Central Bank Performance under Inflation Targeting

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Abstract

The inflation targeting (IT) regime is 17 years old. With practice of IT now in more than 21 countries, there is enough evidence gathered to take stock of the IT experience. In this paper, we analyze the inflation record of IT central banks. We extend the work of Albagli and Schmidt-Hebbel (2004) by looking at a broad range of factors that can influence inflation target deviations and by identifying the empirical determinants of successful monetary policy under IT. We find that part of the cross-country and time variation in inflation deviations from targets can be explained by exchange rate movements, fiscal deficits, and differences in financial sector development. With respect to the components of the IT framework, we find that a higher inflation target and a larger inflation control range are associated with more variable inflation (and output) outcomes. Although the theoretical and empirical literature suggest that greater central bank transparency is desirable, our findings suggest that transparency is either detrimental or unrelated to performance. Interestingly, central banks using economic models do a better job of stabilizing inflation and output around trend.

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1. Introduction

Inflation targeting (IT) is becoming an increasingly popular framework for monetary policy. This monetary regime was first adopted by the Reserve Bank of New Zealand in 1990, followed by the Bank of Canada in 1991 and the Bank of England in 1992. Since then, five other industrial economies and 13 emerging market economies have joined the group and new ones are added each year. The U.S. Federal Reserve is also considering the adoption of IT.[1] The IT regime is 17 years old. With practice of IT now in more than 21 countries, there is enough evidence gathered to take stock of the IT experience.

Although there is ample literature on the macroeconomic effects of IT, a very limited number of papers look at the inflation performance of central banks under IT. Inflation outcomes may be the result of several other factors than monetary policy, especially in the case of small open economies. Nevertheless, on average, a successful IT central bank should be expected to hit its target. What is the relative success of IT central banks in hitting their target? Is the performance of IT central banks different once exogenous inflation shocks are taken into account?

At the same time, there is a general agreement among central bankers and academics that central bank transparency (i.e. the extent to which an institution discloses information that is related to the policymaking process) is key to successful monetary policy. According to the International Monetary Fund, the effectiveness of monetary policy can be strengthened if the goals and instruments of policy are known to the public.[2] If greater effectiveness of policy is indeed associated with greater transparency, then we should expect more transparent central banks to have a better inflation record. What are the institutional determinants of inflation deviations once exogenous economic shocks are controlled for? Do the characteristics of the monetary policy framework (e.g. central bank transparency) matter for the inflation performance?

This paper contributes to the literature by analyzing the inflation performance of IT central banks with a focus on the empirical role of macroeconomic shocks, the financial environment, and the characteristics of the monetary policy framework. In particular, we perform regression-based tests of the hypothesis that greater central bank transparency reduces inflation deviations from targets. The key findings can be summarized as follows:

[1] Meyer and Sack (2006).
[2] Code of Good Practices on Transparency in Monetary and Financial Policies.

- The cross-country and time variation of inflation outcomes relative to targets is substantial;
- Part of this dispersion can be explained by exchange rate movements, fiscal deficits, and differences in financial sector development;
- Central banks using a higher inflation target and a larger control range tend to have larger inflation deviations (and bigger output gaps);
- Measures of transparency are either insignificant or negatively correlated with inflation accuracy;
- Central banks using models do a better job of stabilizing inflation and output around trend;
- Inflation accuracy is strongly correlated with central bank independence.

Our findings could have useful applications. First, a better understanding of the determinants of inflation target deviations could provide guidance to an increasing number of central banks from emerging market economies considering the adoption of IT. Second, it could also help IT countries improve the design of their monetary policy framework by learning from successful IT countries. Third, there might be some useful insights for the U.S. Federal Reserve that would help it better design an eventual inflation target.

This paper is divided into 6 sections. Section 2 discusses the literature on the IT experience and provides some theoretical and empirical facts regarding central bank transparency. Section 3 establishes key stylized facts on the inflation record of IT central banks. Section 4 presents an empirical examination of the factors that influence central bank performance under IT. Section 5 proposes some lessons to learn from our findings and section 6 provides a conclusion.

2. Literature Review

We begin with a survey of the literature on the international experience with inflation targets and then summarize the key conclusions of the research on the role of central bank transparency.

2.1 The Inflation Targeting Experience

It is not possible to discuss the literature on IT without mentioning the ongoing debate regarding the benefits of adopting an inflation target.[3] The main conclusions of this debate are well summarized in Mishkin (2006):

[3] This debate has generated a significant amount of papers. See Levin, Natalucci, and Piger (2004), Orphanides and Williams (2005), Ball and Sheridan (2005), and Gurkaynak et al (2006) to name but a few.

- Inflation and interest rate levels have declined following the adoption of IT ;
- Output volatility has not increased following the adoption of IT ;
- Exchange rate pass-through seems to be attenuated following the adoption of IT;
- IT countries have not done better than non-IT countries since these developments were also experienced by non-IT countries;
- Inflation persistence is lower in IT countries;
- Inflation expectations appear to be better anchored in IT countries.

The macroeconomic benefits of IT remain a source of debate. There is a consensus, however, that IT has led to substantial improvements in the practice of monetary policy. These improvements include a more systematic and consistent internal decision process, more transparent communication with the private sector, and a high degree of accountability (Svensson, 2005). No central bank has given up IT, regardless of the magnitude, duration, and frequency of inflation target misses. Roger and Stone (2005) point out that this is due to the flexibility of the framework in handling shocks, high standards of transparency and accountability, and the lack of alternative monetary regime. Similarly, Paulin (2006) looks at the evolution of the IT arrangements of industrial countries and concludes that the resilience of the regime is attributable to its credibility and flexibility.

Roger and Stone also review the institutional elements of IT frameworks (i.e. the definition of the target in terms of level, range, horizon, and measure) and examine the inflation record of central banks under IT. When comparing actual and targeted inflation they find that:

- There is a greater dispersion of inflation outcomes around targets in emerging market economies relative to developed countries;
- There is a bias around the target, as countries in disinflation process tend to overshoot the target while countries with stable targets tend to undershoot the target;
- The persistence of deviations of inflation from the target is consistent with the typical monetary policy transmission lags.

