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Assessing McCallum and Taylor rules in a cross-section of emerging market economies

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Abstract

The paper estimates McCallum and Taylor monetary policy reaction functions, and hybrids mixing instruments and targets from the two frameworks, for 20 emerging market economies. McCallum-Taylor specifications with an interest rate instrument and a nominal income gap target perform better than benchmark Taylor rules in describing monetary policy in inflation targeting economies. Estimating reaction functions for economies operating monetary and exchange rate targeting regimes produces mixed results, often revealing a lean with the wind behaviour. Instrument smoothing is a feature in the monetary base and in the interest rate reaction functions, but the exchange rate is not consistently significant. The results from the econometric analysis are robust to using alternative estimators.

JEL classification: E52, E58; F41.

Keywords: McCallum and Taylor rules; nominal feedback rule; monetary policy; inflation targeting; emerging markets.

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Tiivistelmä

Tutkimuksessa estimoidaan McCallumin ja Taylorin rahapolitiikkasäännöt kahdellekymmenelle kehittyvälle taloudelle. Työssä käsitellään myös hybridejä sääntöjä, joissa yhdistetään instrumentti- ja tavoitemuuttujia kahdesta eri säännöstä. McCallumin-Taylorin hybridi sääntö, jossa keskuspankin käytössä on korkoinstrumentti ja nimellistulotavoite, kuvaa inflaatiotavoitteen asettaneiden talouksien rahapolitiikkaa paremmin kuin perinteinen Taylorin sääntö. Estimointitulokset rahamäärä- tai valuuttakurssitavoitteen asettaneille maille ovat tavanomaisia, ja niiden mukaan rahapolitiikkakäyttäytyminen on usein tuuleen nojaavaa. Instrumentin tasoittamista ilmenee sekä perusraha- ja korkoreaktiofunktioissa, mutta keskuspankin reaktio valuuttakurssin muutoksiin ei ole kaikkien maiden kohdalla tilastollisesti merkittävä. Ekonometrisen analyysin tulokset ovat robusteja erilaisista estimointimenetelmistä riippumatta.

Avainsanat: McCallumin ja Taylorin säännöt, nimellinen palautesääntö, rahapolitiikka, inflaatiotavoite, kehittyvät taloudet.

1 Introduction

The policy strategy central banks in emerging economies follow can at times be difficult to follow (e.g., Calvo and Mishkin, 2003). In emerging economies fragile institutions, lack of central bank independence, and a scarcity of monetary instruments can render monetary control difficult. But following the crises in the 1990s many emerging market economies have been making considerable efforts to improve policy making institutions and empirical evidence could help in determining how central banks react to fundamental economic developments. Empirically estimated reaction functions can provide valuable information for discussing monetary policy and therefore may ultimately help in safeguarding macroeconomic stability.

The paper contributes by investigating monetary policy behaviour in 20 emerging market economies. The investigation seeks to answer the following questions: Are Taylor-type, interest rate, monetary policy reaction functions useful for understanding monetary policy performance in inflation targeting economies? Can McCallum-type, monetary base, reaction functions help in characterizing central bank policy in economies operating monetary targeting and exchange rate targeting policy strategies? For economies with a dearth of statistical information on the real economy and relatively low levels of institutional development, can a nominal monetary policy feedback rule embodying an inflation targeting mechanism approximate historical monetary policy conduct?

Understanding monetary policy behaviour in relation to the prescriptions of key analytical frameworks is relevant. John B. Taylor argues that the 2008 financial crisis is at least partly to be blamed on a loose United States Federal Reserve monetary policy stance in comparison to the prescriptions of the Taylor rule (see also Billi, 2009). In a *Wall Street Journal* article Taylor writes (9 February 2009, page A19):

> Monetary excesses were the main cause of the boom. The Fed held its target interest rate, especially in 2003-2005, well below known monetary guidelines that say that good policy should be based on historical experience. Keeping interest rates on the track that worked well in the past two decades, rather than keeping rates so low, would have prevented the boom and the bust.

The paper seeks to produce evidence about past monetary policy behaviour by estimating a family of reaction functions deriving from McCallum's (e.g., 1988, 1999) and Taylor's (e.g., 1993, 1999) contributions. The relevant empirical literature on emerging economies often adopts a framework without exercising judgment about which reaction function is adequate on the basis of the declared monetary policy regime and institutional idiosyncrasies. The investigation tackles that shortcoming by assembling a record of monetary policy institutions in 20 emerging markets which informs the subsequent empirical modelling.

The literature investigating monetary policy reaction functions uses much sophistication (e.g., Dolado et al, 2005), but Kozicki (1999) argues that to be useful an empirical rule should be robust to minor variations. The strategy of the paper involves estimating benchmark, comparable, specifications using conventional econometric estimators to gain a better understanding of monetary policy in emerging market economies. Following McCallum (2000), the analysis runs a range of policy feedback rules in determining if the estimated central bank reactions are different depending on the type of instruments and targets considered for each economy.

The rest of the paper proceeds as follows. Section 2 gives an account of developments in monetary policy institutions in emerging market economies. Section 3 explains the monetary policy frameworks used in the empirical modelling. Section 4 describes the time series data and the family of monetary policy reaction functions. Section 5 runs the battery of reaction functions deriving from McCallum's and Taylor's contributions, and discusses the results. Section 6 concludes.

2 Monetary policy in emerging market economies

Monetary policy in emerging markets, as in advanced economies (Bernanke et al, 1999), has evolved from monetary targeting and exchange rate pegging to inflation targeting (e.g., Mishkin, 2000). But emerging countries face many obstacles in consolidating monetary policy. Fry et al (1996) examine 44 developing countries and show that central banks in the sample are moving away from traditional monetary instruments towards a marked-based monetary policy implementation. In that process monetary authorities face serious obstacles, like underdeveloped and inefficient financial systems, and fiscal dominance. Despite the positive developments, Fry et al argue that central banks in developing countries have been ineffective in fulfilling the key mandate of delivering price stability. Much has been made about the transition to a marked-based monetary policy

strategy, but comparable empirical estimates throwing light on the actual policy behaviour in the reforming countries are in short supply.

This paper documents monetary policy institutions in 20 emerging markets and Table 1 displays key information. The sample includes countries from Africa, Asia, Emerging Europe, and Latin America; Table A1 lists all the economies. The sample is also diverse in terms of ranking in World Bank income tables. The group includes countries that are classified as low income like Ghana; lower middle income like the Philippines; upper middle income like Chile; and high income like the Czech Republic. Most countries in the sample are small-open-economies: twelve economies displayed trade-to-GDP ratios above 80% in 2007.[1]

In terms of monetary policy strategies, 14 countries operate inflation targeting regimes, while 6 pursue monetary targeting or exchange rate targeting. The inflation targeting countries adopted the strategy in the 1990s or 2000s, and the full implementation of the approach was sometimes preceded by implicit inflation targeting (see Carare and Stone, 2006). Some economies in the sample temporarily imposed capital controls in the 1990s, with implications for the link between the domestic interest rate, exchange rate, and capital flows, and hence for estimated monetary policy reaction functions.[2] However, excepting 2000 for Colombia and 2001 for Malaysia, all the episodes fall outside the sample period.

Credibility of the monetary authorities with the general public, which is related to formal central bank independence (e.g., de Haan et al, 2008; Arnone et al, 2009), allowed central banks to plan and implement a strategy specifying a target for inflation. The disinflationary macroeconomic environment during the 1990s arguably facilitated reducing the pre-announced inflation targets from double to single digits in the 2000s; by the end of the sample most inflation targeting countries had midpoint targets around 3%.[3] Whether good policy or good luck was responsible for the Great Moderation and the good economic performance during the 1990s and early 2000s is a topic of ongoing debate (e.g., Galí and Gambetti, 2009).

[1] According to data from the World Bank Development Indicators Database.
[2] Countries with controls on inflows include Chile (1991-98), Colombia (1993-00), Malaysia (1994), Czech Republic (1995), Thailand (1995-97), Hungary (1996, 1999) and the Philippines (2000). Controls on outflows were imposed by Venezuela (1994-96), Thailand (1997-98) and Malaysia (1997-01). See International Monetary Fund (2005), p. 44.
[3] The numbers are consistent with inflation targets in the advanced economies of around 2%, considering the existence of Balassa-Samuelson effects that push inflation in non-tradables in emerging countries slightly higher than in advanced economies. See Mihaljek and Klau (2008) for recent evidence about the magnitude of the Balassa-Samuelson effect for Emerging Europe. Khan and Senhadji (2001) find that the threshold at which inflation rates begin to have a negative impact on growth is higher for developing than developed countries.

