The Macroeconomic Effects of Inflation Targeting

Andrew T. Levin, Fabio M. Natalucci, and Jeremy M. Piger

1. INTRODUCTION

Over the past 15 years, explicit inflation targeting (IT) has been adopted by an increasing number of central banks, and a substantial body of literature has emphasized the advantages of this approach as a framework for monetary policy.[1] Nevertheless, empirical analysis has yielded little evidence of any macroeconomic effects of IT. For example, the landmark study of Bernanke, Laubach, Mishkin, and Posen (1999) concluded that the first few countries to adopt IT did not experience any short-run gains in lower output costs of disinflation. Most recently, Ball and Sheridan (forthcoming) considered a wide range of macroeconomic indicators for Organisation for Economic Cooperation and Development (OECD) economies and found no statistically significant differences between the IT and non-IT countries.

In this paper, we evaluate the extent to which IT exerts a measurable influence on expectations formation and inflation dynamics. For the industrialized economies, we address this question by comparing time-series data since 1994 for five IT countries (Australia, Canada, New Zealand, Sweden, and the United Kingdom) with that of seven non-IT countries (the United States, Japan, Denmark, and four of the five largest euro area members—namely, France, Germany, Italy, and the Netherlands).[2] For these economies, we analyze the behavior of medium- and long-term inflation expectations using Consensus Economics Inc. semiannual surveys of market forecasters, and we employ the methods of Stock (1991) and Hansen (1999) to obtain median-unbiased measures of persistence for total and core consumer price inflation (CPI). Finally, since the experience with IT in the emerging market economies (EMEs) is mainly limited to the past few years, our analysis of these economies follows an event-study approach similar to that of Bernanke et al. (1999).

For the industrialized economies, our evidence indicates that IT has played a significant role in anchoring long-run inflation expectations. For the United States and the euro area, private-sector inflation forecasts (at horizons up to ten years) exhibit a highly significant correlation with a three-year moving average of lagged inflation.[3] In contrast, at the longest horizons this correlation is largely absent for the five IT countries, indicating that these countries' central banks have been quite successful in delinking expectations from realized inflation.[4]

We also find that actual inflation exhibits mark-

[1] See Leiderman and Svensson (1995), Bernanke and Mishkin (1997), Bernanke et al. (1999), Schaechter, Stone, and Zelmer (2000), Corbo, Landerretche, and Schmidt-Hebbel (2001), Mishkin and Schmidt-Hebbel (2001), Neumann and von Hagen (2002), Benati (2003), Goodfriend (forthcoming), and Svensson and Woodford (forthcoming).

[2] To avoid consideration of structural breaks midway through the sample, our analysis excludes Norway and Switzerland (which adopted explicit inflation targets in 2000 and 2001, respectively) as well as Finland and Spain (which moved from IT to euro area membership). See Dueker and Fisher (1996).

[3] In related work, Gurkaynak, Sack, and Swanson (2003) find evidence that shifts in private-market perceptions about long-term inflation account for a substantial proportion of the degree to which U.S. long-term bond rates are highly sensitive to federal funds rate surprises. See also Bernanke and Kuttner (2003), Bonfim (2003), and Kozicki and Tinsley (2001a,b).

[4] For results regarding the effects of IT on short-term inflation expectations, see Johnson (2002, 2003) and Gavin (2004).

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edly lower persistence in IT countries.[5] For example, even with only a decade of quarterly data, we can clearly reject the null hypothesis of a unit root in core CPI inflation for Canada, New Zealand, Sweden, and the United Kingdom. Inflation persistence is estimated to be quite low in these countries, with the 90 percent confidence interval for the largest autoregressive root excluding 0.7 in all cases. By contrast, the unit-root null hypothesis cannot be rejected for the United States, the euro area, or Japan.[6]

For the EMEs, the initial experience with IT appears to be largely consistent with that observed by Bernanke et al. (1999) for the industrialized countries.[7] In particular, our event-study approach confirms that the adoption of IT is not associated with an instantaneous fall in private-sector inflation forecasts, especially at longer horizons. Since measures of potential output and the natural unemployment rate are notoriously difficult to construct for EMES, we have not attempted to compute sacrifice ratios for these episodes; however, informal assessment suggests that the adoption of IT was not associated with a marked reduction in the output costs of disinflation.

It should be noted that the absence of instantaneous gains from IT is not necessarily inconsistent with substantial macroeconomic effects over a period of a decade or more. If an economy has already been experiencing low and stable inflation for an extended period, then the adoption of a formal IT regime might not have any immediate benefit—the delinking of expectations from realized inflation would only become visible at some later date when the economy was hit by a substantial shock. On the other hand, if IT is adopted at a point of relatively high or volatile inflation, then the private sector might reasonably be skeptical about the likely duration of the regime, and hence its inflation expectations would only adjust gradually (cf. Erceg and Levin, 2003).

Finally, our analysis underscores the key role of institutional considerations in determining inflation expectations. In particular, as emphasized by Kohn (forthcoming), the volatility of long-term inflation expectations for a number of IT countries is roughly similar to that of some non-targeters such as the United States. Since our analysis suggests that the IT countries have succeeded in delinking inflation expectations from lagged inflation, the ongoing fluctuations in long-term expected inflation for these countries are evidently related to shifting views about the long-term course of monetary policy (e.g., the probability that Sweden or the United Kingdom might join the European Monetary Union).

The remainder of this paper is organized as follows. For the industrial economies, section 2 presents our findings on the determination of inflation expectations, section 3 reports our results regarding inflation persistence, and section 4 presents evidence regarding macroeconomic volatility. For the EMEs, section 5 provides an overview of IT arrangements, and section 6 presents our event-study analysis of the initial effects of IT. Section 7 summarizes our conclusions and discusses some areas for future research.

2. INFLATION TARGETING AND INFLATION EXPECTATIONS IN INDUSTRIALIZED ECONOMIES

In this section we begin our analysis of the macroeconomic effects of IT by investigating the behavior of inflation expectations in our sample of IT and non-IT economies. We are primarily interested in whether inflation expectations, particularly at longer horizons, are relatively more anchored in IT economies.

To measure inflation expectations, we use survey results collected by Consensus Economics. Twice each year, market forecasters are polled regarding their inflation forecasts at horizons of one to ten years. The mean panelist forecast serves as our measure of inflation expectations. We obtained these forecasts from 1994 to the present for each of the countries in our samples, with the exception of Denmark. In the results presented here, the "euro average" we form is a weighted average of France, Germany, Italy, and the Netherlands using GDP shares

[5] Siklos (1999) finds evidence of a decline in inflation persistence in some IT countries; see also Kuttner and Posen (1999). Using a sample of more than 100 countries, Kuttner and Posen (2001) find evidence that inflation-targeting countries experience lower inflation persistence. Corbo et al. (2001) find that IT is associated with lower long-term effects of inflation innovations compared with the non-IT countries.

[6] As shown in section 3, we find that the unit root null hypothesis can be rejected for U.S. total CPI inflation but not for core CPI inflation. A number of studies have considered the extent to which recent U.S. inflation data exhibits less persistence than that of a random walk; cf. Barsky (1987), Evans and Wachtel (1993), Fuhrer and Moore (1995), Brainard and Perry (2000), Taylor (2000), Cogley and Sargent (2002, 2003), Kim et al. (2001), Stock (2002), Pivetta and Reis (2001), Levin and Piger (2002), and Benati (2002). For estimates of inflation persistence for other countries, see also Ravenna (2000) and Batini (2002).

[7] See also Ammer and Freeman (1995), Laubach and Posen (1997), Almeida and Goodhart (1998), and Corbo et al. (2001).

as weights. Thus, our non-IT sample consists of this euro average, Japan, and the United States.

Figure 1 displays the inflation expectation series for four forecast horizons: one, three, five, and six-to-ten years ahead. Note that in many cases, the series drift downward over the early part of the sample. To account for this nonstationarity, the empirical results presented in subsequent sections focus on first differences of the expectation series.

2.1 Volatility of Inflation Expectations

As a first pass at investigating these data, Table 1 presents the standard deviation of the first difference of the expectations series for the four forecast horizons plotted in Figure 1.

Overall, the results in Table 1 suggest that inflation expectations are not noticeably more volatile in non-IT vs. IT economies. Indeed, expectations for the euro average and the United States are less volatile than the average for the IT economies at every forecast horizon and display similar or less volatility than most of the individual IT economies. On the other hand, Japanese inflation expectations are much more volatile than the other economies, particularly at longer horizons.

These results are consistent with those of Kohn (forthcoming), who used Consensus Economics' measures of inflation expectations and found that the volatility of changes in inflation expectations in Germany and the United States are no higher than those in Canada, Sweden, and the United Kingdom. Nevertheless, even if the unconditional volatility of inflation expectations is no less in IT economies, expectations may still be more anchored in IT economies in that they are less responsive to macroeconomic developments. That is, two countries with identical inflation expectation volatility may have such volatility for very different reasons. For example, suppose that IT has anchored inflation expectations in the United Kingdom, making them less responsive to macroeconomic fluctuations. In this case, inflation expectations may still be unconditionally relatively volatile, due to, say, institutional uncertainty surrounding the possible adoption of the euro.

2.2 Sensitivity of Expectations to Realized Inflation

We now estimate the sensitivity of inflation expectations to realized inflation in IT and non-IT countries. In particular, we estimate a pooled regression in which the left-hand-side variable is the first difference of inflation expectations and the right-hand-side variable is the first difference of lagged realized CPI inflation. Formally, we estimate the following equation:

$$\Delta\hat{\pi}_{i,t}^{(q)} = \lambda_i + \beta\Delta\overline{\pi}_{i,t} + \varepsilon_{i,t}, \quad (1)$$

where $\hat{\pi}_{i,t}^{(q)}$ is an expectation of inflation q years in the future in country i, formed at time t, and $\overline{\pi}_{i,t}$ is a three-year moving average of inflation in country i ending at time t. Equation (1) is estimated for our sample of both IT economies and non-IT economies, yielding an estimate of β for each set of countries. Given the relatively high level of expectations volatility in Japan, and the fact that economic performance in Japan has been quite different from that in the euro area and the United States over this sample period, we also present estimates for a non-IT sample consisting of the euro average and the United States only.