Albagli and Schmidt-Hebbel (2004) is the closest study to ours. They look at a number of descriptive statistics of the IT experience and perform a panel analysis of deviations of actual inflation from the target. When controlling for exchange rate shocks, they find that the target level and the size of the

target range are key determinants of inflation target deviations. They also find a role for central bank independence and policy credibility.[4]

2.2 Central Bank Transparency

The optimal monetary policy literature favours greater transparency. Central banks should communicate their complete state-contingent rule given the forward-looking behaviour of economic agents (Woodford, 2005). Orphanides and Williams (2005) show that the monetary authority is able to achieve a substantially better inflation-output gap stabilization trade off when private agents fully understand the equilibrium dynamics implied by the central bank's policy rule. As Woodford notes, better information on the part of financial markets about central bank actions and intentions increases the effectiveness of monetary policy in that the actual changes in the overnight rate required to achieve the desired changes in incentives can be much more modest when expected future rates move as well.[5] In unison with Woodford, Svensson (2005) notes that additional progress in the conduct of monetary policy could be made by central banks being more specific, systematic and transparent about their operational objective, their forecasts, and their communications. More transparent central banks should be expected to have a better inflation record. Demertzis and Hughes Hallett (2003) show that the variance of inflation is a positive function of the lack of central bank transparency perceived by the public.

Although greater transparency may be desirable, it may not be feasible. Macklem (2005), Goodhart (2001, 2005), and Mishkin (2004) argue that the complete state-contingent rule is too complex for a central bank to work out anytime soon. In addition, Morris and Shin (2002) show that when the level of some target variable is highly uncertain (e.g. potential output, fundamental asset prices) and the central bank is unlikely to have superior information about it compared to the private sector, disclosure of the associated target causes financial market participants to ignore their private information and coordinate on the noisy disclosed target, leading to greater volatility. According to Cukierman (2005), full transparency may not be optimal in all instances: problems in the financial system and disagreements within the monetary policy committee (MPC) are situations in which less transparency may be preferable. Yet, there appears to be room for further innovations in transparent monetary

[4] Policy credibility is proxied by the International Country Risk Guide measure of institutional quality and various country risk premia.

[5] As Svensson (2006) notes, it is not the current level but private-sector expectations of the entire future path of the interest rate that matters for the economy. These expectations feed into longer term interest rates and asset prices, which affect private-sector decisions.

policy, as shown by the enthusiasm of Svensson (2006) regarding the experience of Norway with the publication of interest rate path projections.[6]

There is general agreement among central bankers that transparency is a key aspect of successful monetary policy. In a survey of 94 central banks, Fry et al (2000) find that 74 per cent of respondents consider transparency a "vital" or "very important" component of their monetary policy framework.[7] Using the same survey, Geraats (2005) finds that central banks are not transparent in all respects, however. She notes that, while it is common to provide an explanation of policy changes on the day of a change to the instrument rate and to include forecasts in regular central bank reports and bulletins, it is unusual to publish voting records and minutes of MPC meetings. Two papers attempt to measure transparency. Based on the information published by central banks and other government sources, Eijffinger and Geraats (2005) construct an index of central bank transparency for nine countries.[8] While this measure quantifies the degree of openness of central banks based on the information provided, it does not necessarily reflects the true degree of understanding, by the public, of central banking practices. This weakness motivated Kia and Patron (2004) to develop an objective market-based transparency index. Available only for the United States, their index covers the period 1982-2003 and has the advantage of reflecting what market participants understand from the Federal Reserve's actions and signals.

Often taking the form of event studies, the empirical literature evaluating transparency generally comes to the conclusion that greater central bank transparency is beneficial. Chortareas et al (2002) show that the publication of more detailed central bank forecasts reduces average inflation in a cross-section of 82 countries. Geraats et al (2006), use the central bank transparency index of Eijfinger and Geraats (2005) and find some evidence that greater transparency reduces interest rates in 8 industrial economies. In the case of Canada, Parent et al (2003) find that the introduction of a schedule of dates for policy interest rate announcements increased the predictability of the Bank of Canada's interest rate decisions and the financial markets' understanding of Canadian monetary policy.[9] Not all central bank communication channels are as efficient, however. For the U.S., Reinhart and Sack (2006) find

[6] Rudebusch and Williams (2006) show that, in a New Keynesian model, central communication of interest rate projections may improve macroeonomic performance.
[7] Only independence of the central bank and the maintenance of low inflation expectations are rated higher.
[8] According to this index, the most transparent institutions are the Reserve Bank of New Zealand, the Swedish Riksbank, and the Bank of England.
[9] Muller and Zelmer (1999) come to similar conclusions with respect to the introduction of the Bank of Canada's Monetary Policy Report in the 1990s.

that monetary policy testimonies and FOMC statements are more effective than speeches by individual Committee members. None of these papers look at the impact of central bank transparency on the success in hitting the inflation target.

3. Stylized Facts of the Inflation Targeting Experience

Since official inflation targets provide a clear benchmark against which monetary policy can be evaluated, we measure the inflation performance of central banks under IT in terms of deviations of realized total year-over-year CPI inflation from targeted inflation (at the quarterly frequency). We employ total inflation since, although some central banks emphasize a core measure of the CPI, the official target variable is always defined in terms of total inflation because total inflation is highly visible and readily understood by the public. For central banks using an inflation control range, we use the midpoint of the band as the numerical target. This is a realistic assumption since the midpoint of the range is evidently what is aimed for in order to maximize chances of maintaining inflation within the band.[10]

The sample includes 21 IT economies: eight industrial countries (Australia, Canada, Iceland, New Zealand, Norway, Sweden, Switzerland, and the United Kingdom) and 13 emerging market economies (Brazil, Chile, Colombia, the Czech Republic, Hungary, Israel, Korea, Mexico, Peru, the Philippines, Poland, South Africa, and Thailand).[11,12] The country-specific inflation target level or center of target range and regime starting dates are taken from Mishkin and Schmidt-Hebbel (2005). For most countries, these dates cover both declining inflation target (i.e. disinflation) and stable inflation target periods.[13] The sample is an unbalanced panel of 699 observations ending in the fourth quarter of 2005. All statistics are reported in Appendix 1.

As in Paulin (2006), we identify two waves of IT adoption for the industrial economies: one in the first part of the 1990s and another around 2000-01 (Table 1). Using 2005Q4 as the last observation, the average age of the IT regime is about 10 years in industrial economies. Canada, Iceland and New Zealand went through a disinflation episode, which lasted 3.2 years on average. The 2005 target level

[10] Paulin (2006) notes that, in practice, IT central banks tend to downplay the role of the edges of the range, viewing them primarily as a communication tool to provide clarity on the degree of tolerance with respect to the variance of inflation.