The sample of countries includes successful reforming economies in Latin America. The 1980s brought adverse financial conditions affecting already weak economies across Latin America. But major efforts have been made from the beginning of the 1990s to improve policy making, and countries have been choosing from several options for conducting monetary policy (Mishkin and Savastano, 2001). The countries have opted to adopt a full range of polices, including inflation targeting, monetary targeting, and exchange rate targeting.

Chile granted independence to its central bank in 1989. Alongside came a mandate for adopting inflation as monetary policy's main objective. In 1990 a more formal monetary policy stance was signalled by announcing an inflation target range for 1991. But from the mid-1980s until August 1999 the Central Bank of Chile also pursued an exchange rate band regime. Following the formal introduction of inflation targeting the authorities have always made clear that their primary objective is achieving the pre-announced inflation target, and from 1999 inflation is the primary objective of the Central Bank of Chile.

Colombia has also advanced significantly by granting independence to its central bank and operating an inflation targeting strategy since 1999. Otero and Ramírez (2006) investigate Colombia's move in 1991 towards a more independent monetary policy by granting greater autonomy to its central bank. They show that in Colombia's case greater independence has led to a better outcome regarding the central bank's mandate of achieving price stability.

Mexico is making substantial efforts in trying to consolidate sound policy institutions and has met with a fair amount of success: Cecchetti et al (2000) show that monetary policy in Mexico became more efficient, as measured by the lower variability of inflation and output, from 1991 onwards. And since 1999 Mexico is following a formal inflation targeting strategy. Still, Mexico had been pursuing its policy objectives using an unconventional quantitative target-based policy named 'El corto'. From 2008 Mexico shifted to a more conventional policy targeting a short term interest rate.

Peru has also been strengthening monetary policy institutions and implements inflation targeting since 2002. In Peru dollarization is a problem and building credibility is challenging. Uruguay also has a history of dollarization, and has not implemented a full inflation targeting strategy. Uruguay operates a flexible exchange rate regime. Costa Rica follows a mixed strategy of monetary targeting and exchange rate targeting. A further interesting case in Latin America is Venezuela. The central bank has legal mandate to pursue an inflation targeting strategy, but Venezuela in fact operates a regime mixing monetary and inflation targets.

Countries in Emerging Europe have also been working towards building solid monetary policy making institutions. Economies like the Czech Republic, Hungary, and Poland have been fostering central banks with adequate independence for pursuing clear policy goals, as documented by Cukierman et al (2002). Inflation targeting is the monetary policy framework in the three economies. The Czech Republic adopted inflation targeting in December 1997, Poland followed in 1999, and Hungary moved to inflation targeting in June 2001. Jonas and Mishkin (2003) analyse inflation targeting in the Czech Republic, Hungary, and Poland, highlighting past challenges and future prospects. All three economies aim to join the euro area, and e.g. an inflation target of 2% is announced to be in effect in the Czech Republic from January 2010 onwards until euro area accession.

Asian economies provide relevant case studies, not least because in the 1990s crises starting in the region spread to emerging markets across the world. Thailand is a prominent example. During the late 1980s Thailand received a large amount of capital inflows. The development led to inflationary pressures that became a threat to macroeconomic stability. The imbalances were contained until the early 1990s but were at least partly responsible for the economy's downfall later in the decade. Following the Asian crisis, Thailand adopted inflation targeting in 2000.

Malaysia has price stability as primary objective, but does not have an explicit inflation targeting framework. Malaysia operates a managed float exchange rate regime and has been able to keep inflation under control. In the 1990s the Philippines gave independence to monetary policy and from 2002 implements inflation targeting.

The study investigates economies in Africa, a region that is less prominent for overall economic progress and institutional development. Some countries in Africa have been advancing more quickly. South Africa has been formally announcing inflation targets since 2002. The approach demands hard-to-gain fiscal soundness, but lends credibility to the government's commitment to macroeconomic stability.

In other African countries monetary policy has also improved. Countries like Ghana have been fostering good policy institutions, and moved to a full-fledged inflation targeting strategy in 2007. After many years of pursuing monetary targeting Nigeria is also moving towards a marked-based monetary policy strategy. That is also the case with Tunisia, a country considering adopting inflation targeting. But there are obstacles to progress in monetary policy in countries like Ghana, Nigeria, and Tunisia. For instance, doubts about the effectiveness of the transmission mechanism of

monetary policy and the degree of pass through from the exchange rate to prices raise concerns about the viability of implementing market-based monetary policy strategies like inflation targeting.

There is a difference between what countries say and what countries can and actually do. And that is important for understanding the potential benefits of pursuing a policy strategy. Because of that reason, gaining a better understanding about monetary policy by empirically estimating reaction functions can help in ascertaining what countries actually do and the extent to which the performance approximates a rule-like behaviour.

The next section explains the frameworks informing the subsequent empirical modelling of central bank behaviour across emerging market economies.

3 Frameworks for understanding monetary policy behaviour

3.1 McCallum's rule

McCallum's (e.g., 1988) work on monetary base rules is an example of a nominal feedback mechanism. The rule is

$$\Delta h_t = \alpha - \Delta v_t^a + \delta(x_{t-1}^* - x_{t-1}). \quad (1)$$

In (1) h is the log of the monetary base (the monetary policy instrument), α is a constant term intended to account for the steady-state nominal output growth, x is the log of nominal output, Δv^a is the moving average rate of growth of monetary base velocity over the previous four years, and x_t^* is the target value of x_t for period t; Δ is the difference operator; δ is a feedback coefficient informing on how quickly deviations of output from its target are offset by the central bank. McCallum (1987) finds that for the United States a rule like (1) would have been more suitable, in terms of a smoother GNP path, if it had been in practice during 1954-1985. He reaches those conclusions after comparing simulations using (1) with actual policy reactions.

McCallum's rule is operational, as monetary base is under complete control of the central banker, and the variables on the right hand side of (1) are all known to the policy maker at period t. The information advantage stands in contrast to the Taylor rule where nominal interest rates are set

as a function of current period inflation and the output gap – the latter variable is generally not known at period *t*, at least if GDP data are used in its construction.

McCallum's rule is relevant in an environment of deflation and with a zero bound on interest rates. In that environment monetary base growth may provide important information even if nominal policy rates are zero -McCallum (2003) studies the rule's recommendation for base money growth during Japan's deflation in the 1990s. Base money also has a role in signalling commitment in the optimal policy described by Eggertsson and Woodford (2003) at the zero bound.[4] That is relevant since during the sample under study some emerging countries display declining policy interest rates.[5]

3.2 Nominal monetary policy feedback rule (NFR)

The paper also considers a mechanism of the form (see Dueker and Fischer, 1998; McCallum, 1999)

$$\Delta z_t = \delta_0 + \Delta(z-y)_{\langle t|t-1\rangle} + \delta_1(y-y^*)_t . \qquad (2)$$

In equation (2), z is a policy instrument or intermediate target assumed to be controllable by the monetary authorities; y and y^* are the hypothesised nominal target and its reference value; δ_0 is the baseline rate of growth of the nominal target; δ_1 is a feedback parameter which indicates how swiftly the monetary authorities respond to gaps between the actual and desired levels of the nominal target variable; and $\Delta(z-y)_{\langle t|t-1\rangle}$ is a forecast of the relationship amongst the nominal target and the instrument; Δ denotes the difference operator. A major advantage of a NFR like (2) is that it does not depend on real aggregate economic activity variables. Such variables, in particular for the case of developing economies, are sometimes not available at relatively high (quarterly or monthly) frequencies, and are usually wrongly measured.

[4] Even if the central bank missed its price level target, it would supply the amount of money that would be demanded if the price level had been met.
[5] In June 2009 the Czech Republic's policy rate was 1.5%, Thailand's 1.25%, and Israel's 0.5%.