Table 2 reports estimates of the relationship between realized inflation and expected inflation at several different forecast horizons. These estimates suggest that longer-run inflation expectations have been much less responsive to actual inflation devel-

Table 1

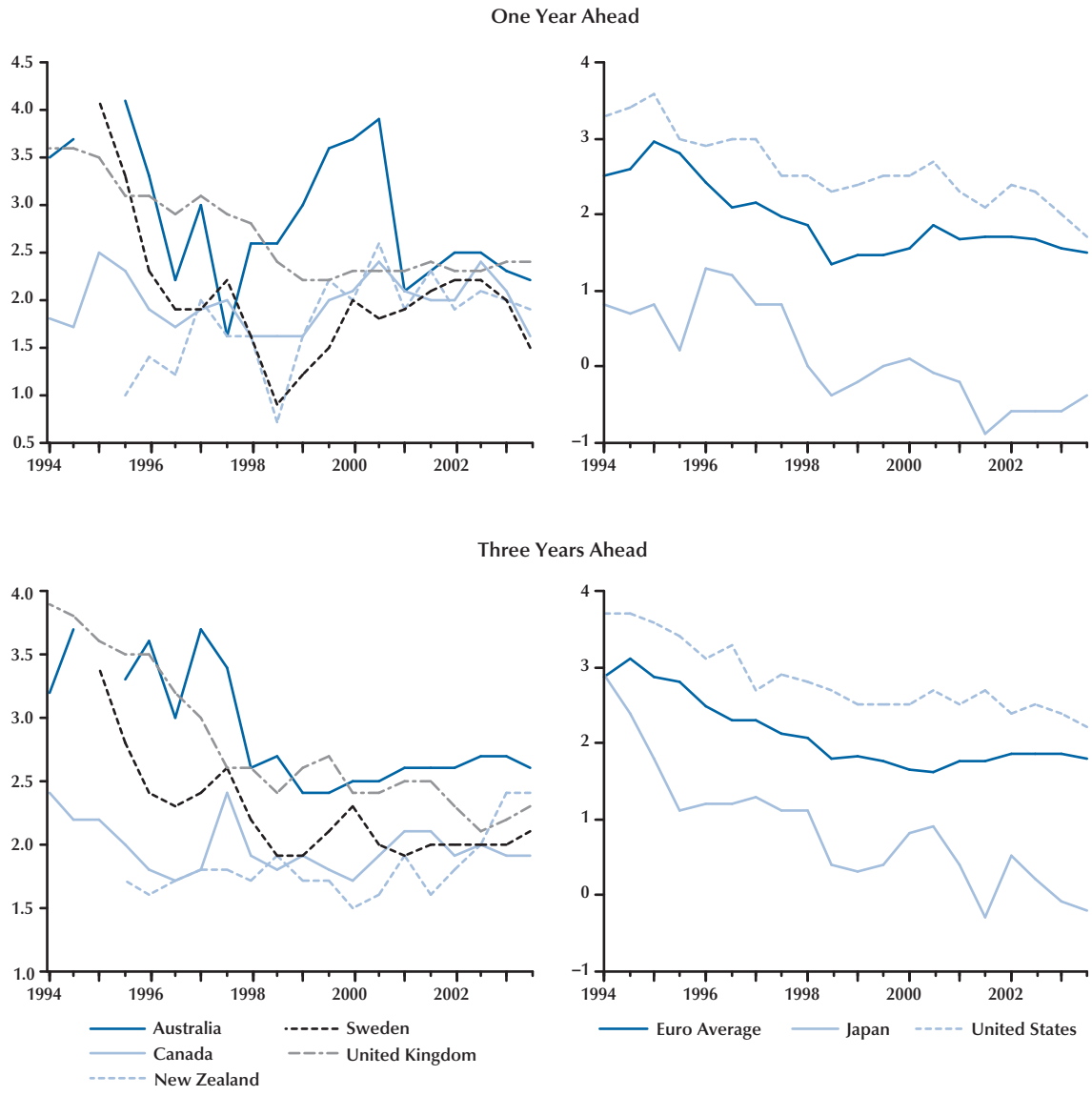
Standard Deviation of Change in Inflation Expectations (1994-2003)

	Horizon (years ahead)			
	1	3	5	6-10
IT sample				
Australia	0.76	0.36	0.41	0.16
Canada	0.33	0.23	0.17	0.21
New Zealand	0.53	0.19	0.16	0.13
Sweden	0.44	0.24	0.19	0.26
United Kingdom	0.16	0.17	0.17	0.21
IT mean	0.44	0.24	0.22	0.19
Non-IT sample				
Euro average	0.22	0.14	0.15	0.10
Japan	0.42	0.40	0.39	0.66
United States	0.25	0.21	0.16	0.11

NOTE: This table contains the standard deviation of the first difference of the mean inflation forecast collected by Consensus Economics Inc. over the period 1994 through the second half of 2003. The "euro average" is a weighted average of France, Germany, Italy, and the Netherlands, using GDP shares as weights.

Figure 1

Inflation Expectations

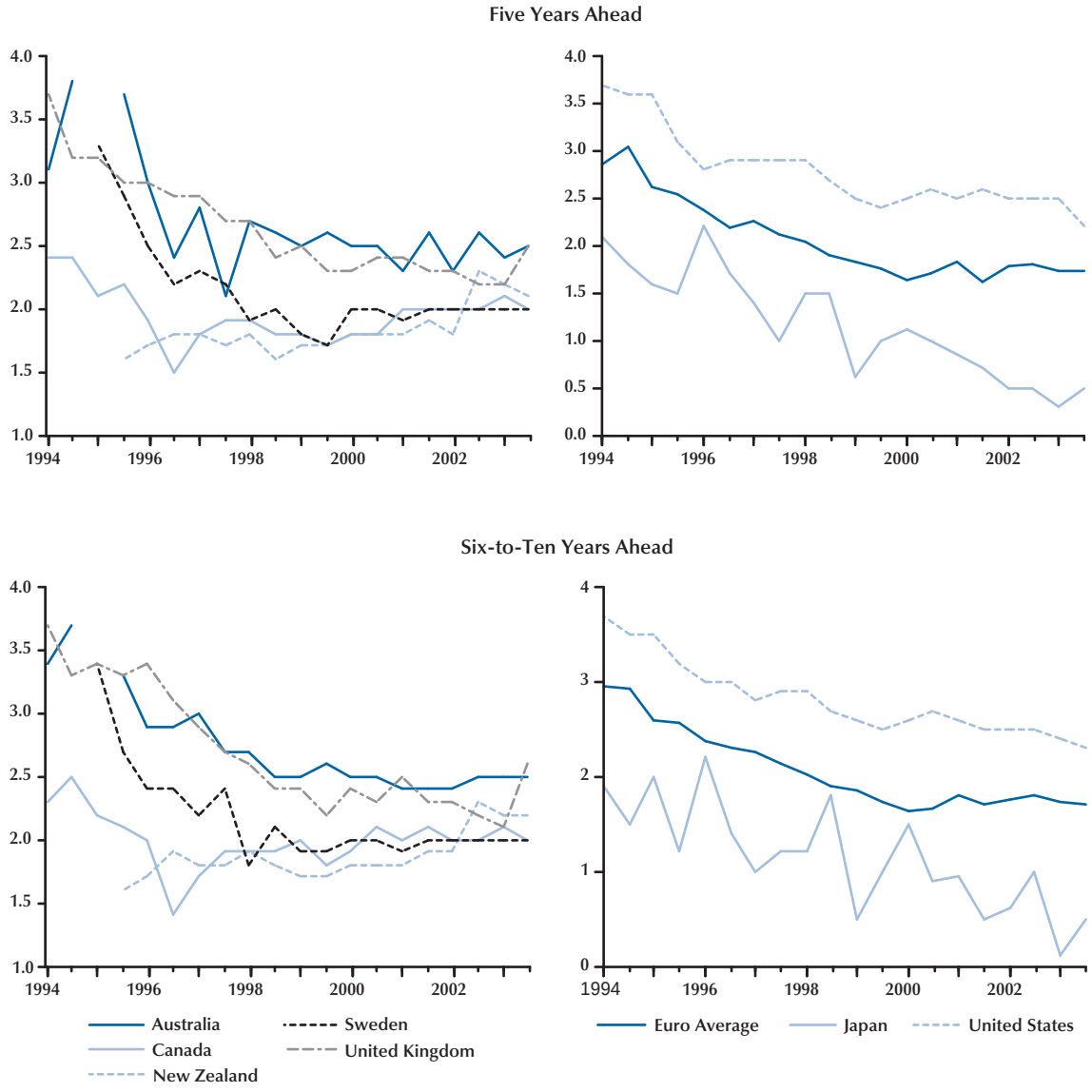


opments in IT countries than in non-IT countries. At the five-year horizon, the estimated response of the change in expected inflation to the change in lagged actual inflation in non-IT economies is over three times that in IT economies. At the six-to-ten-year horizon, the estimated response in non-IT economies is still around 25 basis points, whereas the estimated response in IT countries is close to zero and statistically insignificant. This suggests that IT central banks have been quite successful in delinking expectations from realized inflation. The final row of the table demonstrates that these results are robust to removing Japan from the non-IT group.

Some have argued that, in the United States, the Federal Reserve pursued a policy of "opportunistic disinflation" during the early years of our sample and that the dynamics of inflation are likely different in the years following this disinflation. To investigate this possibility, we estimated equation (1) for U.S. data only, over a sample beginning in 1998 rather

Figure 1 cont'd

Inflation Expectations



NOTE: This figure contains the mean inflation forecast collected by Consensus Economics Inc. over the period 1994 through 2003. "Euro average" is a weighted average of France, Germany, Italy, and the Netherlands, using GDP shares as weights. For Japanese five-year-ahead and six-to-ten year-ahead expectations, the observation for the second half of 1997 was missing. This was replaced by the median of the six adjacent observations for this figure.

than in 1994. Over this period, the estimated response of five-year-ahead inflation expectations on lagged three-year average inflation is 0.34, with a standard error of 0.13, which is similar to the estimate of 0.36 obtained for the U.S. data over the sample beginning in 1994. Also, it is interesting to note that the most recently obtained observation for five-year-ahead U.S. inflation expectations, released by Consensus Forecasts in mid-October of 2003, declined from 2.5 to 2.2 percent, which corresponds to a decline in lagged three-year average inflation from 2.5 to 2.3 percent.