[11] We did not include the euro area in the sample since the ECB does not consider itself an inflation targeter. Albagli and Schmidt-Hebbel (2004) and Roger and Stone (2005) also exclude the euro zone from their sample.

[12] The Slovak Republic, Indonesia, Romania, and Turkey moved to IT in 2005-06.

[13] The stable IT and disinflation periods are also taken from Mishkin and Schmidt-Hebbel (2005).

or center of range is either 2.5 per cent (Australia, Iceland, and Norway) or 2 per cent (Canada, New Zealand, Sweden, and the United Kingdom).[14]

On average, the IT regime is more recent in the emerging market economies (7½ years, Table 2). Three waves of adoption are identified: the early 1990s (Chile, Israel, and Peru), the late 1990s (Brazil, Colombia, the Czech Republic, Korea, Mexico, and Poland), and 2000-01 (Hungary, the Philippines, South Africa, and Thailand). Except for South Africa and Thailand, all countries have been (or are still going) through a disinflation phase. As of the end of 2005, the average disinflation period was 6.2 years, much longer than that for industrial countries. This could be due to higher inflation starting points or lower central bank credibility. With variable size, all emerging market economies (EMEs) use an inflation control range. The average of the midpoint of the range was 3.1 per cent in 2005.

Turning to performance, we find that the mean absolute deviation (MAD) of the year-over-year change in consumer prices from the target is close to 1 percentage point (p.p.) on average in industrial economies (Table 3). Switzerland ranks first with a MAD of 0.39 p.p., but the evidence is limited since the data covers only 5 years. The UK has a remarkable performance with a MAD of 0.76 p.p. Canada ranks fourth with a MAD of 1.01 p.p., which means that on average, consumer price inflation has been close to the edges of the Bank of Canada's 1 to 3 per cent control band. Iceland, with only 4 years of IT experience is the worst performer with a MAD of 1.66 p.p.[15] As in Roger and Stone (2005), we find that central banks tend to overshoot their inflation target during disinflation periods. Canada is an exception to this, however, with an undershooting mean of -0.74 p.p. This result could reflect weaker than anticipated inflation developments in the early 1990s, such as a more severe than expected recession, unexpectedly slow growth in the U.S. economy, fiscal consolidation, or trade liberalization. During stable IT periods, the Anglo-Saxon countries and Iceland have tended to overshoot the target while Norway, Sweden and Switzerland have tended to undershoot. On average, there is little bias around the target during stable IT periods (especially true for Canada). At 6.4 quarters on average, the persistence of inflation deviations, as measured by the average duration of deviations from the target, is consistent with the typical structural VAR estimates of the response of inflation to a monetary policy shock (Christiano, Eichenbaum, and Evans, 1999). Deviations are the least persistent in Canada (4.8

[14] In the United Kingdom, the target was reduced from 2.5 to 2 per cent in 2003. This followed from a change in the measure of the target variable from the CPI excluding mortgage costs to the European Union's HICP. The Swiss National Bank targets an inflation rate of below 2 per cent, which we equivalently express as a 0 to 2 per cent control range.

[15] We obtain similar qualitative results when using relative deviations instead of absolute deviations.

quarters) and the most persistent in Sweden and Iceland (8.2 and 8.5 quarters, respectively). Large inflation deviations, measured by the number of times that deviations from the target have been larger than 2 percentage points are more frequent in Canada, New Zealand, and Australia. This could reflect higher inflation volatility due to a greater exposure of these countries to commodity price shocks. For countries using target bands, we also calculate the frequency of being outside of the range during periods of stable IT. By this metric, Canada has the best performance among industrial countries since inflation outcomes have been outside of the target band in only 8 out of 40 quarters. The Australian performance is much weaker with year-over-year inflation outside of the band two thirds of the time.

The inflation performance is relatively weaker and more heterogeneous in EMEs (Table 4). The average MAD is two times larger than that of the industrial countries. The worst performers are Brazil and South Africa (with MADs of more than 3 percentage points) while Chile, Korea and Thailand have mean absolute deviations comparable to that of the industrial countries. On average, there is a small bias towards undershooting the inflation target in EMEs. While this is surprising, it masks significant differences. For the disinflation periods, Brazil and Hungary overshoot their target significantly (> 2 p.p.) while Colombia and Korea undershoot their target by 2 and 1.5 p.p., respectively. For the stable IT periods, Israel and Mexico have the largest biases around the target. The persistence of inflation deviations is slightly higher for EMEs (7 quarters on average). It is the highest for the Czech Republic, Korea and Mexico and the lowest in Thailand, Peru, Colombia and Chile. Large inflation deviations are more frequent in EMEs, especially in Brazil, Israel and Poland. Inflation outcomes outside of the bands are also slightly more frequent on average.

Taking these results together, it appears that the United Kingdom and Chile are among the best inflation performers of the industrial and emerging market economies, respectively. Overall, inflation deviations are fairly heterogeneous in terms of magnitude, persistence, and frequency. This could be the result of differences in exogenous economic shocks, institutions and policy frameworks, or commitment to the inflation target. The next section will attempt to quantify the contribution of these factors.

4. Empirical Determinants of Inflation Performance

We extend the work of Albagli and Schmidt-Hebbel (2004) by looking at a broader range of determinants of central bank performance under IT . Recall that these authors examined the role of the target level and range, the exchange rate, various measures of risk, and central bank independence.

Aside from the definition of the inflation target and central bank independence, they did not look at factors that are specific to the monetary policy framework. Our contribution is to try to account for transparency and other institutional measures specific to central bank practices. Since the financial system is a key component of the monetary transmission mechanism, we also look at the role of the financial environment. Krause and Rioja (2006) find that higher financial development improves monetary policy efficiency. Given this finding, we should expect central bank's success in hitting the inflation target to increase with the degree of financial market sophistication.