3.3 Taylor's rule

Taylor's (1993) rule advocates setting the US federal funds rate (i) in relation to the rate of inflation (π), an equilibrium real funds rate (r^*), plus an evenly weighted average of two gaps: the four-quarter moving average of the actual inflation rate given by the GDP deflator less a target rate (π^*), and the percent deviation of real GDP from an estimate of its potential level (y). Taylor's rule incorporates monetary policy's key objectives. In equation form Taylor's rule is

$$i_t = \pi_t + r^* + 1.5(\pi_t - \pi^*) + 0.5(y_t). \quad (3)$$

Taylor's original paper proceeds assuming the weights on inflation and output. But Taylor's linear feedback rule has subsequently been shown to arise from solving the problem that a policymaker faces in theoretical optimal monetary policy models. The *Taylor principle*, meaning that the nominal policy interest rate moves more than one-for-one with inflation, is a fundamental aspect leading to stability in theoretical models (e.g., Woodford, 2001; Davig and Leeper, 2007).

Subsequent modelling investigates (3) empirically. Basically, this literature estimates monetary policy's reactions to inflation and output gaps, and it considers lags on the central bank's interest rate to account for instrument smoothing. Clarida et al (1998) model forward-looking Taylor-type monetary policy reaction functions for France, Germany, Italy, Japan, the UK, and the US. See also the contributions in Taylor (1999).

The paper estimates Taylor-type interest rate feedback rules for the inflation targeting countries in the sample; section 2 and Table 1 contain further details on the inflation targeting countries. Inflation targeting as a policy framework does not necessitate any mechanical rule-based approach to hit announced target. Svensson (1999) studies an implicit rule for inflation targeting that is close to Taylor's[6]. The mechanism in Svensson adjusts the short-term interest rate on the basis of the average nominal interest rate and the deviation of a conditional inflation forecast from an inflation target.

The Taylor rule in the paper links the policy interest rate to the contemporaneous output gap and inflation. But assuming a lag in the impact from the output gap to inflation introduces a forward-looking element to the policy rule: the policy maker may be reacting to future price pres-

[6] Svensson (1999) shows how monetary targeting could be implemented within an inflation targeting strategy. The framework implies a frequent adjustment of the money stock such that the interest rate is compatible with the future inflation target.

sures originating from an increasing output gap. The lag it takes the output gap to hit inflation is a common feature of small macro models used for analysing monetary policy (see, for example, Carlin and Soskice, 2005).

4 Data and empirical model specifications

4.1 Data

The study employs quarterly time series data. The nominal interest rates used in estimating the benchmark Taylor rule and the hybrid McCallum-Taylor counterpart are the official policy interest rates listed in Table 1. The rate of inflation is the annual change in the price index. The exchange rate variable in the entire family of rules is the annual change in the price of domestic currency per US dollar. The output gap is based on GDP data and section 5 further discusses its computation. The sources for all the data are central bank websites, the International Monetary Fund's International Financial Statistics, and the CEIC database. Table 2 explains the notation and data transformations for the variables feeding the family of rules in the paper.

4.2 Specifying the reaction functions

In the spirit of McCallum (2000), the paper estimates a family of rules mixing targets and instruments from the prevalent frameworks for analysing monetary policy performance. The battery of specifications in the empirical modelling are:

$$R_t = \varphi_T R_{t-1} + \beta\left(\overline{\pi}_t - \pi^*\right) + \lambda\left(y_t - \widetilde{y}\right) + \delta_T \Delta e_t \qquad \textit{Taylor} \qquad (4)$$

$$R_t = \varphi_{MT} R_{t-1} + \rho\left(\Delta x_t^* - \Delta x_{t-1}\right) + \delta_{MT} \Delta e_t \qquad \textit{Hybrid McCallum-Taylor} \qquad (5)$$

$$\Delta b_t = \mu_M \Delta b_{t-1} + \theta\left(\Delta x_t^* - \Delta x_{t-1}\right) + \delta_M \Delta e_t \qquad \textit{McCallum} \qquad (6)$$

$$\Delta b_t = \mu_{HM}\Delta b_{t-1} + \chi\left(\pi_t - \Delta\bar{p}_t + \bar{y}_t\right) + \delta_{HM}\Delta e_t \qquad \begin{matrix} \textit{Hybrid} \\ \textit{McCallum-Hall-Mankiw} \end{matrix} \tag{7}$$

$$\begin{matrix} \Delta m_t - \Delta(m-p)_{\langle t|t-1\rangle} = \\ \omega\left(\Delta m_t - \Delta(m-p)_{\langle t|t-1\rangle}\right)_{t-1} + \beta_{DF}\left(\pi_t - \bar{\pi}_t\right) + \delta_{DF}\Delta e_t \end{matrix} \qquad \begin{matrix} \textit{NFR} \\ \textit{McCallum-Dueker-Fisher} \end{matrix} \tag{8}$$

The lagged policy instrument is an important feature in equations (4) to (8) and is intended to account for smoothing by the monetary authorities via the coefficients φ_T, φ_{MT}, μ_M, μ_{HM}, and ω (see English et al, 2003). Equation (4) is the benchmark Taylor-type monetary policy reaction function. Following the discussions in Taylor (2001), the arguments in Svensson (2000), and the large empirical literature on monetary policy in open economies (e.g., Morón and Winkelried, 2005), equation (4) and the other specifications allow for feedback from the exchange rate. The exchange rate variable is the annual depreciation of the exchange rate expressed in percentage points, and an increase in *e* is a depreciation. In equation (4) an increase in the exchange rate is expected to produce an increase in the interest rate ($\delta_T > 0$) if the monetary authorities lean against the wind.

The output gap is based on Hodrick-Prescott filtered GDP data.[7] The paper uses revised data available at the end of the sample, and does not make an attempt at measuring policy makers' reactions to real time output data.[8] The coefficient on the output gap is expected to be positive ($\lambda > 0$), indicating that the central bank increases the interest rate in actual output is above potential output.

As mentioned in the previous section, according to the Taylor principle the nominal policy interest should move one-for-one with inflation ($\beta > 0$).

Equation (5) is a hybrid mixing an interest rate instrument with a McCallum nominal income gap target and an exchange rate variable. An important variable in the rule is the nominal GDP target. For inflation targeting countries the nominal income target is computed by applying the

[7] In addressing the end-of-sample problem associated with the filter, we calculate six out-of-sample forecasts based on an AR(1) model for the GDP series in first differences, and apply the filter to the constructed longer GDP series in levels terms.

[8] Orphanides (2003) shows how the overestimation of potential output gave the Fed policy an inflationary bias during the 1970s. But Orphanides and van Norden (2002) investigate the consequences of using real-time measures of the output gap for the US: the findings from the exercises do not provide superior insights for that economy.

HP filter to the real GDP data and taking the growth rates of the resulting trend series, and adding this measure of real trend growth to the inflation target announced by the central bank. An increase in the nominal income gap should lead to a reduction in the interest rate, that is $\rho < 0$; in equation (5) an increase in the exchange rate should lead the central bank to react by increasing the interest rate ($\delta_{MT} > 0$).

Analysing countries that do not target inflation explicitly involves computing the nominal income target by applying the HP filter to the nominal GDP data and taking the growth rates of the resulting trend series, once more abstracting from cyclical fluctuations in nominal output. In modelling the G7 economies McCallum and Hargraves (1994) use the average growth rate for real GDP over several decades and an inflation target of 2 percent per annum. Whereas the G7 are advanced economies, emerging economies often experience rapid structural change and potential growth rates are time-variant even during a short time frame.

Equation (6) is McCallum's benchmark feedback mechanism including an exchange rate variable ($\delta_M < 0$). Equation (7) is a hybrid mixing a monetary base instrument with a target following Hall and Mankiw (1994). The hybrid target is specified as the deviation of annual inflation from its moving average and an output gap. In equations (6) and (7) an increase in the McCallum and in Hall-Mankiw targets should lead to a reduction in the monetary base, i.e. a tightening of the monetary policy stance; so $\theta < 0$ and $\chi < 0$ are expected. In the reaction functions with a monetary base instrument the coefficients on the exchange rate are expected to be negative ($\delta_M < 0$ and $\delta_{HM} < 0$) if the central bank tightens its policy stance following a depreciation.