These findings are broadly consistent with those reported by Castelnuovo, Nicoletti-Altimari, and

Table 2

Estimated Response of Change in Inflation Expectations to Change in Realized Inflation

	Horizon (years ahead)			
	1	3	5	6-10
IT	0.00	0.20	0.09	0.01
	(0.10)	(0.06)	(0.05)	(0.05)
Non-IT	–0.03	0.25	0.29	0.24
	(0.17)	(0.11)	(0.11)	(0.08)
Euro area and United States	–0.06	0.30	0.34	0.24
	(0.19)	(0.12)	(0.11)	(0.08)

NOTE: This table holds estimates of β from equations (1) and (2) applied to both IT and non-IT economies over the period 1994-2003. Standard errors are in parentheses. Estimation was performed via generalized least squares assuming cross-sectional heteroskedasticity. Similar results are obtained when estimation is performed via a seemingly unrelated regression.

Palenzuela (2003; CNP), who analyzed the relationship between changes in long-term expected inflation (at a horizon of six-to-ten years) and changes in one-year-ahead expected inflation. Using Consensus Economics' survey data for the period 1995-2002, CNP obtained regression coefficients of 0.21 for the United States, 0.31 for Switzerland, and 0.43 for Japan, compared with an average coefficient of 0.13 for the five IT countries in our sample. For the euro area, CNP used the sample period 1999-2002 and obtained a regression coefficient of 0.08, closer to that of IT economies than non-IT economies.

Finally, it is interesting to note that Ball and Sheridan (forthcoming) found that one-year-ahead inflation expectations are about one-third less responsive to realized inflation developments in IT economies than in non-IT economies, but this difference is not statistically significant. This evidence is consistent with the results in Table 2 for forecast horizons of one and three years. However, it seems reasonable that IT, by revealing a long-run trend rate of inflation, would have its greatest chance of success at anchoring long-horizon expectations.

Indeed, the results in Table 2 suggest that long-run inflation expectations are substantially more anchored in IT economies.[8]

[8] For more discussion of Ball and Sheridan (forthcoming), see Gertler (forthcoming).

3. INFLATION TARGETING AND INFLATION DYNAMICS IN INDUSTRIALIZED ECONOMIES

In the previous section, we studied the behavior of inflation expectations in IT and non-IT economies. In this section we turn our analysis to the dynamics of actual inflation. We are particularly interested in whether inflation persistence is lower in IT countries than in non-IT countries.

3.1 A Look at the Data

Our data consist of inflation rates for our sample of IT economies (Australia, Canada, New Zealand, Sweden, and the United Kingdom) and non-IT economies (Denmark, France, Germany, Italy, the Netherlands, Japan, and the United States). We also consider a euro-area average inflation rate, which is average inflation across the 12 countries that have adopted the euro; the sample period runs from the first quarter of 1994 to the second quarter of 2003 for all countries.

For each country, we analyze two measures of inflation, the first based on the total CPI and the second based on the core CPI, measured as the total CPI less food and energy prices. Inflation is calculated as the annualized quarterly percentage change in the price index. All data were obtained from the OECD. We identify three specific cases in which exogenous shifts in tax rates resulted in large transitory fluctuations in the inflation series. These consist of the introduction of the goods and services tax (GST) in Australia in the third quarter of 2000; large changes in cigarette taxes in Canada in the first two quarters of 1994; and an increase in the consumption tax in Japan in the second quarter of 1997. As shown by Franses and Haldrup (1994), such outliers can induce substantial downward bias in the estimated degree of persistence. Thus, before analyzing the inflation series, we replace the outliers with interpolated values (the median of the six adjacent observations that were not themselves outlier observations). The total and core CPI inflation rates for each country are shown in Figure 2.

3.2 Methodology

To measure inflation persistence, we estimate a univariate autoregressive process for each inflation series:

$$\pi_t = \mu + \sum_{j=1}^{K} \alpha_j \pi_{t-j} + \varepsilon_t, \quad (2)$$

Figure 2

Inflation Rates

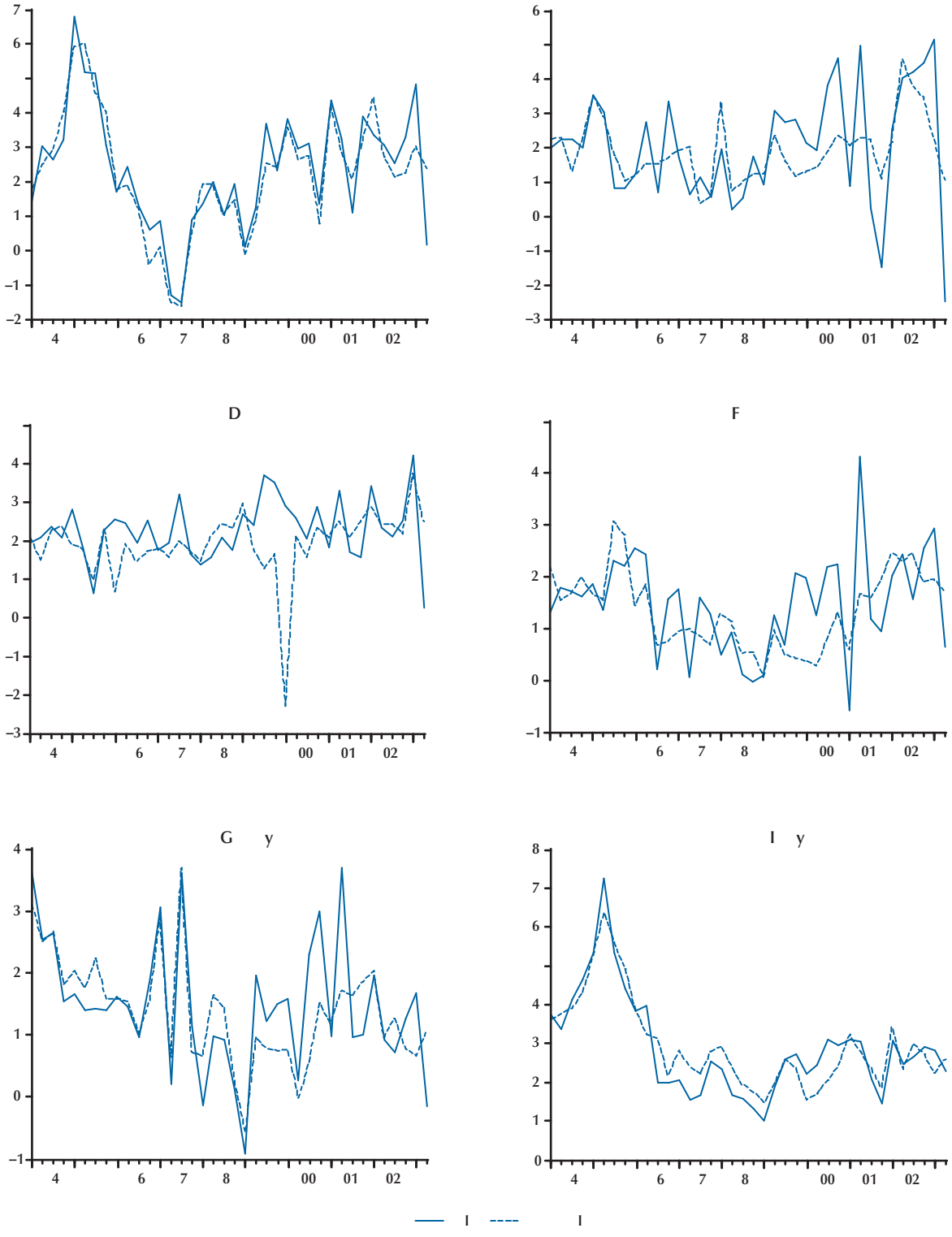


Figure 2 cont'd

Inflation Rates

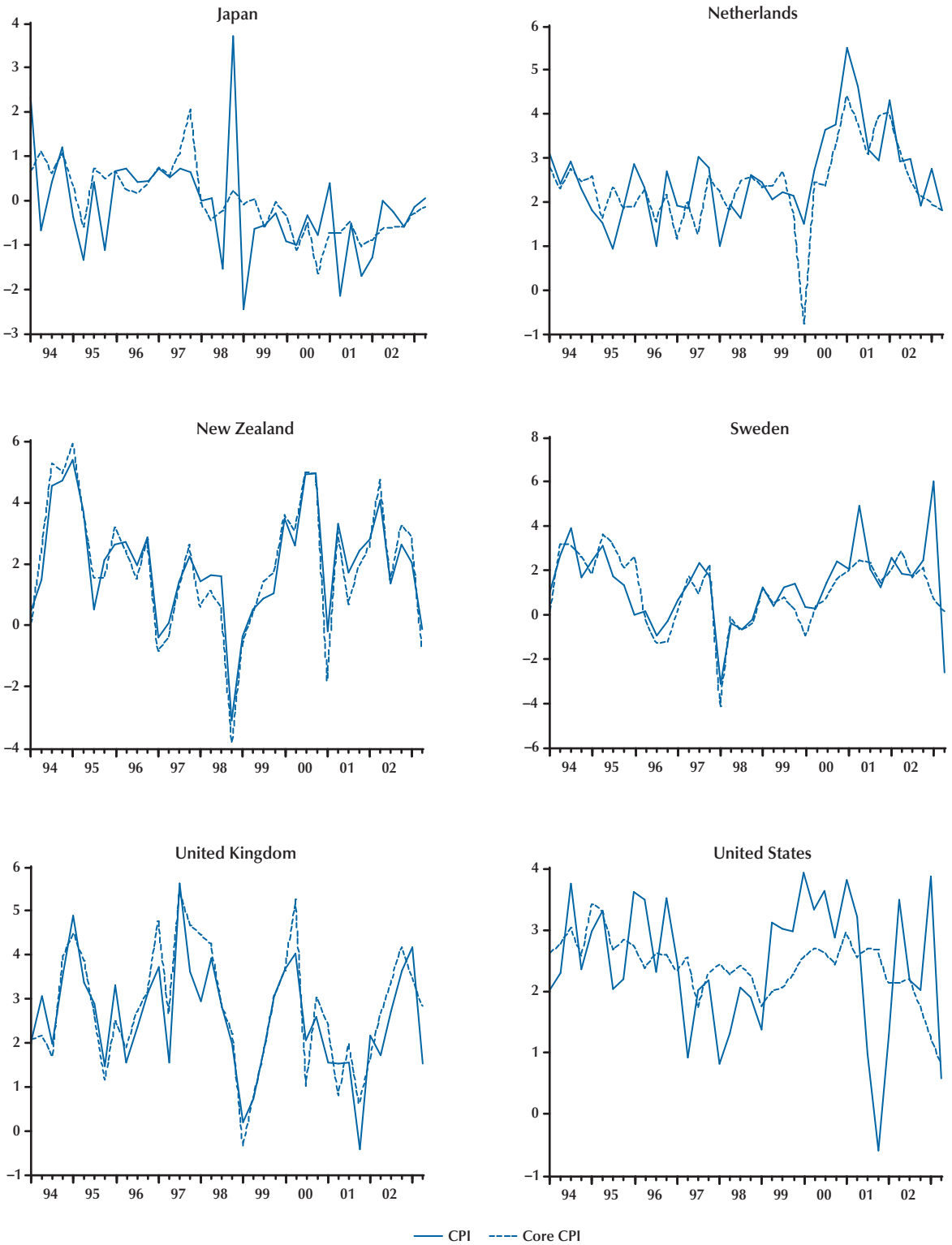


Table 3

Persistence Estimates for Inflation

	Core CPI		Total CPI	
Country	Median unbiased	Upper 95th percentile	Median unbiased	Upper 95th percentile
IT countries				
Australia	0.70	1.02	0.47	0.80
Canada	0.27	0.63	–0.22	0.21
New Zealand	0.24	0.60	0.25	0.61
Sweden	0.16	0.54	0.04	0.44
United Kingdom	0.33	0.68	0.06	0.45
Non-IT countries				
Denmark	0.66	1.00	–0.74	–0.23
Euro area	0.84	1.06	0.87	1.06
France	0.75	1.04	0.91	1.07
Germany	0.77	1.04	0.81	1.05
Italy	0.88	1.07	0.88	1.07
Netherlands	0.39	0.74	0.51	0.83
Japan	0.82	1.05	0.72	1.03
United States	1.04	1.10	0.54	0.86

NOTE: For each country in the sample, this table records the median unbiased estimate and the upper bound of the two-sided 90 percent confidence interval for the largest autoregressive root of core and total CPI inflation, estimated over 1994:Q1–2003:Q2. Estimates were computed based on Stock (1991), using equation (2).

where ε_t is a serially uncorrelated, homoskedastic random error term. To obtain a scalar measure of persistence from equation (2), we use the largest autoregressive root, denoted ρ and defined as the largest root of the characteristic equation $\lambda^K - \sum_{j=1}^{K} \alpha_j \lambda^{K-j} = 0$. The largest autoregressive root has intuitive appeal as a measure of persistence, as it determines the size of the impulse response, $\frac{\partial \pi_{t+j}}{\partial \varepsilon_t}$, as j grows large. We apply the procedures developed in Stock (1991) to obtain median unbiased estimates and an upper 95th percentile estimate, which is the upper bound of a two-sided 90 percent confidence interval.

As a robustness check, we also consider an alternative measure of persistence, namely, the sum of the autoregressive coefficients, $\alpha \equiv \sum_{j=1}^{K} \alpha_j$. As noted by Andrews and Chen (1994), α also has intuitive appeal as a measure of persistence, as it is monotonically related to the cumulative impulse response of π_{t+j} to ε_t. We construct a median unbiased and upper 95th percentile estimates for α using the "grid bootstrap" procedure of Hansen (1999). This technique simulates the sampling distribution of the t-statistic $t = \frac{\hat{\alpha} - \alpha}{se(\hat{\alpha})}$ over a grid of possible true values for α to construct confidence intervals with correct coverage.

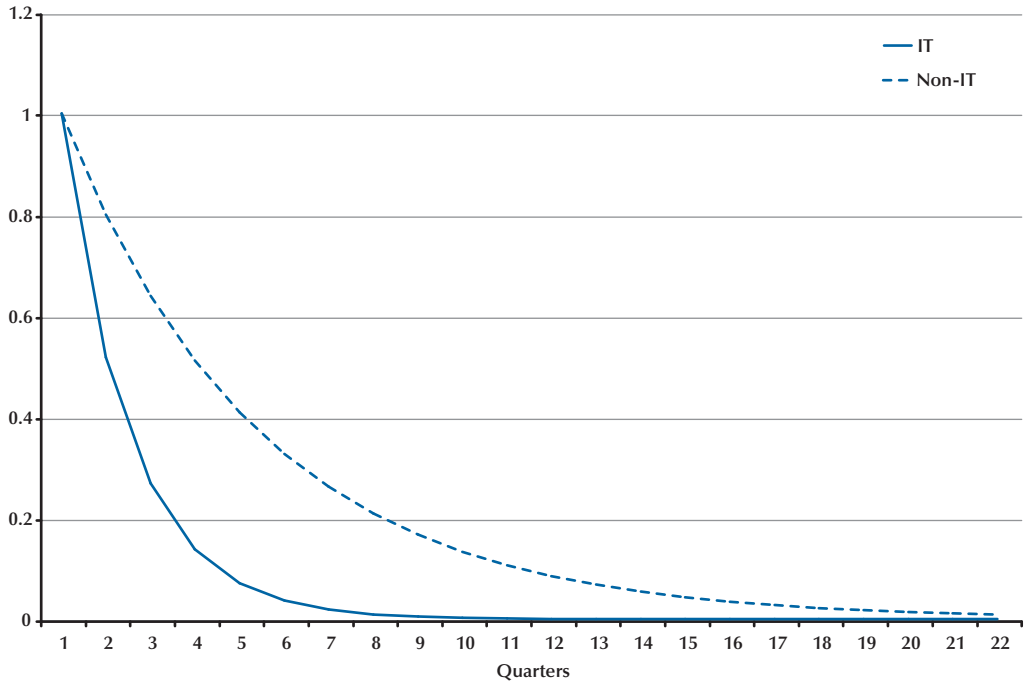
To estimate (1), an autoregressive lag order K must be chosen for each inflation series. For this purpose, we utilize Akaike information criterion, the information criterion proposed by Akaike (1973), with a maximum lag order of $K = 4$ considered. The lag order chosen for each series is reported in Appendix Table A1.

3.3 Persistence Estimates

We begin by discussing persistence estimates for the core CPI. Table 3 presents these results for each country in the sample. Note that values less than unity for the upper 95th percentile estimate imply that a unit root can be rejected for this series

Figure 3

Average Impulse Response Functions Based on Core CPI



at the 5 percent level of significance (based on a one-tailed test).

Consider first the results for the non-IT economies. Table 3 demonstrates that for Denmark, the euro area, Japan, and the United States, the upper 95th percentile estimate is above unity, suggesting that core CPI inflation in these economies displays behavior consistent with a unit-root process. The median unbiased estimate is also quite high in general, above 0.8 for the euro area, Japan, and the United States.

The results for the IT countries stand in contrast to those for the non-IT economies. For Canada, New Zealand, Sweden, and the United Kingdom, the upper 95th percentile estimate is less than unity, meaning that the unit root null hypothesis can be rejected for these series. This is true even though the sample size of roughly 40 observations is relatively short. Indeed, the median unbiased estimate is roughly 0.3 or less for these countries, which suggests a *white noise* process for inflation.

We now turn to the results for total CPI inflation, also shown in Table 3. In this case, the evidence is more mixed for the non-IT economies. In particular, while the unit-root null hypothesis cannot be rejected for both the euro area and Japanese inflation rates, it is rejected for both Denmark and the United States. For the IT economies, inflation persistence is again estimated to be quite low, with the unit-root null hypothesis rejected for all five IT countries. Australia displays the highest median unbiased point estimate of approximately 0.5 (similar to the estimate for the United States), while the remaining four countries have median unbiased estimates of less than 0.3.[9]

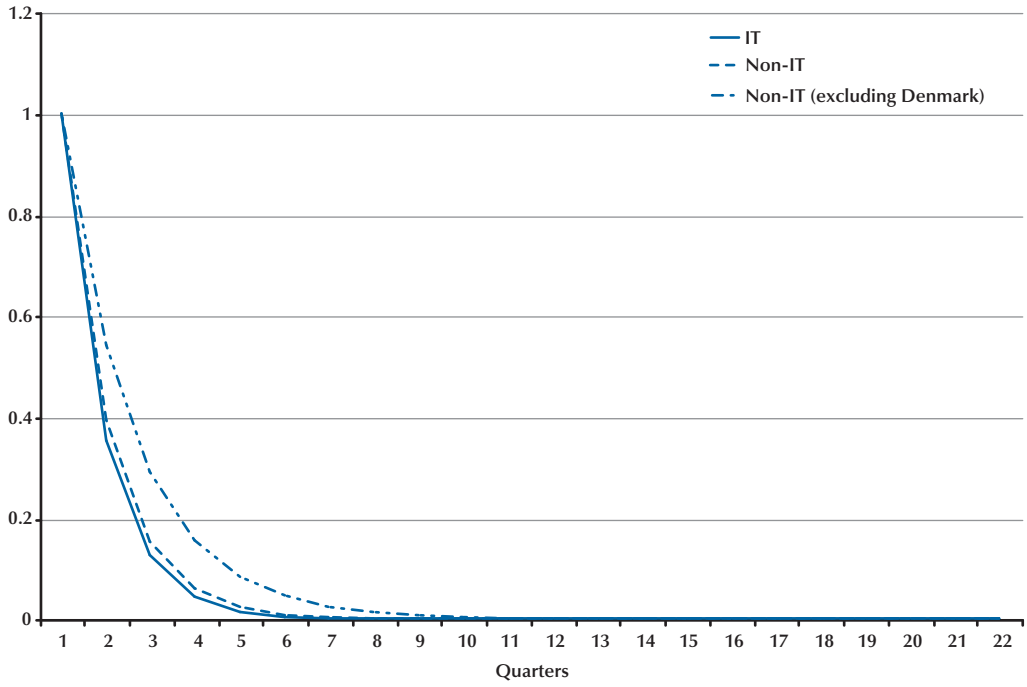
3.4 Impulse Response Functions

An intuitive way to interpret our measures of inflation persistence is to compute an impulse response function, which gives the response of inflation at various future dates to a shock that occurs today. Figure 3 displays average impulse response functions based on core CPI inflation both for the five IT countries in our sample and for a non-IT sample consisting of Denmark, the euro area,

[9] Note that estimated Australian inflation persistence is high relative to the other IT economies for both core and total CPI inflation. We have also estimated inflation persistence for the Australian CPI excluding mortgage interest and obtained similar results to those for the total CPI.