The criterion we use to define central bank performance under IT is inflation deviations, i.e. the absolute value of year-over-year total CPI inflation minus the inflation target or center of control band. Since this criterion might be seen as somewhat narrow, we also estimate equations in which the dependent variable is central bankers' loss, i.e. a weighted average of inflation deviations from the target and output deviations from potential.[16] This is a realistic exercise since the monetary policy objective typically includes not only stability of inflation around the target but also stability of the real economy. It is also consistent with the fact that central banks may have to make compromises in the short-run for longer term performance. For instance, in the case of a negative shock to supply, some central banks may be willing to tolerate higher inflation in the short-run in order to minimize the output consequences.

Depending on the specification, the dependent variable is regressed on lags, macroeconomic control variables (*MACRO*), financial environment controls (*ENV*), and central banks' institutional factors (*INST*). In panel form with fixed effects, we estimate the following equation:

$$\left|inf_{it} - inf_{it}^{*}\right| = a + c_i + \sum_{k=1}^{m} b_k \left|inf_{it-k} - inf_{it-k}^{*}\right| + \boldsymbol{d} MACRO_{it} + \boldsymbol{g} ENV_{it} + \boldsymbol{k} INST_{it} + e_{it},$$

where *i* corresponds to the 21 IT countries previously described and *t* is a time index covering various sample periods ending in 2005Q4. The macroeconomic control variables that we use to capture exogenous inflation shocks include the absolute deviations of output, the nominal exchange rate, the price of oil, and other commodity prices (all relative to their HP-filtered trend) and various measures of risk.[17] We also include the fiscal deficit or debt relative to GDP to account for the fact that successful

[16] Potential output is estimated with a simple HP filter using λ=1600.

[17] We use the nominal exchange rate for consistency with Albagli and Schmidt-Hebbel (2004). The real exchange rate provides comparable results since the absolute value of the exchange rate gap is very similar in

disinflations depend on fiscal reforms, especially in EMEs. Financial environment controls can be grouped into variables that capture the degree of financial market development (index of financial market sophistication, stock market capitalization or turnover relative to GDP) and the health of the banking sector (indexes of banking financial soundness or strength, market share of state-owned banks).

Central banks' institutional determinants are grouped into three categories: IT design, transparency proxies, and other. The first category includes the inflation target level, the size of the target range, and the policy horizon (i.e. the period over which inflation is expected to return to the target).[18] Since central banks might become better at targeting inflation with the accumulation of experience, we also try the age of the IT regime. Instead of trying to build indexes of central bank transparency such as those described in section 2, we use various proxies of the degree of openness of monetary institutions in their communications with the public: the number of inflation reports published per year, the provision of quantitative forecasts, and the publication of minutes of MPC meetings.[19] Finally, although not directly related to the concept of transparency, we also look at the role of the frequency of official monetary policy meetings, the use of models, the size of the MPC, and central bank independence. Appendix 2 provides the exact definition and source of all the explanatory variables that we considered as potential determinants of inflation target deviations and loss.

Characteristics of the monetary policy framework (*INST*)

IT design	Transparency	Other
• Target level • Size of target range • Target horizon • Age of IT regime	• Number of inflation reports per year • Provision of quantitative forecasts • Publication of minutes of MPC meetings	• Freq. of MPC meetings • Use of models • Size of MPC • Independence

We begin with a simple cross-section regression with each variable evaluated at its sample mean. Table 5 (Appendix 3) reports the statistically significant determinants of inflation deviations. In the macroeconomic variables category, we find that absolute exchange rate deviations and the fiscal deficit are positive determinants of inflation target misses. The significance of the exchange rate is not

real and nominal terms. This reflects the fact that exchange rate deviations from trend generally occur in response to movements in the nominal value of the exchange rate rather than in relative prices.

[18] Given that most central banks do not officially announce a control horizon, we infer it from the horizon of the inflation forecasts found in central banks' inflation reports.

[19] The Kia and Patron (2004) measure relies on Fed Funds rate and Treasury bill rate daily data, making it virtually impossible to reproduce for a wide array of countries. The index by Eijfinger and Geraats (2005) covers only 9 industrial countries and does not vary over time.

a surprise given that most of the countries in the sample are small open economies. A drop in the fiscal deficit of 2 percentage points (equivalent to going from Poland's to Switzerland's average deficit) reduces inflation deviations from the target by a sizable 0.43 percentage points. The insignificance of the output gap could be explained by a flattening of the Phillips curve during the 1990s.[20] The insignificance of oil prices is a surprise given that we are looking at total inflation.[21] As we could expect, the soundness of private commercial banks facilitates the conduct of monetary policy. An increase in the index of 1 point (equivalent to a change from Brazil to United Kingdom banking sector health) reduces inflation deviations by 0.37 percentage points. In terms of the characteristics of the monetary policy framework, we find that a higher inflation target value and a wider target range both reduce accuracy. This is in line with Albagli and Schmidt-Hebbel (2004) and suggests that a lower target will be easier to hit on average.[22] Finally, we find that central banks with policy instrument independence have significantly better inflation outcomes, which probably reflects a stronger ability to commit to price stability (Cukierman et al, 1992). The other institutional measures, including the age of the IT regime and the proxies for transparency, are all statistically insignificant. Taken together, these regressors explain 70 per cent of the cross-country variation in absolute inflation deviations.

While introducing a time dimension to the data yields similar results, it also increases the number of statistically significant determinants. Table 6 reports these determinants. The pooled panel regression shows that there is a high persistence in inflation deviations from the target (the sum of the two lags is 0.61). Exchange rate deviations and the fiscal deficit (now with a one-quarter lag) remain positive contributors to deviations. The only financial environment control that is statistically significant is the index of private banks' financial strength, for which a 1 point rise reduces deviations by a small 0.03 percentage points. With respect to the monetary policy framework, the target level and size of range remain positively correlated with inflation target misses, while central bank independence (target and instrument) continues to be associated with better performance. Surprisingly, we find that central banks that publish the minutes of their MPC meetings tend to miss their target by a quarter of a

[20] For instance, Dotsey, King, and Wolman (1999) find that this could be due to a lower frequency of price adjustments when inflation is low. This does not imply that inflation is not affected by demand and supply conditions, but rather suggests that the policy rate has moved in such a way that excess demand has not translated into actual inflation.

[21] Commodity prices and the different measures of risk examined by Albagli and Schmidt-Hebbel (2004) are also not statistically significant. The insignificance of the risk variables could be due to the fact that this concept is captured by other (e.g. fiscal) variables in the equation.