Equation (8) is a nominal feedback rule following Duecker and Fisher's (1996) analysis of monetary policy in Switzerland. The analysis in this paper estimates the variable $\Delta(m-p)_{\langle t|t-1\rangle}$, which amounts to a technical approximation to the internal predictions a central bank is supposed to generate and use when designing its policy. In generating that variable the paper estimates a structural time series model from which a data sequence is generated for all the points in the given sample through the application of a Kalman filter. In producing the series $\Delta(m-p)_{\langle t|t-1\rangle}$ the analysis only uses information available up to the period t - 1 (Harvey, 1989). In equation (8) the coefficients β_{DF} and δ_{DF} are expected to be negative if the monetary authorities bring the implicit inflation target down following a increase in the inflation gap or a depreciation in the exchange rate.

5 Estimating the monetary policy reaction functions

5.1 Interest rate reaction functions for inflation targeting economies

Table 3 reports OLS estimates of Taylor-type reaction functions (equation 4) for the inflation targeting countries. The most important common element of policy behaviour in this group of estimates is instrument smoothing, showing high and statistically significant coefficients on lagged policy rates (English et al, 2003). Rudebusch and Svensson (1999) argue that gradualism in policy is characteristic of inflation targeting countries. The limited statistical significance of the inflation gap coefficient is unexpected given the success in disinflationary process in these economies.

The analysis also estimates equation (4) using the generalised method of moments (GMM) estimator and the results are reported in Table 3a. The instrument set for the GMM estimates contains lags 2 and 3 of the interest rate, and lags 1 and 2 of the inflation gap, the output gap, the exchange rate, and oil prices. The over-identifying restrictions for the set of instruments cannot be rejected for any economy in the sample in the entire family of rules.[9] The GMM estimates show that the coefficient on the inflation gap is statistically significant and positive in 5 economies, and the same holds for the output gap coefficient in 7 countries. Chile is the only economy displaying strong interest rate responses to the inflation gap and to the output gap. Figure 1 displays the actual path of the monetary policy interest rate and the inflation gap in Chile, showing a close relationship.

In economies for which the exchange rate variable is statistically significant it always carries the expected positive sign, excepting Peru. Israel's estimates point to strong responses to both inflation gap and the exchange rate. But Israel has also experienced deflation during the estimation sample.[10]

The insignificance of the exchange rate in Chile is a relevant result: it can be interpreted as the success of its monetary authorities in consolidating the inflation targeting regime. The reason is that from the mid-1980s until August 1999 the Central Bank of Chile had an exchange rate band regime in place. The estimations in the paper only span the formal post-1999 inflation targeting af-

[9] In the estimations where base money is the policy variable the monetary base replaces the interest rate in the instrument set.
[10] Benhabib, Schmitt-Grohé and Uribe (2001) theoretically show the undesirable possibility that Taylor-rules could drive the economy into a liquidity trap through self-fulfilling deflationary paths.

ter which the authorities have made clear that the primary objective is achieving the pre-announced inflation target.[11]

Mexico displays no significant response to the inflation gap and only a weakly significant reaction to the output gap. The estimated reaction function for South Korea indicates 'leaning with the wind' behavior, but the economy has managed to keep its inflation gap relatively low.

The paper explores the possibility that the behaviour of inflation targeting emerging economies is better described using a hybrid McCallum-Taylor policy reaction function mixing an interest rate instrument with a nominal income target (equation 5). Tables 4 and 4a show the OLS and the GMM estimates for the hybrid McCallum-Taylor reaction function. For most economies, we obtain the expected coefficient on the nominal income gap – a fall in nominal GDP growth with respect to its target implies a reduction in policy interest rates. In the GMM estimations the coefficient is statistically significant and negative in 10 countries.

The benchmark Taylor reaction function does not carry the expected sign for the inflation gap and the exchange rate for Peru, but the anomaly is corrected in the hybrid specification. The hybrid reaction functions further produce higher or equivalent R squared values for most economies under study, although the differences are not large. The results provide evidence that, on average, the behaviour of the inflation targeting emerging economies can be better captured by a hybrid McCallum-Taylor rule than by the benchmark Taylor-type reaction function.

The limited significance of the inflation target in the benchmark Taylor-rules could reflect the benign macroeconomic environment that has allowed for a disinflationary process without a strong stabilizing reaction from the monetary authority. However, there is evidence of stabilizing monetary policy in the hybrid McCallum-Taylor estimates where the nominal income gap is often significant. The importance of the exchange rate is limited even for those inflation targeters that are most open in terms of international trade (Czech Republic, Hungary, Thailand), and that arguably reflects the successful consolidation of the inflation targeting regimes.

[11] Schmidt-Hebbel and Tapia (2002) estimate a Taylor-type reaction function for Chile using time series data ranging from 1991 to 2001. Amongst other findings, Schmidt-Hebbel and Tapia reveal that the central bank increases monetary policy's interest rate following an exchange rate depreciation.

5.2 Monetary base reaction functions

Tables 5 and 6 report OLS and GMM estimates for the two rules with monetary base as the central bank's policy variable (equations 6 and 7). The results from running a McCallum-type rule, reported in Table 5, show that Uruguay and Venezuela follow a policy whereby an increase in the nominal income gap is met with an increase in monetary base, i.e. the central bank is leaning against the wind. Uruguay displays an estimated coefficient on the nominal income gap quite close to the value of 0.5 employed by McCallum in modelling Japan and the US (e.g. McCallum, 2003). The finding holds for the OLS and GMM estimates, and it is also true for Venezuela in the case of the OLS estimation. But the GMM estimate for Venezuela shows deviations from the target nominal income path are met with a relatively strong movement in the monetary base, significantly exceeding the McCallum-proposed value of 0.5. The strong reactions could be destabilizing for the economy.

Instrument smoothing is significant in the estimates for the four economies. The reaction of base money to the exchange rate is less important in the case of the McCallum-type rules than in its McCallum-Hall-Mankiw variant. In the case of the GMM estimates, only Costa Rica displays a statistically significant reaction to the exchange rate that is accommodative -exchange rate depreciations are met with an increase in base money.

Running the McCallum-Hall-Mankiw reaction functions reveal base money growth reactions with a statistically significant and positive coefficient to the hybrid gap in the case of Malaysia and Uruguay, suggesting that policy is accommodative. In the case of Venezuela the sign on the hybrid gap coefficient is negative, with a relatively high coefficient estimate, indicating a strong stabilizing reaction. Instrument smoothing is important in all other cases except for Malaysia. Monetary base growth's reaction to the exchange rate is statistically significant only in the case of Malaysia and Uruguay, with opposite signs[12]. Malaysia, where an appreciation in the exchange rate is met with expansionary domestic monetary policy in both the McCallum and McCallum-Hall-Mankiw variants, is the most open amongst the four economies studied.

Comparing the two reaction functions with base money growth as the policy instrument is expected to reveal that the estimated coefficients on the nominal income gap (Table 5) and on the hybrid target (Table 6) carry opposite signs: such is the case for the GMM estimates for all countries excepting Uruguay. Further comparing the two tables, only Venezuela seems to be consistently

[12] Malaysia had a dollar peg until 2005, so the paper also runs the reaction functions using a nominal effective exchange rate. The only difference arising from the exercises is that lagged policy variable becomes significant in the McCallum-Hall-Mankiw specification.

pursuing a policy of leaning against the wind, no matter how the target variable is specified. Such a reading would be possible also in the case of Uruguay on the basis of the McCallum-estimates, but its monetary base is positively associated with an increase in the hybrid Hall-Mankiw gap.

5.3 Nominal feedback rules

The paper estimates the historical behaviour of the monetary authorities in Ghana, Nigeria, and Tunisia employing a nominal monetary policy feedback rule (NFR) incorporating an implicit inflation targeting mechanism. The NFR is an alternative McCallum-type rule (see McCallum, 1999). The results in Table 7 reveal that the central banks of Ghana and Nigeria have, on average, pursued accommodative policies: the implicit inflation target increases when inflation is above the trend level. So the central banks display lean with the wind biases.