Figure 4

Average Impulse Response Functions Based on Total CPI



Japan, and the United States.[10] The figure makes clear that inflation shocks are much less persistent in the sample of IT economies. For example, nearly half of a one-unit shock to inflation in the IT economies has worn off after just one quarter, and 90 percent after just four quarters. By contrast, for the non-IT sample, it is four quarters before half of the effect of a one-unit shock has dissipated and eleven quarters before this effect has fallen by 90 percent.

Impulse response functions can also help in understanding the relationship between our results and those of Ball and Sheridan (forthcoming), who found no significant difference in the persistence of total CPI inflation for IT and non-IT industrial economies. Figure 4 gives the average impulse response functions for total CPI inflation. Consistent with Ball and Sheridan, the impulse response functions for IT and non-IT economies are nearly identical, suggesting there are less-obvious differences in persistence between IT and non-IT economies.

The results for total CPI inflation are influenced by the averaging of persistence estimates across countries for the purpose of computing the impulse response functions, which masks important details about individual countries. For example, Denmark displays considerable negative serial correlation for total CPI inflation, which lowers the average impulse response function for non-IT economies. This can be seen in Figure 4, which also plots an average impulse response function for the non-IT group, excluding Denmark, and suggests greater differences in persistence between the IT and non-IT group.

4. MACROECONOMIC VOLATILITY IN INDUSTRIAL ECONOMIES

4.1 Output Volatility

One potential explanation for their damped levels of inflation persistence is that IT countries have practiced an active monetary policy, quickly stamping out deviations of inflation from target levels.

[10] Following Ball and Sheridan (forthcoming), the average impulse response functions are computed by first averaging the autoregressive (AR) coefficients across groups of countries and then computing an impulse response function based on these average coefficients. For simplicity, the impulse response functions are calculated based on an AR(1) representation for inflation, with the AR(1) coefficients taken from the median unbiased estimates for α reported in Appendix Table A2. Thus, the impulse response functions are a smoothed version of an impulse response function based on the full set of autoregressive coefficients.

Table 4

Standard Deviation of Core CPI Inflation and Real GDP Growth (1994-2003)

	Standard deviation, output	Standard deviation, inflation	$VAR(\pi_t)/VAR(\varepsilon_t)$
IT countries			
Australia	2.54	1.73	2.04
Canada	2.03	0.93	1.23
New Zealand	3.97	2.10	1.16
Sweden	3.29	1.58	1.19
United Kingdom	1.33	1.37	1.24
IT mean	2.63	1.54	1.37
Non-IT countries			
Denmark	3.34	0.90	1.07
Euro area	2.01	0.68	2.39
France	2.42	0.75	2.08
Germany	2.28	0.87	1.36
Italy	1.80	1.14	3.41
Netherlands	4.34	0.90	1.29
Japan	1.46	0.75	1.73
United States	2.17	0.50	2.25

If this were the case, one would expect to see heightened levels of output volatility in IT countries where the monetary authority manipulated the output gap to reverse shocks to inflation (cf. Cecchetti and Ehrmann, 1999). To investigate this potential explanation, the first column of Table 4 also reports the standard deviation of real gross domestic product (GDP) growth computed from 1994 to the present for our sample of IT and non-IT economies.

As is apparent from the table, IT economies do not seem to display heightened volatility of real GDP growth relative to non-IT economies. In particular, the five IT economies are spread relatively evenly throughout the distribution of GDP volatility. This suggests that the low levels of inflation persistence in IT countries have *not* come at the expense of heightened output-growth volatility. This suggests that IT has improved the tradeoffs policymakers face in these countries.[11]

4.2 Inflation Volatility: Propagation or Shocks?

All else being equal, the relatively low levels of inflation persistence documented for IT countries should suggest relatively low levels of unconditional inflation volatility in these countries. However, as the second column of Table 4 documents, since 1994 the standard deviation of core CPI inflation does not appear to have been lower in IT economies relative to non-IT economies. Indeed, each IT economy has had higher inflation variance over this period than Denmark, the euro area, Japan, and the United States.

Using the autoregression in (2), the volatility of inflation can be decomposed into two sources: one due to the variance of the shocks to the auto regression and one due to the propagation of shocks through the autoregressive dynamics. The final column in Table 4 gives one measure of this decomposition—the ratio of the total variance of the inflation series to the variance of shocks to the autoregression. With the exception of Australia, these ratios are only slightly above unity in the IT countries, consistent with a white noise process for the inflation series. By contrast, this ratio is near or above 2.0 in the euro area, Japan, and the United States. Thus, it appears that the volatility of inflation in these non-IT economies contains a substantial propagation component, while in the IT countries the initial impact of shocks accounts for nearly all inflation variance. That overall variance is roughly

[11] For evidence regarding changes in output volatility across countries see van Dijk, Osborn, and Sensier (2002) and Stock and Watson (forthcoming).

similar in the two economies suggests that shocks to inflation in IT countries have been large relative to non-IT countries, and, had these economies not experienced low levels of inflation persistence, inflation volatility would have been even higher.

5. THE CHARACTERISTICS OF INFLATION TARGETING IN EMERGING MARKET ECONOMIES

In recent years, a growing number of EMEs have adopted IT as the main anchor guiding monetary policy.[12] During the mid-to-late 1990s, monetary aggregates became increasingly difficult to gauge, due to instability in money demand, while financial crises contributed to the widespread collapse of exchange rate pegs. As a result, many EMEs turned to IT as the only nominal anchor still viable.

The seminal papers on IT in emerging markets were aimed at identifying the prerequisites for successful adoption, based on the experience of industrial countries.[13] Subsequent analysis centered on special issues for EMEs, including fiscal dominance and the role of exchange rates.[14] Finally, a number of recent studies have analyzed the initial effects of IT for EMEs in Eastern Europe and Latin America.[15]

This section investigates the experience of EMEs, focusing on the circumstances under which they adopted IT and on some of the distinctive features and problems in the emerging market context. The next section considers the effects of IT in these economies, focusing in particular on the impact on inflation expectations.

Chile introduced IT in 1991. After gaining independence in 1990, the central bank of Chile faced a significant increase in inflation following expansionary policies in 1989 and the oil price spike related to the first Gulf War. Having already unsuccessfully experienced two exchange rate–based stabilization programs in the past and with monetary aggregates difficult to control due to instability in money demand, IT was the only viable alternative. A key feature of the Chilean experience has been the gradual approach to disinflation, which has produced low inflation without suffering excessively large output costs. Chile had an exchange rate band around a crawling peg until August 1999; it has since adopted a fully floating exchange rate regime. IT in Chile has been generally successful in bringing down inflation, even though a strong fiscal position and a sound financial system played an important role in supporting this performance.

Israel's monetary policy framework has been centered on the coexistence of two nominal goals, the inflation target and a crawling exchange rate band, supported by one instrument, the interest rate. Following the 1985 stabilization program, characterized by a fixed but adjustable nominal exchange rate, at the beginning of 1992 Israel adopted an explicit inflation target. Inflation has been successfully reduced from double digits to practically zero. However, the emergence of a conflict between the two nominal objectives often required sterilized foreign exchange intervention, with associated quasi-fiscal costs and weakening of the central bank's credibility. With the widening of the band to 36 percent and the setting of a clear hierarchy of priorities, this conflict appears now to have lessened.

The successful experience of Chile and Israel paved the way for the adoption of IT in other EMEs. In East Asia, the first country to introduce this monetary policy framework was South Korea. Before the adoption of IT in 1998, monetary policy had been conducted by deciding on monetary aggregates as an intermediate target. However, following rapid structural changes experienced by financial markets in the 1990s, the M2 aggregate began to show unstable movements. With the 1997 financial crisis forcing the abandonment of the exchange rate peg, Korea turned to IT as the only nominal anchor for monetary policy still available. Thailand and the Philippines shared a similar experience and adopted IT in 2000 and 2002, respectively.

A trend toward more-flexible exchange rates has also been observed in some of the transition economies of Central and Eastern Europe. Following price liberalization and exchange rate devaluation in the early years of transition, most countries resorted to exchange rate pegs to stabilize their price levels. However, a sharp appreciation of the real exchange rate generated large balance-of-payment

[12] Since Chile and Israel first introduced IT in the early 1990s, EMEs that have formally instituted IT include Brazil, Colombia, the Czech Republic, Hungary, South Korea, Mexico, Peru, the Philippines, Poland, South Africa, and Thailand. See Table 5 for details.

[13] See, for instance, Masson, Savastano, and Sharma (1997) and Agenor (2000).

[14] See Amato and Gerlach (2002), Blejer et al. (2000), Cukierman, Miller, and Neyapti (2002), and Mishkin (2000).

[15] Fraga, Goldfajn, and Minella (2004) is a comprehensive study of the performance of IT in EMEs, with special attention to the Brazilian case. For further lessons from Latin America, see Calderon and Schmidt-Hebbel (2003), Corbo and Schmidt-Hebbel (2001), and Mishkin and Savastano (2002). For analysis of IT in transition economies, see Jonas and Mishkin (2003).

problems, forcing some countries to abandon the peg and float their currencies: the Czech Republic in May 1997 after currency turbulence and the Slovak Republic and Poland in 1998. Hungary never adopted a fully floating exchange rate, but has been living with a ±15 percent exchange rate band since 2001.