[22] While this result may reflect the fact that the variability of inflation declines with its level, the same result holds in a model of proportional instead of absolute inflation deviations.

percentage point more than those that do not. This is in line with the findings of Reinhart and Sack (2005), suggesting that the publication of minutes is a fairly inefficient communication channel for monetary policy. Central banks with larger MPCs have a slightly better inflation performance, consistent with the idea that, although with some obvious limits, a larger number of board members should involve a broader range of experiences and perspectives, and hence be better in dealing with uncertainty and processing the relevant information (Berger et al, 2006).[23] Finally, though by an economically small amount, a longer inflation control horizon lowers inflation deviations. This could suggest that by giving more attention to the medium term, the monetary authority is able to better anchor private-sector inflation expectations. With an adjusted R^2 of 66 per cent, the model fits the data reasonably well.

The addition of country-specific fixed effects in the panel estimation reduces the number of possible determinants to test since many of them are time-invariant and therefore need to be dropped in the presence of country dummy variables. Again, inflation deviations have considerable persistence, with the coefficient on the lagged dependent variable summing to about 0.6 (Table 7). Exchange rate deviations and the fiscal deficit continue to be the main macroeconomic variables correlated with inflation deviations. Private banks' financial strength remains statistically significant, now with a much larger coefficient (-0.42). A higher level for the inflation target leads to larger misses.

The previous specification might suffer from endogeneity due to the presence of the lagged dependent variable among the regressors and the fixed effects characterizing the heterogeneity between the countries. The OLS estimator is biased and inconsistent in this context. To eliminate the potential correlation between the regressors and the error term, we use instrumental variable (IV) estimation.[24] The main findings from the previous regression are unaltered, suggesting that endogeneity is perhaps not a serious problem (Table 8).

Turning to the central banks' loss function, we examine three definitions of the dependent variable:

- Absolute loss: $0.5*|\pi^{gap}|+0.5*|y^{gap}|$;

[23] While the optimal size of the MPC is an empirical issue, Sibert (2006) argues that "the ideal monetary policy committee may not have many more than five members". Our results are in line with this since the size of the monetary policy committee in the sample ranges from 3 (Switzerland) to 10 (Poland).

[24] More precisely, the two lags of the dependent variable are instrumented with the other right-hand side regressors.

- Quadratic loss with equal weights: $0.5*(\pi^{gap})^2+0.5*(y^{gap})^2$;
- Quadratic loss with unequal weights: $0.8*(\pi^{gap})^2+0.2*(y^{gap})^2$;

where π^{gap} is the inflation deviation and y^{gap} is the output gap. In addition to equal weights on output and inflation in the loss function, we also try the weights from the estimated Taylor frontiers of Cecchetti and Krause (2002). In that case, the weight on inflation is 0.8 for every country except Chile, Israel, and Mexico (0.3).[25] Estimation results with loss as the dependent variable are reported in Tables 9, 10, and 11. Not surprisingly, in addition to lags of inflation deviations, lags of the absolute value of the output gap are now statistically significant. The lagged exchange rate gap and the fiscal deficit are positively correlated with loss. Two other macroeconomic control variables are now significant: the fiscal surplus relative to GDP and oil price deviations are negatively and positively correlated with quadratic loss, respectively (Table 11).[26] The financial environment control variable that is statistically significant across all regressions of loss is the market share of state-owned banks. The coefficient is positive, indicating that countries with low private banking sector development tend to have more variable output and inflation outcomes. This could be due to many things, including a less efficient transmission mechanism. Several characteristics of the monetary policy framework are statistically significant. A higher level and a wider control range for the inflation target are both associated with larger monetary policy losses. Interestingly, central banks using models (with more than 10 equations) to guide the conduct of policy obtain lower losses. We also find that a greater frequency of official MPC meetings is associated with improved performance. This could be due to a better timeliness of policy decisions or to transparency benefits in that more frequent meetings allow the central bank to convey its view to the public more efficiently. The age of the IT regime remains insignificant. Finally, as in the regressions using inflation deviations only, the publication of minutes is harmful to performance.

In the introduction of the paper, we asked the question of whether the performance of IT central banks is different once exogenous inflation shocks are taken into account. One way of answering this question is to compare the actual and predicted MADs of inflation. A higher predicted than actual MAD implies either unaccounted for negative inflation shocks or good luck whereas a lower predicted than actual MAD implies either unaccounted for positive inflation shocks, policy mistakes, or bad luck. The

[25] Such weights for Chile are questionable given the country's good inflation record since the adoption of IT.
[26] Oil gaps are rarely significant, which could reflect the fact that some of the IT countries produce oil.

actual and predicted MADs are very similar in industrial economies (Table 12).[27] This means that, based on the equation's fundamentals, central banks' average reactions to inflation shocks have been generally optimal in these countries. Performance is weaker in EMEs (Table 13). If we assume that inflation shocks are properly taken into account in the model, then comparing the actual and predicted MADs (i.e. the MAD gaps) provides a better metric to evaluate performance since it relates the bank's actual inflation record to what it would be expected to obtain knowing the shocks. For example, central bank A, with a MAD of 1 p.p., would be positioned higher in the original ranking than central bank B, with a MAD of 2 p.p. Suppose, however, that central bank A obtains a predicted MAD of 0.5 p.p. while central bank B gets 2 p.p. Then the ordering is reversed since central bank B responded adequately to the shocks while central bank A underperformed. Interestingly, this is actually the case of Switzerland and Iceland, for which the ranking is completely reversed. Canada's relative performance is barely affected, moving down from the fourth to the fifth position. In EMEs, Brazil, Israel, and the Philippines register the largest improvements in their rank. According to the MAD gaps, the central banks that are the most committed to keeping inflation at the target (or the luckiest) are those of Iceland, Norway, Korea, and Thailand. A caveat to this finding, however, is that the distribution of the MAD gaps is significantly less dispersed than that of the MADs per se, which yields less clear-cut rankings. Calculating the predicted values of inflation deviations in terms of the other measures shown in Tables 3-4 would provide a more complete picture of performance.[28]

5. Lessons

Table 14 recapitulates the variables considered in the empirical analysis and their correlation with inflation deviations or loss. In summary, the key elements standing out of the regressions are:

- Deviations of total inflation from targeted inflation are persistent;
- Inflation deviations are correlated with exchange rate movements and fiscal deficits;
- Inflation deviations and loss are negatively correlated with banking sector development and strength;

[27] The predicted MADs are given by averaging the fitted values from the pooled regression of Table 6.