Ghana's adoption of a formal inflation targeting regime had a negative and statistically significant impact on the implicit inflation target variable, and that can be interpreted as a successful introduction of the new policy regime. Figure 2 shows the results from running exercises using the NFR estimated for Ghana in forecasting inflation after the introduction of fully-fledged inflation targeting in May 2007. The figure shows that the forecasts over-predict the implicit inflation target, which can serve as a measure of the new regime's success in bringing down inflation.

The outcomes of the empirical exercises for Ghana and Nigeria are sensible, given the degree of dependence that the central banks of these countries have historically had on the government's requirements. The fact that responses like those of an implicit inflation targeting regime cannot be consistently found for both countries should be considered in the light of the rules versus discretion debate (Kydland and Prescott, 1977), and the literature on central bank (non) independence springing from Alesina and Summers (1993).

Tunisia, however, displays results signalling that the central bank leans against the wind: the coefficient on the inflation gap and on the exchange rate depreciation is negative. The coefficients imply that the monetary authorities tighten the policy stance when inflation is above its trend and when the exchange rate is depreciating. The results reflect a commitment to improving policy outcomes.

6 Conclusion

The paper investigates monetary policy behaviour in emerging market economies. The analysis empirically estimates McCallum and Taylor monetary policy reaction functions for 20 economies implementing diverse monetary policy strategies. The modelling finds that the behaviour of the inflation targeting economies is better captured with a hybrid McCallum-Taylor rule incorporating a nominal income target than with a benchmark Taylor-type rule. Countries pursuing a mix of monetary and exchange rate targets portray differences in the reaction of policy to domestic targets - output gap, inflation gap, or a nominal income target- and the exchange rate.

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Table 1 Monetary policy regimes in selected emerging countries

Country		Period	Monetary policy strategies	Inflation target and range
1	Chile*	1991-1998 From 1999	Target from 1991, announced in September 1990 Full IT Interest rate: MPR is the policy rate	CPI 1991: 15%-20% 1992: 13%-16% 1993: 10%-12% 1994: 9%-11% 1995: ±8% 1996: ±6.5% 1997: ±5.5% 1998: ±4.5% Since 1999: 3% ±1%
2	Colombia	1999-present	IT Interest rate: overnight rate	CPI 2007 and 2008: 3.5% and 4.5% 2009: 3.0% and 3.5%
3	Costa Rica	From November 1995	Price and exchange rate stability/Crawling peg exchange rate regime. Interest rate: bonos de estabilización monetaria 6 meses (BME)	-
4	Czech Rep.	December 1997-present	IT Interest rate: 2 week repo rate	Net inflation 1998: 5.5%-6.5% 1999: 4%-5% 2000: 3.5%-5.5% 2001: 2%-4% CPI target band 2002-2005: moving from 3-5% to 2%-4% 2006-2009: CPI 3%
5	Ghana	From 2002 From May 2007	Implicit IT Full IT	CPI excluding energy and utility
6	Hungary	Mar 1995 – May 2001 June 2001-present	Crawling peg IT	CPI 2001: 7% ±1% 2002: 4.5% ±1% 2003-2004 : 3.5% ±1% 2005: 4% ±1% 2006: 3.5% ±1% Since 2007 : 3%

7	Israel	1992-present	IT Interest rate: headline rate (simple)	CPI 1992: 14–15% 1993: 10% 1994: 8% 1995: 8%–11% 1996: 8%–10% 1997: 7%–10% 1998: 7%–10% 1999: 4% 2000: 3%-4% 2001: 2.5%–3.5% 2002: 2%–3% Since 2003: 1%-3%
8	Malaysia	1976-1992 1993-1998 Sep 1998-Jul 2005 Jul 2005-present	Peg to composite basket Managed float Peg to USD Managed float	-
9	Mexico*	1987-1991 1991-1994 1995-1998 1999-2001 2001-present	*Pacto* programme Pegged exchange rate policy Exchange rate band Monetary targeting, since 1995 *corto* quantitative operating target IT light Full IT Interest rate: 28-day CETES From January 2008: interest rate target	CPI 1999: 13% 2000: <10% Since 2001: 3%
10	Nigeria	1974 to present	Monetary targeting (1974-92 direct control; indirect control from 1993) Interest- and exchange-rate controls in the 1970s and 1980s Market determined interest rates from 1986, alongside financial deregulation From 1996 full deregulation of interest rates Interest rate: policy rate is MPR	-

11	Peru	From 1994 January 2002	Announced inflation targets. Monetary targeting Full IT Interest rate: overnight bank loans The Peruvian monetary strategy allows switching from targeting overnight interest rate to monetary aggregate due to dollarization and potential adverse balance sheet effects	CPI 2.5% ±1%
12	Philippines	1984-1995 1995-2001 2002-present	Monetary targeting (with free float) IT light IT Interest rate: repo rate	CPI 2002-2003: 4.5%-5.5% 2004: 4%-5% 2005: 5%-6% 2006-2007: 4%-5% 2008: 4.0% ±1%
13	Poland	Until 1998 From 1999-present	Combination of monetary targeting and crawling peg IT Interest rate: reference rate	CPI 1999: 6.6%-7.8% 2000: 5.4%-6.8% 2001: 6%-8% 2002: 5% ±1% 2003: 3% ±1% Since 2004: 2.5% ±1%
14	South Africa	From 1985 From February 2000	M3 monetary targeting During the 1990s: monetary policy package also looking at the exchange rate and bank credit Full IT; monitoring of M3 as an information variable in the IT framework Targets announced in 2000 to be effective from 2002 Interest rate: Discount rate	CPIX (overall price index excluding the cost of changes in mortgage costs) 2002-2003: 3%-6% range 2004: initially 3%- 5%, but changed to 3%-6% Since 2005: 3%-6% range
15	South Korea	March 1990-Dec 1997 April 1998-present	Managed float (with monetary targeting) IT (with free float) Interest rate: base rate	CPI 1999: 3% ±1% 2000: 2.5% ±1% 2001-2003: 3%±1% 2004-2006: 2.5% ±3.5% 2007-2009: 3% ± 0.5%

16	Thailand	November 1984-Jun 1997 July 1997-May 2000 May 2000-present	Peg to currency basket Monetary targeting (with floating exchange rate) IT Interest rate: 14-day repo rate up until 16 January 2007, after which 1-day repo rate Since 12 February 2008, 1-day bilateral repo rate	Core inflation Since 2000: 0%-3.5%
17	Tunisia	1990s	Monetary growth targeting/constant real exchange rate rule	-
18	Turkey	1981-Feb 2001 2002-2005 2006-present	Crawling peg Implicit IT (with float) IT Interest rate: overnight lending rate	CPI 2002: 35% 2003: 20% 2004: 12% 2005: 8% 2006: 5% Since 2007: 4%
19	Uruguay	Before 2002 From 2002	Exchange rate peg Flexible exchange rate	-
20	Venezuela	1989-92 1993-2002 From 2002	Flexible exchange rate/monetary targeting Price stability as primary objective Mix of monetary and inflation targets	-

Sources: central banks' web pages. * Mishkin and Schmidt-Hebbel (2001), Table 2.