In need of a new nominal anchor, the Czech Republic was the first country to adopt IT at the beginning of 1998. Poland followed suit in mid-1998. In contrast, Hungary's move to IT has been more gradual, with a progressive widening of the exchange rate band and the introduction of IT in 2001.[16]

Mexico and Brazil were the first (and the largest) Latin American countries to introduce an IT regime. In Mexico, after floating the peso in December 1994, the central bank tried to maintain its monetary targeting regime for a few years. Due to the unreliability of the relationship between the monetary base and inflation, however, the stance of monetary policy was difficult to assess and the Bank of Mexico lacked a nominal anchor to guide inflation expectations. IT was the natural candidate: It was introduced gradually and adopted in 1999.

In Brazil, the *real* plan introduced in 1994 successfully reduced inflation from above 2000 percent to 1.5 percent in 1998. However, the Brazilian government was not as successful in implementing much-needed fiscal reforms. Following concerns about the fiscal balance, the real came under speculative attack at the end of 1998 and collapsed in January 1999. The central bank acknowledged the need to put in place a nominal anchor and, after sharply raising interest rates to slow the fall of the currency, introduced an IT regime in June 1999.

In Colombia and Peru, some characteristics of an IT regime were already present in the first half of the 1990s.[17] However, many important features were missing, including the publication of inflation reports, multi-year targets for inflation, transparency, etc. We therefore set the IT adoption date in September 1999 for Colombia and January 2002 for Peru.[18]

In South Africa, following financial liberalization and other structural developments in the 1990s, the changing relationship between growth in money supply, output, and prices made explicit monetary growth targets less and less useful. In 1998, M3 growth guidelines started to be accompanied by informal targets for inflation, and in early 2000 a formal IT framework was finally introduced.[19]

After having investigated the circumstances under which these EMEs adopted IT, we are now interested in the main characteristics of these regimes, particularly compared with industrial countries. Table 5 summarizes the main features of IT in EMEs. There are several points worth noting. First of all, the current inflation targets are relatively low and not much higher than they are in industrial countries.[20] The experience of EMEs with respect to the disinflation process has varied, with some countries following a gradual approach and others being more aggressive. Overall, as shown in Figure 5, most of the countries have been successful in bringing down inflation from double digits to single digits.[21] But what should the appropriate target level be for EMEs? It is sometimes argued that central banks in EMEs should aim for somewhat higher rates of inflation than industrial economies, due to the presence of the Balassa-Samuelson effect. This is still an open question.

Second, EMEs seem split in choosing either a target point with a range around it or a target range. When countries choose a target point, the range is always ±1 percent.[22] Instead, when they choose a target range, this can be as narrow as 1 percent and as wide as 3.5 percent.[23] Only one country, Thailand, has chosen a target range with a lower threshold of 0 percent. It remains an open question whether a

[16] The ±15 percent exchange rate band was introduced in May 2001, and the rate of crawl was eliminate only in October 2001.

[17] These include some degree of central bank independence, the announcement of explicit numerical targets for the one-year-ahead inflation rate (often in conjunction with the government economic program), etc.

[18] The experience of Colombia is similar to Brazil's, where, after unsuccessfully defending the exchange rate band in September 1999, the authorities let the currency float and adopted IT as the nominal anchor. For Peru, we refer to the January 2002 Monetary Program, which states that "As of this year, the Central Reserve Bank of Peru (BCRP) has adopted an Explicit Inflation Targeting system." Other authors (e.g., Fraga, Goldfajn, and Minella, 2004) set the adoption date in 1994.

[19] See Casteleijn (2001).

[20] With the exception of Brazil, the inflation targets are included in a range between 0 and 6 percent. If we also exclude Colombia, the Philippines, and South Africa, the targets are centered on 2 to 3 percent.

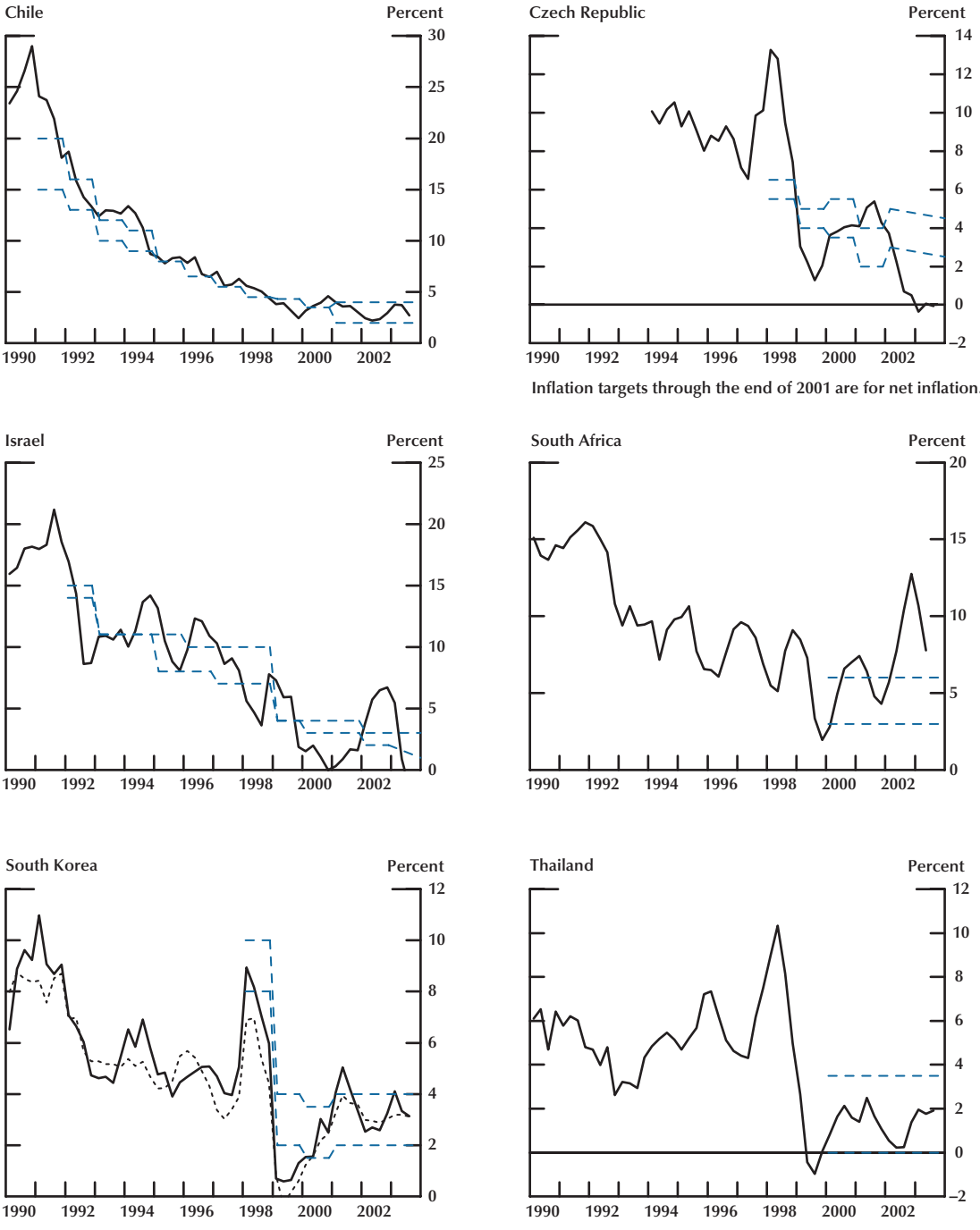
[21] CPI 12-month percent changes in November 2003 were at or below 5 percent in 10 of 13 countries. The exceptions are Brazil, Colombia, and Hungary, with inflation at 11.1, 6.1, and 5.6 percent, respectively.

[22] Only one country, Brazil, has a range of ±2.5 percent (for 2004 and 2005).

[23] Brazil, again, is the only exception to this regularity. See Table 5 for details.

Figure 5

Inflation Rates and Targets (quarterly inflation rates are year over year)

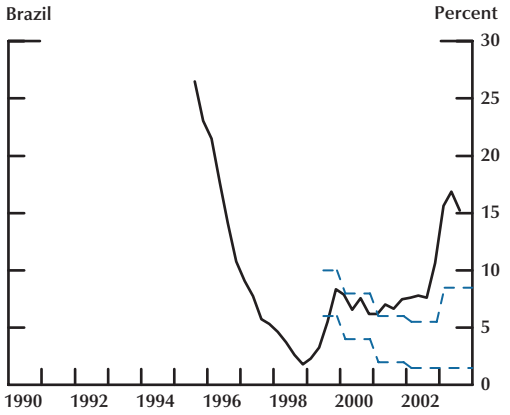


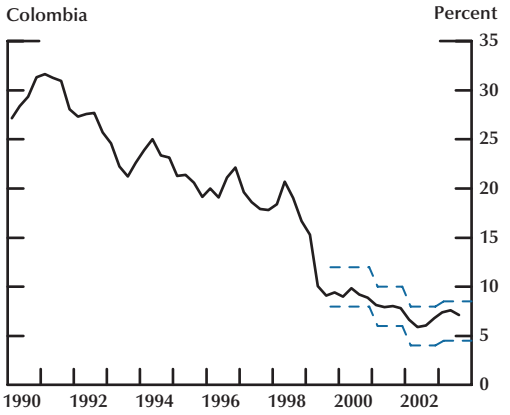
Inflation targets through the end of 2001 are for net inflation.

Since 2000, core inflation (the dotted line) has been targeted; previously, CPI (the solid line) was targeted.