[28] There are two other caveats to this exercise. The predicted MADs are partly based on lags of inflation deviations, which could include policy mistakes. This implies that good forecasting performance (i.e. a small MAD gap) might arise simply from the ability of the model to correctly predict these mistakes. Also, the predicted MADs do not relfect the real-time exercise that the monetary policymaker is facing since the determinants already include the effects of policy (Lucas critique).

- A higher inflation target and a larger control range are associated with more variable output and inflation outcomes relative to trend;
- Inflation deviations are not correlated with the age of the IT regime;
- Results for transparency are disappointing: the publication of MPC minutes is associated with higher inflation deviations from target and loss, while the other transparency measures are insignificant;
- The use of models helps central banks stabilize inflation and output around trend;
- Inflation accuracy is strongly correlated with central bank independence.

What lessons can we learn from these findings?

Lesson 1: Frequent macroeconomic shocks imply that inflation target deviations are unavoidable. When such shocks happen, we should expect inflation to remain away from target for a relatively prolonged period, especially when fiscal policy is loose or in the presence of an unsophisticated financial sector. The persistence of deviations, combined with the inherent imprecision of IT, is perhaps why many central banks use an inflation control range.

Lesson 2: While there are advantages in communicating the inflation target in terms of such a range, these benefits are not without a cost. Central banks opting for such a framework need to be ready to tolerate larger deviations around the median point of the range on average. While this may seem obvious, our empirical results allow us to quantify this cost: a ±1 per cent target range contributes by about 0.4 percentage points to inflation deviations. In addition, the fact that loss remains positively correlated with the size of the target range suggests that the costs of letting inflation vary are not offset by the benefits of lower output variance.

Lesson 3: Although imperfectly measured, greater central bank transparency does not guarantee better output and inflation outcomes. In fact, our proxies suggest that greater transparency might deteriorate the inflation performance. This contrasts with the theoretical and empirical literature concluding that greater transparency is desirable. In fact, our results tend to give some credit to the thesis of limits to transparency. As is the case for the consensus view on the effects of IT, it may be that the advantages of transparency are observable mainly in terms of improvements in the practical aspects of monetary policy, such as greater accountability and more systematic communications.

Lesson 4: The fact that central bank performance is not correlated with the age of the IT regime implies that central banks do not get better at targeting inflation by simply "doing it". While this may seem disappointing, it highlights the role of the characteristics of the monetary policy framework, such as target and instrument independence. Our results further suggest that, in addition to aiming for low inflation, developing and using economic models to guide policy decisions should lead to better performance.

6. Conclusion

When comparing deviations of actual inflation from targeted inflation for 21 IT countries over the period 1990-2005, we find that inflation deviations are fairly heterogeneous. The United Kingdom and Chile are among the best inflation performers of the industrial and emerging market countries, respectively. Canada has also a very good inflation record. The empirical analysis suggests that part of the cross-country and time variation in inflation deviations can be explained by exchange rate movements and fiscal deficits. Consistent with Krause and Rioja (2006), banking sector development is positively correlated with performance. With respect to central banks' institutional characteristics, our key findings are in line with Albagli and Schmidt-Hebbel (2004): a higher inflation target and a larger control range are associated with more variable output and inflation outcomes while the opposite is true for central bank independence. Contrary to our expectations, measures of central bank transparency are either uncorrelated or positively correlated with inflation deviations and loss. What makes a successful IT central bank? Results suggest that, in order to minimize inflation and output deviations from trend, the monetary policy framework should include the following features: a low numerical target, a relatively narrow control range, confidentiality of MPC minutes, the use of economic models to guide policy decisions, and independence from the government.

As a future step to this research, a theoretical framework along the lines of Demertzis and Hughes Hallett (2003) would be helpful to formalize the link between central bank transparency and inflation performance and to better justify the specification of the empirical model. We could also try to obtain other measures of the financial environment and central bank transparency.

While we moved away from the question of the benefits of adopting an inflation target, simple extensions to the analysis presented here would allow us to contribute to the IT debate. For instance, we could add non-IT economies to the sample and redefine performance in terms of inflation deviations relative to a trend. Alternatively, we could argue that central bank performance should be

measured by the degree to which inflation expectations remain anchored in the face of shocks (c.f. Levin et al (2004)). In that case, we could look at the role of the inflation target, central bank transparency, and the other factors listed in this paper, as potential determinants of inflation persistence.

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Appendix 1: Stylized facts of the inflation targeting experience

Table 1: Inflation targeting key dates (industrial economies)

	IT start	Disinflation	Stable IT	2005 IT level
Australia	1994Q3		1994Q3→	2-3
Canada	1991Q1	→1995Q4	1996Q1→	1-3
Iceland	2001Q1	→2002Q4	2003Q1→	2.5
New Zealand	1990Q1	→1992Q4	1993Q1→	1-3
Norway	2001Q1		2001Q1→	2.5
Sweden	1995Q1		1995Q1→	1-3
Switzerland	2000Q1		2000Q1→	<2
United Kingdom	1992Q1		1992Q1→	2
Average	9.7 years	3.2 years	7.8 years	2.1

Source: Mishkin and Schmidt-Hebbel (2005) and author's calculations

Table 2: Inflation targeting key dates (EMEs)

	IT start	Disinflation	Stable IT	2005 IT level
Brazil	1999Q1	→		2-7
Chile	1991Q1	→2000Q4	2001Q1→	2-4
Colombia	1999Q1	→		4.5-5.5
Czech Rep.	1998Q1	→		2-4
Hungary	2001Q1	→		2.5-4.5
Israel	1992Q1	→2002Q4	2003Q1→	1-3
Korea	1998Q1	→1998Q4	1999Q1→	2.5-3.5
Mexico	1999Q1	→2002Q4	2003Q1→	2-4
Peru	1994Q1	→2001Q4	2002Q1→	1.5-3.5
Philippines	2001Q1	→		5-6
Poland	1998Q1	→2003Q4	2004Q1→	1.5-3.5
South Africa	2001Q1		→	3-6
Thailand	2000Q1		→	0-3.5
Average	7.5 years	6.2 years	3.3 years	3.1

Source: Mishkin and Schmidt-Hebbel (2005) and author's calculations

Table 3: Inflation performance (industrial economies)

