short-run restrictions are motivated from South Africa being a small open economy so that we impose the restriction that domestic aggregate supply and demand shocks (δ_1 and u_1) have no effect on the price of imported commodities. The long-run restriction is the standard long-run neutrality assumption that aggregate domestic demand shocks have no long-run effect on domestic real output. This requires a restriction on the long-run multipliers of the C(L) matrix, whereas the other five restrictions will come from constraints on the contemporaneous matrix D_0 directly.

We impose the restrictions as follows:

$$\begin{bmatrix} B_{11}(1) & B_{12}(1) & B_{13}(1) & B_{14}(1) \\ B_{21}(1) & B_{22}(1) & B_{23}(1) & B_{24}(1) \\ B_{31}(1) & B_{32}(1) & B_{33}(1) & B_{34}(1) \\ B_{41}(1) & B_{42}(1) & B_{43}(1) & B_{44}(1) \end{bmatrix} \begin{bmatrix} D_{11},0 & 0 & 0 & 0 \\ D_{21},0 & D_{22},0 & D_{23},0 & 0 \\ D_{31},0 & D_{32},0 & D_{33},0 & 0 \\ D_{41},0 & D_{42},0 & D_{43},0 & D_{44},0 \end{bmatrix} = \begin{bmatrix} C_{11}(1) & C_{12}(1) & C_{13}(1) & C_{14}(1) \\ C_{21}(1) & C_{22}(1) & C_{23}(1) & C_{24}(1) \\ C_{31}(1) & C_{32}(1) & C_{33}(1) & C_{34}(1) \\ C_{41}(1) & C_{42}(1) & C_{43}(1) & C_{44}(1) \end{bmatrix}$$

where

$$B(1)\, D_0 = C(1) \qquad [8]$$

is the long-run restriction, where $B(1) = \sum_{j=0}^{\infty} B_j$ and $C(1) = \sum_{j=0}^{\infty} C_j$ represent the (4×4) long-run matrix B(L) and C(L), respectively (equation 8 follows from equation 5). Since the long-run restriction is that aggregate demand shocks have no long-run effects upon the growth rate of output, y_t, this means $C_{23}(1) = 0$ or

$$B_{21}(1)D_{13,0}+B_{22}(1)D_{23,0}+B_{23}(1)D_{33,0} = C_{23}(1)=0 \qquad [9]$$

With these restrictions, the system in equation [3] is now just identifiable. The system is linear in its equations and can be solved numerically to obtain the coefficients of the D_0 matrix. Together with the estimated coefficients in B(L) from the reduced-form VAR, we can compute impulse response functions for inflation, output, and the discount rate to the identified structural shocks and also report forecast-error variance decompositions.

APPENDIX 3.1

SAMPLE AUTOCORRELATIONS: LM TESTS

Sample: 1990-2008

Lags	1	2	3	4	5	6
pre-targeting	15.2	27.0	36.0	24.5	13.0	26.3
	(0.51)	(0.06)	(0.00)	(0.08)	(0.67)	(0.05)
post- targeting	14.6	5.2	12.5	17.2	14.9	18.9
	(0.55)	(0.99)	(0.71)	(0.37)	(0.53)	(0.27)

Notes: SVAR Residual Serial Correlation LM Tests, Null Hypothesis: no serial correlation at lag order h, probability values are in parentheses below LM stats.

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