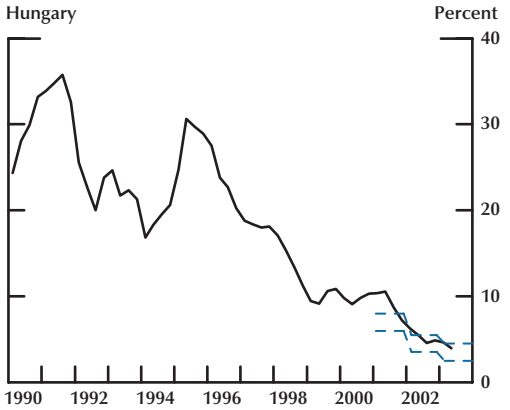
Figure 5 cont'd

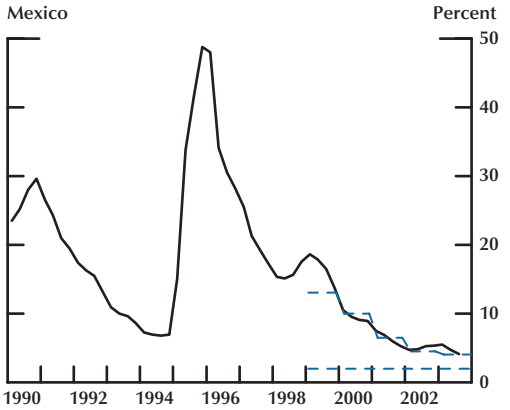
Inflation Rates and Targets (quarterly inflation rates are year over year)





The band of ± 2 percent was made explicit in 2003.





The lower band was made explicit in 2003.

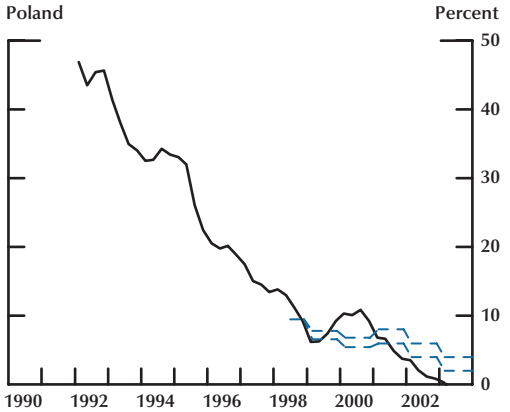


Figure 5 cont'd

Inflation Rates and Targets (quarterly inflation rates are year over year)

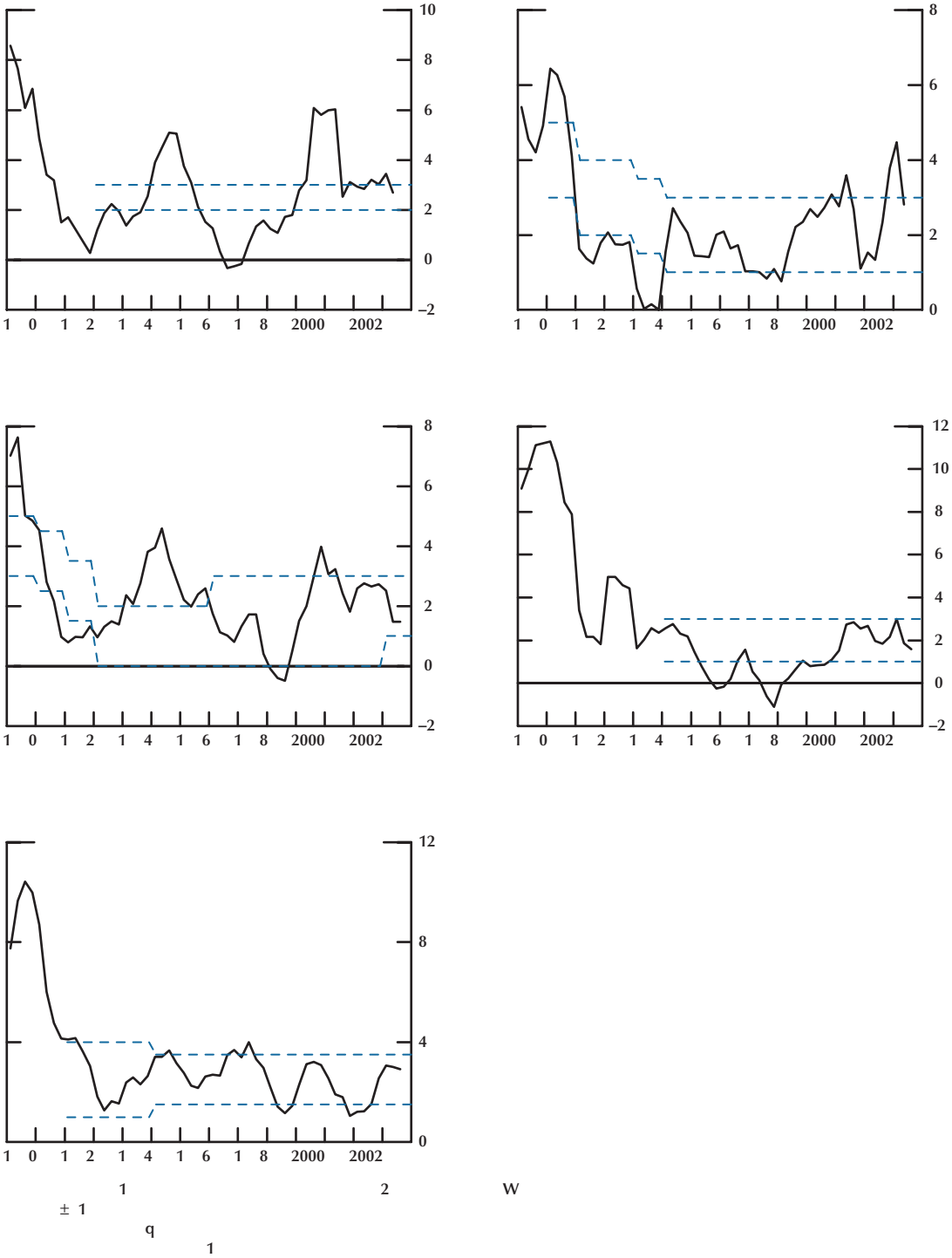


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Table 5

Features of IT Regimes in Developing Countries

	Brazil	Chile	Colombia	Czech Republic	Hungary	Israel
Date first issued	Jun 1999	Jan 1991	Sep 1999	Jan 1998	Aug 2001	Jan 1992
Current target	1.5-8.5	2-4 centered at 3	6	3-5 declining to 2-4	3.5 ±1	1-3
Target duration	5.5 ± 2.5 (2004) 3.5 ± 2.5 (2005)	Medium term	5-6 (2004)	Through Dec 2005	3.5 ±1 (2004) 2 (long term)	2003 onward
Inflation measure	National consumer price index (IPCA): a measure of inflation in 9 metro areas plus 2 other urban areas	CPI; central bank monitors core inflation (which excludes vegetable, fruit, and fuel prices	CPI	CPI	CPI	CPI
Target announcement	Set by National Monetary Council, composed by finance minister, planning minister, and central bank president	Central bank in consultation with government	Jointly by government and central bank	Central bank	Central bank	Minister of finance in consultation with prime minister and governor of central bank
Inflation report	Yes	Yes	Yes	Yes	Yes	Yes
Published forecast	Yes	Yes	Yes	Yes	Yes	No
Other objectives	—	—	—	—	±15% band around parity with Euro	±36% crawling band around parity with a currency basket representing Israel's foreign trade
Mandate	Price stability, sound financial system	Price stability, functioning payments system	Price stability	Price stability	Price stability	Price stability
Other features	Letter from central bank president to minister of finance if target breached	—	—	—	—	Public explanation when deviations from target are greater than ±1%

Korea	Mexico	Peru	Philippines	Poland	South Africa	Thailand
Apr 1998	Jan 1999	Jan 2002	Jan 2002	Jun 1998	Feb 2000	May 2000
3 ±1	3 ±1	2.5 ±1	4.5-5.5	3 ±1	3-6	0-3.5
2.5-3.5 (average 2004-2006)	Around 3 (medium term)	2004	4-5 (2004)	2.5 ±1 (medium term)	2004	2004
Core inflation (CPI inflation minus non-cereal agricultural products and petroleum-based products)	CPI	CPI	CPI, although four core inflation measures are monitored by the central bank	CPI	CPI (excluding mortgage interest costs)	Core CPI (excluding raw food and energy prices)
Central bank in consultation with government	Central bank	Central bank	Set and announced jointly by central bank and government	Central bank	Central bank	Government in consultation with central bank
Yes	Yes	Yes	Yes	Yes	Yes	Yes
Yes	Yes	Yes	Yes	No	No	Yes
—	—	Foreign exchange operations	—	—	—	—
Price stability	Price stability, sound financial system, functioning payments system	Price stability	Price stability conducive to balanced and suitable economic growth, monetary stability, convertibility of currency	Price stability, necessary in building the permanent foundation of long-term economic growth	Price stability, sound financial system	Price stability
—	—	—	Letter from central bank governor to president when target breached			Public explanation when target breached

target point or a target range should be chosen. In favor of the target point, it should be noted that the point appears to be more effective in focalizing inflation expectations. And the range around it still allows for some flexibility in the event of forecast errors or unexpected events. In the presence of a target range, instead, the thresholds sometimes seem to be assuming life on their own.

Third, following the earlier experience of industrial countries, most EMEs moved away from one-year-ahead inflation targets and adopted multi-year targets or some definition of a medium-term target.[24] This can be interpreted as a sign that the disinflation process from high levels of inflation has come close to an end, forcing these countries to "think medium-term" and develop a more operational concept of price stability.

Fourth, most EMEs target the CPI because it is well understood by the public and quickly available.[25] Despite this, emerging and advanced countries have at least two main differences in their respective CPI baskets. First, the share of food is larger in EMEs. This implies a more volatile CPI, since food prices are related to weather conditions and therefore tend to move more unpredictably. Second, regulated prices have a greater impact in EMEs, especially during the early years of the disinflation process. Consequently, it is more difficult for the central bank to effectively control inflation, with potential damage to the central bank's credibility.[26] However, while targeting core inflation would probably be more appropriate, a measure of inflation that disregards food and regulated prices might not reflect the cost of living, putting the public support for an independent central bank at risk.

Finally, EMEs seem to be moving away from previous attempts to control two objectives, inflation and the exchange rate, with one instrument.[27] In fact, only Hungary and Israel still have a band for the nominal exchange rate. There are several reasons why EMEs may want to pay greater attention to exchange rates than industrial countries. First, with large shocks and sizable capital flows, neglecting the exchange rate may generate unwelcome volatility. Second, in countries with historically high inflation, the exchange rate may work as a focal point for inflation expectations.[28] Third, since firms and governments in EMEs borrow mainly in foreign currency, large depreciations may increase the burden of foreign-denominated debt, producing a massive deterioration of balance sheets and increasing the risks of a financial crisis.[29] However, most EMEs have decided to focus their efforts primarily on controlling inflation and have abandoned the idea of managing extensively the exchange rate, which can be interpreted as an additional sign of their intention to embrace a fully fledged IT regime.