	MAD (p.p.)	Rank	Bias^{disinflation} (p.p.)	Bias^{stable} (p.p.)	Persistence (quarters)	Large Deviations	Beyond Bands
Australia	1.21	7		0.15	7.2	11	31/46
Canada	1.01	4	-0.74	0.01	4.8	9	8/40
Iceland	1.66	8	2.58	0.30	8.5	5	--
New Z.	0.98	3	0.89	0.52	6.1	7	12/32
Norway	1.15	6		-0.73	5.7	3	--
Sweden	1.14	5		-0.86	8.2	5	23/44
Switzerland	0.39	1		-0.05	5.3	0	--
UK	0.76	2		0.20	5.3	0	--
Average	1.04	--	0.91	-0.06	6.4	5	44%

Author's calculations. MAD: mean absolute deviation of actual inflation from target, bias: mean of inflation deviations, persistence: average duration of inflation deviations, large deviations: inflation deviations greater than 2 percentage points, beyond bands: number of times that inflation is outside of the range during stable IT periods.

Table 4: Inflation performance (EMEs)

	MAD (p.p.)	Rank	Bias^{disinflation} (p.p.)	Bias^{stable} (p.p.)	Persistence (quarters)	Large Deviations	Beyond Bands
Brazil	3.58	13	2.51		8.3	16	--
Chile	1.09	2	0.66	-0.53	4.4	8	5/20
Colombia	2.21	6	-2.03		4.2	14	--
Czech R.	2.39	8	-1.00		9.7	13	--
Hungary	2.23	7	2.20		8.5	8	--
Israel	2.39	9	-1.14	-1.77	5.9	30	9/12
Korea	1.29	3	-1.48	-0.53	9.7	6	9/24
Mexico	1.84	5	0.15	1.60	12.5	5	9/12
Peru	1.68	4	0.63	-0.45	4.1	12	8/16
Philippines	2.60	11	-1.35		8.5	7	--
Poland	2.57	10	-0.57	0.39	7.3	18	5/8
S. Africa	3.02	12		0.89	5.7	10	12/20
Thailand	0.65	1		-0.02	2.3	0	3/24
Average	2.12	--	-0.13	-0.05	7.00	11.3	50%

See Table 3 footnote.

Appendix 2: Regression data

Dependent variable:

- Year-over-year growth in total CPI minus (time-varying) inflation target, absolute value, International Monetary Fund, IFS (**aid**).

Macroeconomic control variables (*MACRO*):

- Output gap: Real GDP minus hp-filtered trend, absolute value, International Monetary Fund, IFS (**aygap**).
- Exchange rate: Nominal exchange rate minus hp-filtered trend, absolute value, International Monetary Fund, IFS (**aexgap**).
- Price of oil: Nominal WTI price minus hp-filtered trend, absolute value (**aoilgap**).
- Commodity prices: minus hp-filtered trend, absolute value, Bank of Canada (**bcne**, **bcpi**)
- Risk: political risk (polity index), International Country Risk Guide measures of institutional quality (various sub-indices), financial ratings (Moody's, S&P, EMBI)
- Fiscal deficit (surplus) relative to GDP: International Monetary Fund, IFS, World Bank (=0 if surplus (deficit), **deficit** (**surplus**)).
- Government debt to GDP: World Bank (**debt**)

Financial environment control variables (*ENV*):

- Financial market sophistication index: Global Competitiveness Report 2005-06 (**fm_soph**)
- Stock market capitalization relative to GDP: World Bank (**sm_cap**)
- Stock market turnover: World Bank (**sm_turn**)
- Soundness of private banks index: Global Competitiveness Report 2005-06 (**soundness_banks**)
- Private banks' financial strength: Moody's weighted average bank financial strength rating (**bank_fin_str**)
- Market share of state-owned banks: LaPorta et al (2002) (**state_owned**)

Monetary policy framework variables (*INST*):

- Official inflation target level: Mishkin Schmidt-Hebbel (2005), includes disinflation periods (**it_level**)
- Size of inflation control range: Mishkin Schmidt-Hebbel (2005) (**it_range**)
- Inflation forecast horizon: Fracasso et al (2003) (**horizon**)
- Age: number of quarters since the start of the IT regime, Mishkin and Schmidt-Hebbel (2005) dates (**age**)
- Number of inflation reports per year: Roger and Stone (2005) (**ir_year**)
- Provisions of quantitative forecasts of output and inflation: Roger and Stone (2005) (**quant_forecast**)
- Publication of MPC minutes: Fracasso et al (2003) (**minutes**)
- Frequency of MPC meetings: Roger and Stone (2005) (**freq_meetings**)
- Use of models: models with at least 10 equations (Fry et al) (**use_models**)
- Size of MPC (internal, external, total): Roger and Stone (2005) (**mpc_int**, **mpc_ext**, **mpc_size**)
- Independence: target independence (=1 of central bank decides inflation targer independently, 0 if not, **targ_indep**), instrument independence (=1 of central bank sets monetary policy independently, 0 if not, **inst_indep**) (Fry et al), governor turnover rate (Freytag 2001, Sturm and de Haan 2001, author's calculation), other measures (Cukierman et al, 1992)

Appendix 3: Results

Table 5: Cross-section model (at mean)

Dependent variable: absolute inflation deviations (aid) Number of observations: 21 Adjusted R^2: 70%		
	Coefficient	t-stat
aexgap	0.049	2.89
deficit	0.215	2.99
soundness_banks	-0.369	-2.08
it_range	0.186	1.54
it_level	0.088	1.68
inst_indep	-1.526	-2.27
constant	3.902	2.79

Table 6: Pooled model

Dependent variable: absolute inflation deviations (aid) Number of observations: 696 Adjusted R^2: 66%		
	Coefficient	t-stat
aid_{t-1}	0.882	25.18
aid_{t-2}	-0.268	-8.46
$aexgap_{t-1}$	0.040	5.41
$deficit_{t-1}$	0.046	3.02
bank_fin_str	-0.027	-1.66
it_range	0.176	3.19
it_level	0.008	0.63
targ_indep	-0.366	-3.15
inst_indep	-0.673	-2.58
minutes	0.247	2.88
mpc_size	-0.027	-1.87
horizon	-0.017	-3.02
constant	1.320	4.06