Table 2 Variables in the family of monetary policy reaction functions

Variable	Description	Units
Monetary policy instruments		
R_t	Interest rate controlled by the monetary authorities	Percentage
Δb_t	Annual rate of change in the log of the monetary base: $\Delta b_t = b_t - b_{t-4}$	Percent x 100
$\Delta m_t - \Delta(m-p)_{\langle t \mid t-1 \rangle}$	Annual change in the log of the nominal monetary aggregate ($\Delta m_t = m_t - m_{t-4}$) minus the predicted annual change in the real monetary aggregate $\Delta(m-p)$ using information available in the previous period	Percent x 100
Monetary policy targets		
$(\bar{\pi}_t - \pi^*)$	Inflation gap defined as the difference between a moving average of annual inflation, measured as $\pi_t = p_t - p_{t-4}$, and the inflation target announced by the monetary authorities in inflation targeting economies	Percent x 100
$(y_t - \tilde{y})$	Output gap defined as deviations of log output from trend log output computed using the Hodrick-Prescott filter	Percent x 100
$(\Delta x_t^* - \Delta x_{t-1})$	McCallum's nominal income gap measure, expressed as the difference between the annual change in the target nominal income and the annual change in the previous period's annual nominal income. For the inflation targeting economies is the sum of real output passed through the HP filter and the inflation target announced by the monetary authorities.	Percent x 100
$(\pi_t - \Delta\bar{p}_t + \hat{y}_t)$	Hybrid gap measure following Hall and Mankiw, expressed as deviations of annual inflation from its moving average and a measure of the real output gap	Percent x 100
Δe_t	Annual change in the log of the nominal exchange rate	Percent x 100

Table 3 Taylor-type reaction functions for inflation targeting economies, OLS

The dependent variable is R (%)

Countries / Coefficients	Chile 99Q2-07Q3	Colombia 00Q1-07Q3	Czech Republic 98Q1-08Q3	Hungary 02Q1-08Q3	Israel 96Q1-08Q4	Mexico 99Q1-07Q3	Peru 02Q1-07Q1
Inflation gap $\bar{\pi}_t - \pi_t^*$ (%): β	0.44 (0.28)	-0.18 (0.33)	-0.09 (0.09)	0.36 (0.37)	0.16* (0.09)	-0.24 (0.30)	-0.32 (0.61)
Real output gap $y_t - \tilde{y}_t$ (%): λ	0.23*** (0.07)	0.09 (0.17)	0.26** (0.10)	0.04 (0.16)	0.06 (0.04)	0.42* (0.22)	0.28** (0.12)
Exchange rate Δe_t (%): δ_T	0.009 (0.01)	0.01 (0.01)	0.007 (0.008)	-0.002 (0.029)	0.06** (0.02)	0.03 (0.04)	0.04 (0.09)
Lagged policy rate R_{t-1} (%): φ_T	0.64*** (0.19)	0.75*** (0.12)	0.94*** (0.06)	0.80*** (0.14)	0.86*** (0.05)	0.77*** (0.09)	0.12 (0.54)
R^2	0.85	0.88	0.97	0.68	0.95	0.95	0.66

Table **3** continued…

Countries / Coefficients	Philippines 02Q1-08Q3	Poland 01Q1-08Q3	South Africa 01Q1-07Q3	South Korea 00Q1-08Q3	Thailand 02Q4-08Q3	Turkey 02Q3-07Q4
Inflation gap $\bar{\pi}_t - \pi_t^*$ (%): β	0.14** (0.05)	0.19 (0.15)	0.005 (0.09)	-0.21** (0.08)	0.25*** (0.07)	0.25 (0.17)
Real output gap $y_t - \tilde{y}_t$ (%): λ	-0.02 (0.19)	0.25* (0.13)	0.50 (0.40)	0.04 (0.03)	0.10 (0.10)	0.06 (0.57)
Exchange rate Δe_t (%): δ_T	0.03** (0.01)	0.01 (0.02)	0.01 (0.01)	0.004 (0.006)	0.03*** (0.01)	0.10** (0.04)
Lagged policy rate R_{t-1} (%): φ_T	0.68** (0.16)	0.83*** (0.04)	0.93*** (0.11)	0.83*** (0.10)	0.83*** (0.09)	0.82*** (0.16)
R^2	0.77	0.98	0.91	0.92	0.97	0.98

Notes on Table 3: OLS ordinary least squares. Coefficients' significance is determined using jackknife heteroskedasticity and autocorrelation consistent standard errors displayed inside parentheses (MacKinnon and White, 1985). ***, ** and * denote coefficient significance at the 1, 5 and 10 levels, respectively.

Table 3a Taylor-type reaction functions for inflation targeting economies, GMM

The dependent variable is R (%)

Countries / Coefficients	Chile 99Q2-07Q3	Colombia 00Q1-07Q3	Czech Republic 98Q1-08Q3	Hungary 02Q1-08Q3	Israel 96Q1-08Q4	Mexico 99Q1-07Q3	Peru 02Q1-07Q1
Inflation gap $\bar{\pi}_t - \pi_t^*$ (%): β	0.46*** (0.10)	-0.01 (0.25)	-0.01 (0.05)	0.21 (0.14)	0.12** (0.05)	-0.16 (0.13)	-0.64*** (0.18)
Real output gap $y_t - \tilde{y}_t$ (%): λ	0.38*** (0.05)	0.41** (0.15)	0.04 (0.05)	-0.02 (0.16)	0.03 (0.04)	0.20* (0.11)	0.24*** (0.04)
Exchange rate Δe_t (%): δ_T	-0.002 (0.005)	0.03** (0.01)	-0.006 (0.008)	-0.003 (0.029)	0.12*** (0.01)	0.10*** (0.03)	-0.08*** (0.02)
Lagged policy rate R_{t-1} (%): φ_T	0.68*** (0.19)	0.68*** (0.05)	1.00*** (0.05)	0.46** (0.21)	0.83*** (0.03)	0.91*** (0.05)	0.003 (0.14)
R^2	0.81	0.86	0.90	0.38	0.93	0.93	0.68
J-statistic	0.11	0.13	0.09	0.19	0.12	0.10	0.18

Table 3a continued…

Countries / Coefficients	Philippines 02Q1-08Q3	Poland 01Q1-08Q3	South Africa 01Q1-07Q3	South Korea 00Q1-08Q3	Thailand 02Q4-08Q3	Turkey 02Q3-07Q4
Inflation gap $\bar{\pi}_t - \pi_t^*$ (%): β	0.19*** (0.02)	0.001 (0.04)	-0.11*** (0.02)	-0.34*** (0.03)	0.39*** (0.10)	0.54*** (0.02)
Real output gap $y_t - \tilde{y}_t$ (%): λ	-0.64*** (0.09)	0.36*** (0.04)	0.84*** (0.24)	0.11*** (0.01)	-0.32*** (0.11)	-1.29*** (0.16)
Exchange rate Δe_t (%): δ_T	0.02*** (0.007)	0.001 (0.008)	0.02*** (0.006)	0.006 (0.004)	-0.02 (0.01)	0.11*** (0.008)
Lagged policy rate R_{t-1} (%): φ_T	0.59*** (0.04)	0.94*** (0.01)	1.14*** (0.02)	0.67*** (0.05)	0.47*** (0.12)	0.39*** (0.03)
R^2	0.61	0.98	0.90	0.90	0.93	0.98
J-statistic	0.17	0.12	0.20	0.13	0.17	0.20

Notes on Table 3a: GMM generalized method of moments. The instruments are lags 2 and 3 of the interest rate, and lags 1 and 2 of the inflation gap, the output gap, the exchange rate, and oil prices. ***, ** and * denote coefficient significance at the 1, 5 and 10 levels, respectively. The J-statistic tests the validity of the over-identifying restrictions for the GMM estimations.

Table 4 Hybrid McCallum-Taylor monetary policy reaction functions for inflation targeting economies, OLS

The dependent variable is R (%)

Countries / Coefficients	Chile 99Q2-07Q3	Colombia 00Q1-07Q3	Czech Republic 98Q1-08Q3	Hungary 02Q1-08Q3	Israel 96Q1-08Q4	Mexico 99Q1-07Q3	Peru 02Q1-07Q1
Nominal income gap $\Delta x_t^* - \Delta x_{t-1}$ (%): ρ	-0.09*** (0.06)	-0.24*** (0.07)	-0.05 (0.03)	-0.11* (0.07)	-0.10** (0.04)	-0.14 (0.08)	-0.11*** (0.03)
Exchange rate Δe_t (%): δ_{MT}	0.02 (0.02)	0.01 (0.01)	0.02* (0.008)	-0.01 (0.02)	0.05** (0.02)	-0.01 (0.05)	0.12 (0.07)
Lagged policy rate R_{t-1} (%): φ_{MT}	0.86*** (0.08)	0.76*** (0.11)	0.85*** (0.06)	0.74*** (0.10)	0.88*** (0.04)	0.80*** (0.06)	0.43 (0.23)*
R^2	0.86	0.91	0.97	0.70	0.95	0.94	0.60
Countries / Coefficients	Philippines 02Q1-08Q3	Poland 01Q1-08Q3	South Africa 01Q1-07Q3	South Korea 00Q1-08Q3	Thailand 00Q4-08Q3	Turkey 02Q3-07Q4	
Nominal income gap $\Delta x_t^* - \Delta x_{t-1}$ (%): ρ	-0.06 (0.04)	-0.20** (0.08)	-0.14* (0.08)	0.008 (0.02)	-0.11*** (0.02)	0.002 (0.119)	
Exchange rate Δe_t (%): δ_{MT}	0.02 (0.01)	0.02 (0.02)	0.02* (0.01)	-0.01* (0.007)	0.02** (0.01)	0.12** (0.05)	
Lagged policy rate R_{t-1} (%): φ_{MT}	0.76** (0.14)	0.92*** (0.05)	0.83*** (0.06)	1.09** (0.08)	0.95*** (0.04)	0.85*** (0.04)	
R^2	0.71	0.98	0.91	0.90	0.95	0.98	

Notes on Table 4: OLS ordinary least squares. Coefficients' significance is determined using jackknife heteroskedasticity and autocorrelation consistent standard errors displayed inside parentheses (MacKinnon and White, 1985). ***, ** and * denote coefficient significance at the 1, 5 and 10 levels, respectively.