Table 7: Fixed effects model

Dependent variable: absolute inflation deviations (aid) Number of observations: 682 Adjusted R^2: 67%		
	Coefficient	t-stat
aid_{t-1}	0.881	25.77
aid_{t-2}	-0.289	-9.24
$aexgap_{t-1}$	0.032	4.11
$deficit_{t-1}$	0.037	2.42
bank_fin_str	-0.422	-2.91
it_level	0.023	1.62
constant	3.850	3.01

Table 8: Fixed effects model (instrumental variables)

Dependent variable: absolute inflation deviations (aid) Number of observations: 682 Adjusted R^2: 54%		
	Coefficient	t-stat
aid_{t-1}	0.933	6.31
aid_{t-2}	-0.306	-3.58
$aexgap_{t-1}$	0.027	3.23
$deficit_{t-1}$	0.034	2.10
bank_fin_str	-0.320	-1.78
it_level	0.029	1.83
constant	2.179	1.85

Table 9: Absolute loss model (pooled)

Dependent variable: absolute loss (loss) Number of observations: 636 Adjusted R^2: 62%		
	Coefficient	t-stat
aid_{t-1}	0.470	12.26
aid_{t-2}	-0.146	-2.82
aid_{t-3}	0.034	0.68
aid_{t-4}	-0.045	-1.40
$aygap_{t-1}$	0.067	3.74
$aygap_{t-2}$	-0.043	-2.38
$aygap_{t-3}$	0.030	1.62
$aygap_{t-4}$	0.309	17.00
$a\_exch\_gap_{t-1}$	0.013	1.74
$deficit_{t-3}$	0.032	2.22
state_owned	0.005	3.28
it_range	0.154	3.60
minutes	0.181	2.36
constant	-0.073	-0.75

Table 10: Quadratic loss model (pooled)

Dependent variable: quadratic loss (loss_2)
Number of observations: 459
Adjusted R^2: 60%

	Coefficient	t-stat
aid_{t-1}	2.028	5.46
aid_{t-2}	-1.386	-4.28
$aygap_{t-2}$	-0.538	-3.64
$aygap_{t-3}$	0.214	1.42
$aygap_{t-4}$	2.900	18.97
$aexgap_{t-1}$	0.162	2.38
$deficit_{t-3}$	0.183	1.43
state_owned	0.034	1.93
it_range	0.734	1.97
it_level	0.517	3.20
use_models	-1.819	-2.67
freq_meetings	-0.014	-3.28
constant	-3.697	-3.56

Table 11: Quadratic loss model (pooled, Cecchetti-Krause weights)

Dependent variable: Cecchetti-Krause loss (loss_ck)
Number of observations: 491
Adjusted R^2: 46%

	Coefficient	t-stat
aid_{t-1}	2.620	10.12
aid_{t-2}	-0.776	-3.38
$aygap_{t-4}$	1.047	9.10
$aexgap_{t-1}$	0.216	4.15
$aexgap_{t-4}$	0.141	2.89
$aoilgap_{t-1}$	0.035	1.63
$surplus_{t-2}$	-0.295	-2.26
state_owned	0.017	1.45
it_range	0.743	2.53
it_level	0.154	1.55
use_models	-0.947	-1.84
minutes	0.813	1.50
constant	-4.159	-5.10

Table 12: Predicted inflation performance (industrial economies)

	Actual MAD (p.p.)	Predicted MAD (p.p.)	Difference (act.-pred., p.p.)	Actual ranking	Predicted ranking
Australia	1.21	1.14	0.07	7	6
Canada	1.01	0.95	0.06	4	5
Iceland	1.66	1.71	-0.05	8	1
New Z.	0.98	0.88	0.10	3	7
Norway	1.15	1.19	-0.04	6	2
Sweden	1.14	1.14	0.00	5	3
Switzerland	0.39	0.23	0.16	1	8
UK	0.76	0.71	0.05	2	4
Average	1.04	1.00	0.04	--	--

The actual ranking is based on the actual MADs of inflation while the predicted ranking is given by the MAD gaps.

Table 13: Predicted Inflation performance (EMEs)

	Actual MAD (p.p.)	Predicted MAD (p.p.)	Difference (act.-pred., p.p.)	Actual ranking	Predicted ranking
Brazil	3.58	3.27	0.31	13	7
Chile	1.09	0.97	0.12	2	5
Colombia	2.21	--	--	6	--
Czech R.	2.39	1.94	0.45	8	9
Hungary	2.23	1.72	0.51	7	12
Israel	2.39	2.31	0.08	9	3
Korea	1.29	1.53	-0.24	3	2
Mexico	1.84	1.55	0.29	5	6
Peru	1.68	1.21	0.47	4	10
Philippines	2.60	2.50	0.10	11	4
Poland	2.57	2.25	0.32	10	8
S. Africa	3.02	2.54	0.48	12	11
Thailand	0.65	1.00	-0.35	1	1
Average	2.12	1.90	0.21	--	--

See Table 12 footnote. Colombia is excluded due to missing data.

Table 14:Potential determinants and their correlation with inflation deviations or loss

MACRO	Inflation deviations	Loss
Output deviations	ns	+
Exchange rate deviations	+	+
Price of oil deviations	ns	+, small
Commodity price deviations	ns	ns
Country risk premium	ns	ns
Fiscal deficit/GDP	+	+
Fiscal surplus/GDP	ns	-
Government debt/GDP	ns	ns
ENV		
Financial market development		
Financial market sophistication index	ns	ns
Stock market capitalization/GDP	ns	ns
Stock market turnover/GDP	ns	ns
Banking sector health		
Private banks soundness index	-	ns
Private banks financial strength index	-	ns
Market share of state-owned banks	ns	+, small
INST		
IT design		
Inflation target level	+	+
Size of inflation target range	+	+
Inflation control horizon	-, small	ns
Age of the IT regime	ns	ns
Transparency		
Number of inflation reports per year	ns	ns
Provision of quantitative forecasts	ns	ns
Publication of MPC minutes	+	+
Other		
Frequency of official MPC meetings	ns	-, small
Use of models	ns	-
Size of MPC	-, small	ns
Central bank independence	-	ns

"+", "-", and "ns" mean that regression results indicate positive, negative, and no correlation between the variable and absolute inflation deviations or loss, respectively. "small" is added when the effect is judged economically small. See Appendix 2 for a definition of the variables.