Table 4a Hybrid McCallum-Taylor monetary policy reaction functions for inflation targeting economies, GMM

The dependent variable is R (%)

Countries / Coefficients	Chile 99Q2-07Q3	Colombia 00Q1-07Q3	Czech Republic 98Q1-08Q3	Hungary 02Q1-08Q3	Israel 96Q1-08Q4	Mexico 99Q1-07Q3	Peru 02Q1-07Q1
Nominal income gap $\Delta x_t^* - \Delta x_{t-1}$(%): ρ	-0.11** (0.04)	-0.23*** (0.02)	-0.09** (0.03)	-0.18*** (0.03)	-0.07 (0.04)	-0.09 (0.07)	-0.16*** (0.01)
Exchange rate Δe_t (%): δ_{MT}	-0.03 (0.02)	-0.00 (0.00)	0.00 (0.00)	-0.02*** (0.00)	0.05*** (0.01)	0.01 (0.47)	0.07*** (0.01)
Lagged policy rate R_{t-1} (%): φ_{MT}	1.01*** (0.07)	0.72*** (0.04)	0.91*** (0.04)	0.69*** (0.04)	0.83*** (0.02)	0.84*** (0.03)	0.29*** (0.08)
R^2	0.61	0.90	0.94	0.68	0.94	0.92	0.40
J-statistic	0.14	0.11	0.13	0.14	0.12	0.09	0.15
Countries / Coefficients	Philippines 02Q1-08Q3	Poland 01Q1-08Q3	South Africa 01Q1-07Q3	South Korea 00Q1-08Q3	Thailand 00Q4-08Q3	Turkey 02Q3-07Q4	
Nominal income gap $\Delta x_t^* - \Delta x_{t-1}$(%): ρ	-0.15** (0.06)	-0.23*** (0.04)	-0.16*** (0.03)	0.05** (0.02)	-0.13*** (0.02)	-0.27*** (0.07)	
Exchange rate Δe_t (%): δ_{MT}	0.01** (0.00)	0.01 (0.01)	0.03*** (0.00)	-0.01 (0.00)	0.02*** (0.00)	0.03 (0.02)	
Lagged policy rate R_{t-1}(%): φ_{MT}	0.95*** (0.05)	0.99*** (0.01)	0.91*** (0.02)	-1.15*** (0.09)	0.80*** (0.05)	0.86*** (0.02)	
R^2	0.71	0.98	0.91	0.87	0.93	0.96	
J-statistic	0.14	0.09	0.19	0.16	0.15	0.24	

Notes on Table 4a: GMM generalized method of moments. The instruments are lags 2 and 3 of the interest rate, and lags 1 and 2 of the nominal output gap, the exchange rate, and oil prices. ***, ** and * denote coefficient significance at the 1, 5 and 10 levels, respectively. The J-statistic tests the validity of the over-identifying restrictions for the GMM estimations.

Table 5 McCallum-type reaction functions, OLS and GMM

The dependent variable is the rate of change of the monetary base (Δb) (%)

Countries Coefficients	Costa Rica 00Q1-07Q2		Malaysia 01Q1-08Q3		Uruguay 01Q1-07Q1		Venezuela 02Q1-07Q4	
Nominal income gap $\Delta x_t^* - \Delta x_{t-1}$ (%): θ	OLS	GMM	OLS	GMM	OLS	GMM	OLS	GMM
	-2.25** (1.09)	-1.97* (1.11)	-0.29* (0.15)	-0.02 (0.20)	0.44* (0.22)	0.63*** (0.14)	0.63** (0.28)	1.03*** (0.24)
Exchange rate Δe_t (%): δ_M	0.72 (0.78)	0.79** (0.32)	-0.57*** (0.19)	0.01 (0.19)	-0.05 (0.16)	-0.02 (0.09)	-0.21 (0.24)	0.17 (0.12)
Lagged policy instrument Δb_{t-1}(%): μ_M	0.57*** (0.11)	1.14*** (0.14)	0.19* (0.10)	1.45*** (0.31)	0.70*** (0.12)	0.49*** (0.09)	0.91*** (0.14)	0.84*** (0.09)
R^2	0.77	0.58	0.50	-0.35	0.63	0.56	0.72	0.51
J-statistic	-	0.13	-	0.09	-	0.17		0.15

Notes on Table 5: OLS ordinary least squares. Coefficients' significance is determined using jackknife heteroskedasticity and autocorrelation consistent standard errors displayed inside parentheses (MacKinnon and White, 1985). For Venezuela the instrument is proxied by a narrow monetary aggregate. GMM generalized method of moments. The instruments are lags 2 and 3 of the monetary base, and lags 1 and 2 of the nominal income gap, the exchange rate, and oil prices. ***, ** and * denote coefficient significance at the 1, 5 and 10 levels, respectively. The J-statistic tests the validity of the over-identifying restrictions for the GMM estimations.

Table 6 McCallum-Hall-Mankiw reaction functions, OLS and GMM

The dependent variable is the rate of change of the monetary base (Δb) (%)

Countries / Coefficients	Costa Rica 00Q1-07Q2		Malaysia 01Q1-08Q3		Uruguay 01Q1-07Q1		Venezuela 02Q1-07Q4	
	OLS	GMM	OLS	GMM	OLS	GMM	OLS	GMM
Hybrid target Hall-Mankiw $\pi_t - \Delta\bar{p}_t + \hat{y}_t$ (%): χ	0.72 (1.09)	0.98 (1.10)	1.04** (0.39)	1.39** (0.56)	-0.47 (0.96)	2.28** (0.86)	-1.25* (0.69)	-3.89*** (0.87)
Exchange rate Δe_t (%): δ_{HM}	0.66 (0.83)	-0.37 (0.37)	-0.68*** (0.22)	-0.60** (0.22)	0.06 (0.14)	0.33** (0.13)	-0.27 (0.22)	-0.30 (0.23)
Lagged policy instrument Δb_{t-1}(%): μ_{HM}	0.77*** (0.14)	0.89*** (0.10)	-0.12* (0.07)	-0.07 (0.41)	0.83*** (0.09)	0.64*** (0.12)	0.96*** (0.14)	0.80*** (0.14)
R^2	0.71	0.61	0.37	0.39	0.72	0.21	0.72	0.27
J-statistic	-	0.17	-	0.14	-	0.10	-	0.16

Notes on Table 6: OLS ordinary least squares. Coefficients' significance is determined using jackknife heteroskedasticity and autocorrelation consistent standard errors displayed inside parentheses (MacKinnon and White, 1985). For Venezuela the instrument is proxied by a narrow monetary aggregate. GMM generalized method of moments. The instruments are lags 2 and 3 of the monetary base, and lags 1 and 2 of the hybrid Hall-Mankiw target, the exchange rate, and oil prices. ***, ** and * denote coefficient significance at the 1, 5 and 10 levels, respectively. The J-statistic tests the validity of the over-identifying restrictions for the GMM estimations.

Table 7 McCallum-Dueker-Fischer nominal feedback equations, OLS

The dependent variable is the implicit inflation target

$$\Delta m_t - \Delta(m-p)_{\langle t|t-1\rangle} \ (\%)$$

Countries / Coefficients	Ghana 86Q1-06Q4	Nigeria 86Q1-06Q3	Tunisia 93Q3-07Q1
Inflation gap $\pi_t - \pi_t^*$ (%): β_{DF}	0.62*** (0.09)	1.11*** (0.39)	-7.96*** (1.56)
Exchange rate Δe_t (%): δ_{DF}	0.08 (0.08)	-	-1.23*** (0.22)
Inflation targeting dummy from 2002	-6.55** (2.63)	-	-
R^2	0.63	0.66	0.75

Notes on Table 7: OLS ordinary least squares. Coefficients' significance is determined using standard errors displayed inside parentheses. ***, ** and * denote coefficient significance at the 1, 5 and 10 levels, respectively. The coefficients reported are the long-run solutions to autoregressive distributed lag models of order 4. All the solutions are valid according to the corresponding Wald tests. The real money demand forecast is computed using a STM and the Kalman filter. The reference inflation rate used in computing the inflation gap is the 16 quarter moving average of the inflation rate.

Table A1 List of countries in the sample

1. Chile	11. Peru
2. Colombia	12. Philippines
3. Costa Rica	13. Poland
4. Czech Republic	14. South Africa
5. Ghana	15. South Korea
6. Hungary	16. Thailand
7. Israel	17. Tunisia
8. Malaysia	18. Turkey
9. Mexico	19. Uruguay
10. Nigeria	20. Venezuela

Figure 1 Monetary policy interest rate and inflation gap in Chile

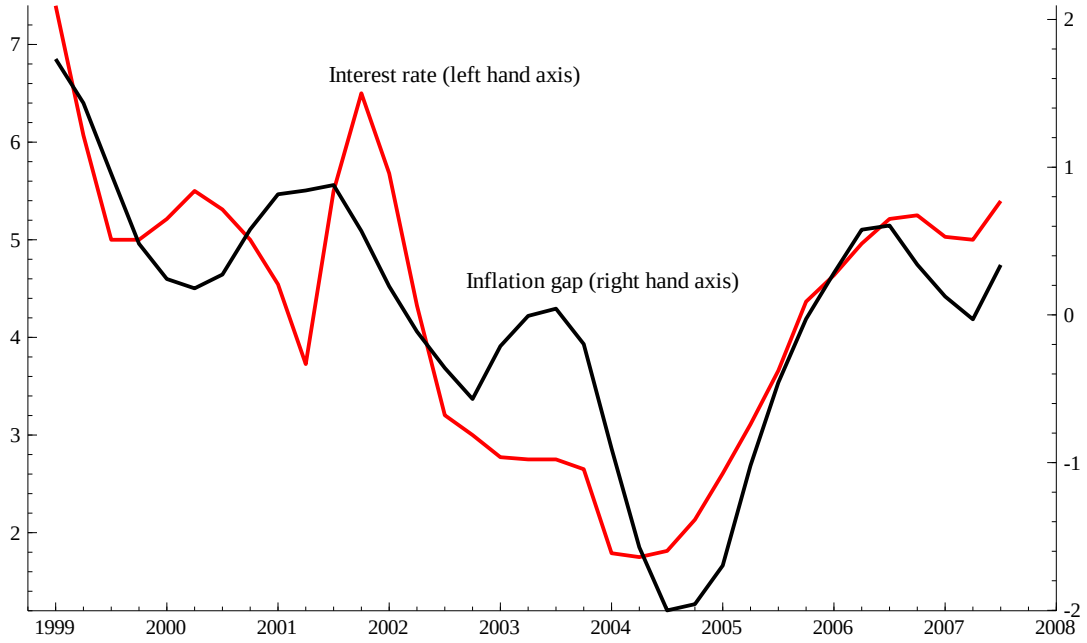
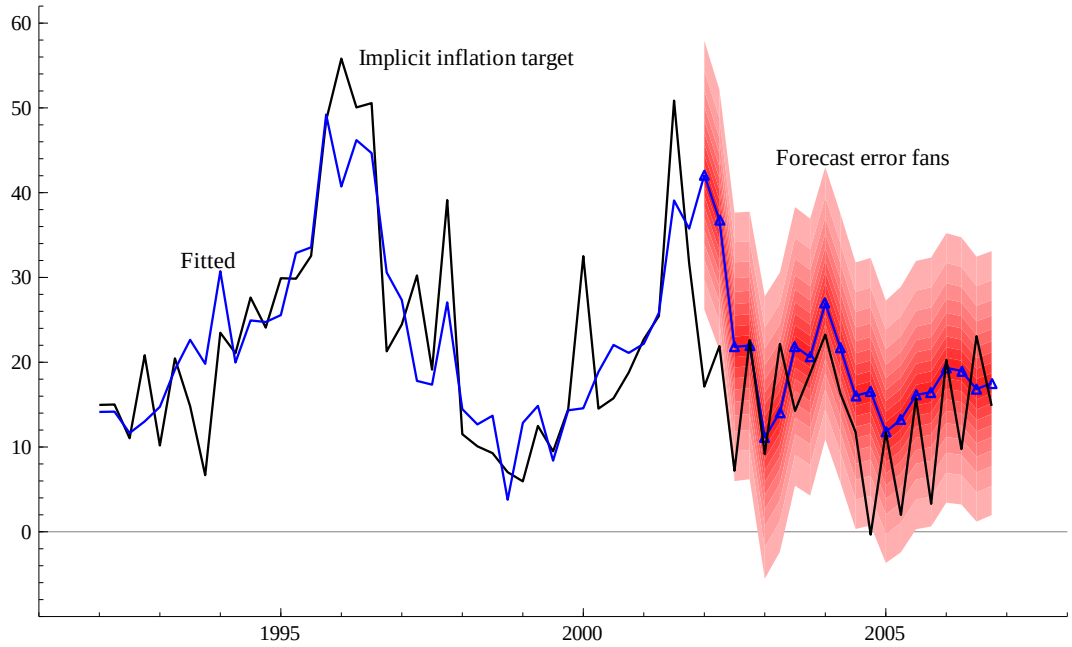
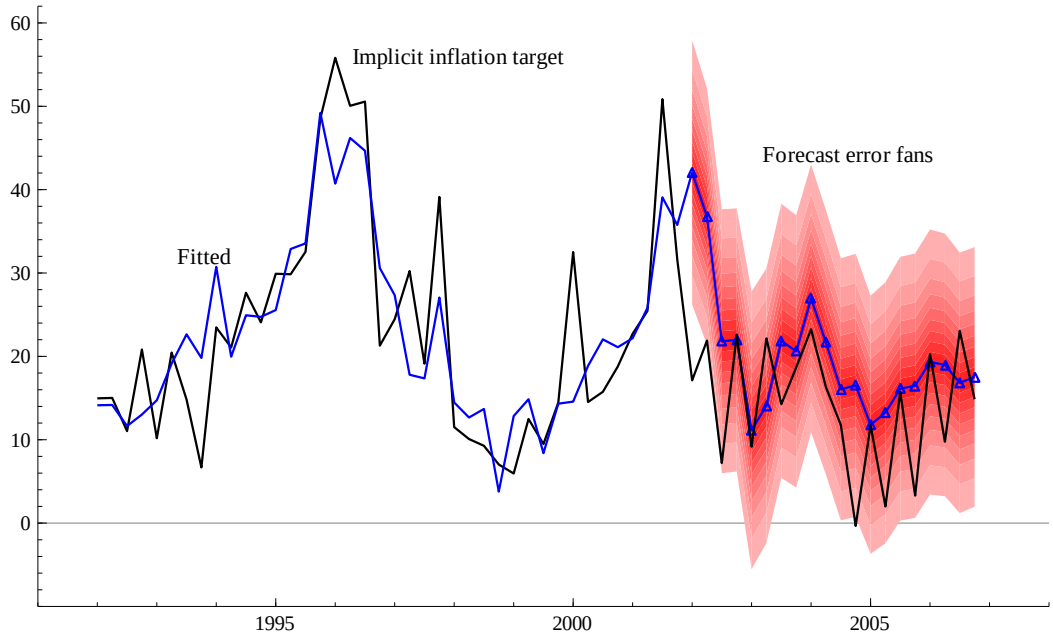


Figure 2 Forecasting the implicit inflation target in Ghana following inflation targeting adoption
Two forecast error fans shown in the red shaded area





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