6. THE EFFECTS OF INFLATION TARGETING IN EMERGING MARKET ECONOMIES

In considering the effects of IT in EMEs, we begin by focusing on inflation expectations. For each country for which data are available, Figure 6 plots (i) realized inflation (measured as Q4/Q4); (ii) one-year-ahead expected inflation (on a Q4/Q4 basis), where the expectation is formed in the fourth quarter of the current year; and (iii) long-run (6 to 10 years) inflation expectations, where the expectation is formed in the fourth quarter of the current year. Inflation expectations are again measured based on surveys conducted by Consensus Economics. The figure contains data for three years before and after the adoption date. The data used in creating Figure 6 are shown in Appendix Table A3.

We begin by considering long-term inflation expectations. The main result is that, *as in industrial countries, IT does not seem to have had a large initial impact on long-term expected inflation*. In other

[24] This is true for Brazil, Chile, the Czech Republic, Hungary, Israel, South Korea, Mexico, and Poland.

[25] Exceptions are Brazil, South Korea, South Africa, and Thailand. Other countries (Chile and the Philippines) monitor some measures of core inflation.

[26] Two broader issues are related to the central banks' ability to control inflation in EMEs. One has to do with the Balassa-Samuelson effect, which implies an appreciation of the real exchange rate either via higher inflation or via an appreciation of the nominal exchange rate. The second issue has to do with the difficulty of forecasting inflation. This is true after a regime change, during disinflation from high inflation levels, and because of EMEs' sensitivity to commodity prices and disproportionate dependence on capital flows.

[27] A strategy of dual objectives was originally adopted in some EMEs to speed up the disinflation process. The introduction of exchange rate flexibility became necessary to resolve the tension between maintaining the disinflationary momentum and guarding against a loss of competitiveness. As the disinflation process continued, the bands were typically broadened and subsequently abandoned as they became a source of policy conflict, undermining the credibility of the inflation target. The experience of Hungary in January, June, and December 2003 highlights the risks of combining IT and exchange rate management in periods of speculative attacks and large swings in market sentiment.

[28] Depreciations have historically tended to have larger inflationary effects in EMEs, as pass-through effects have been faster.

[29] For the discussion on the composition of the CPI basket and the role of the exchange rate in EMEs, we relied on Amato and Gerlach (2002).

Figure 6

Event Study: IT in EMEs

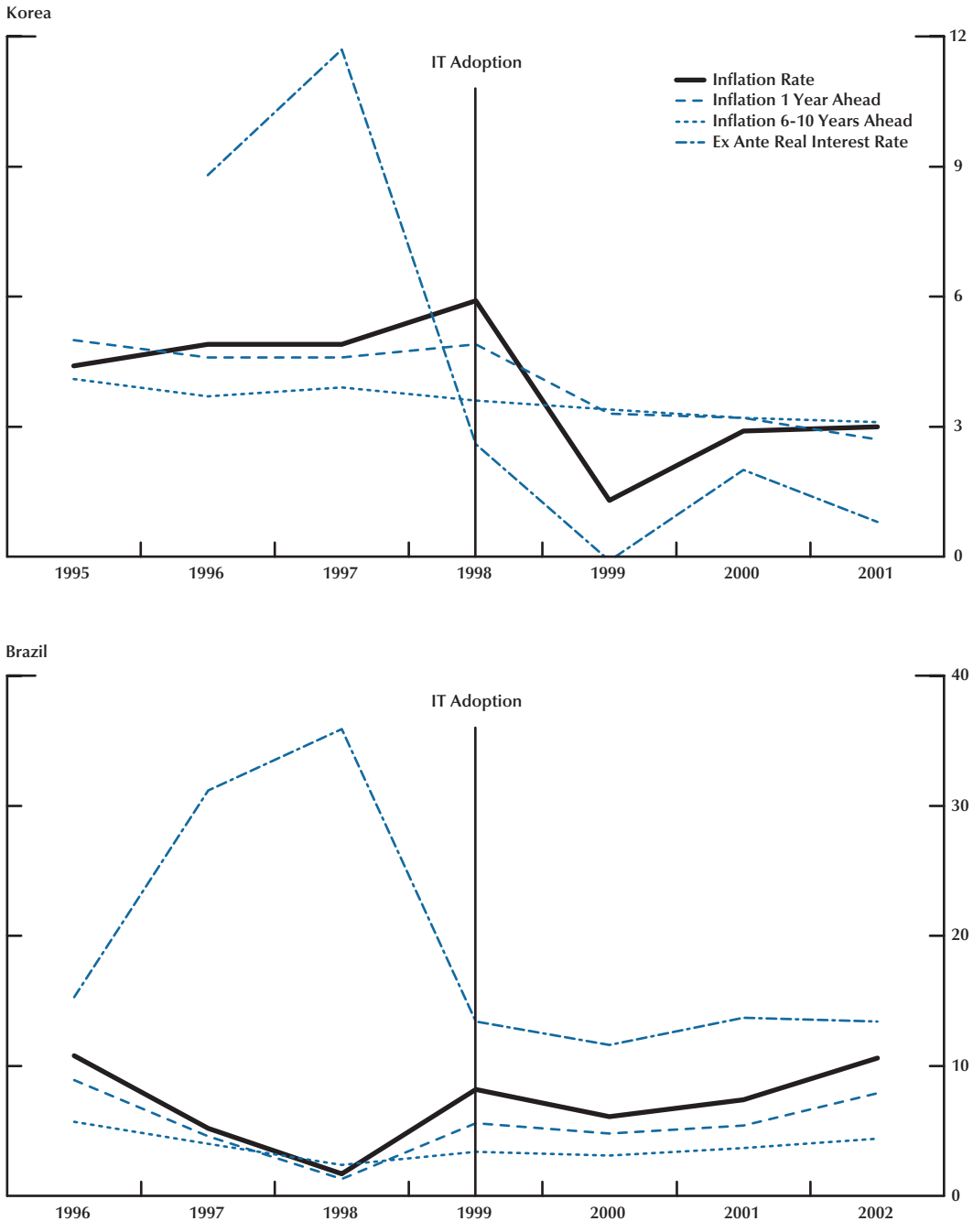


Figure 6 cont'd

Event Study: IT in EMEs

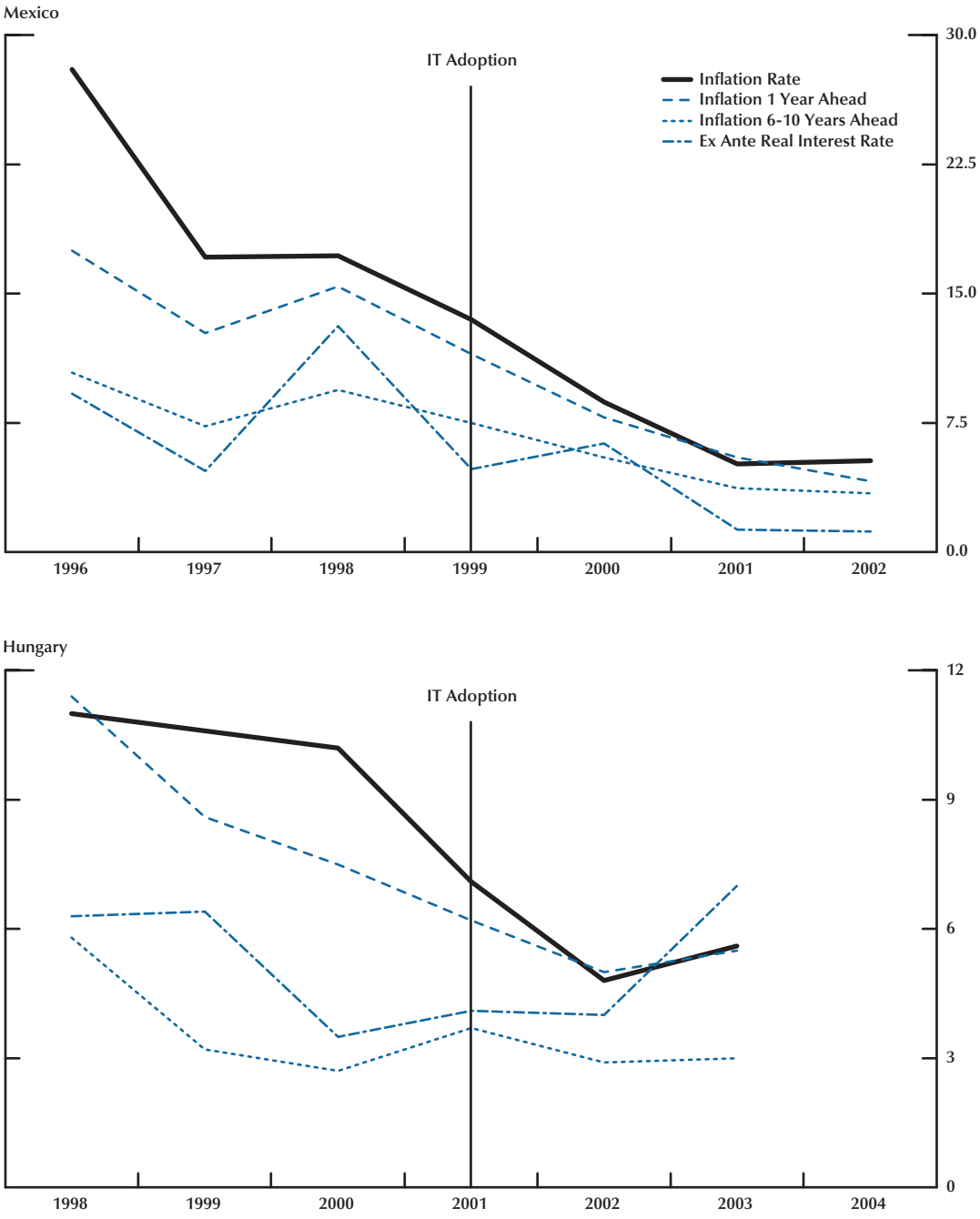
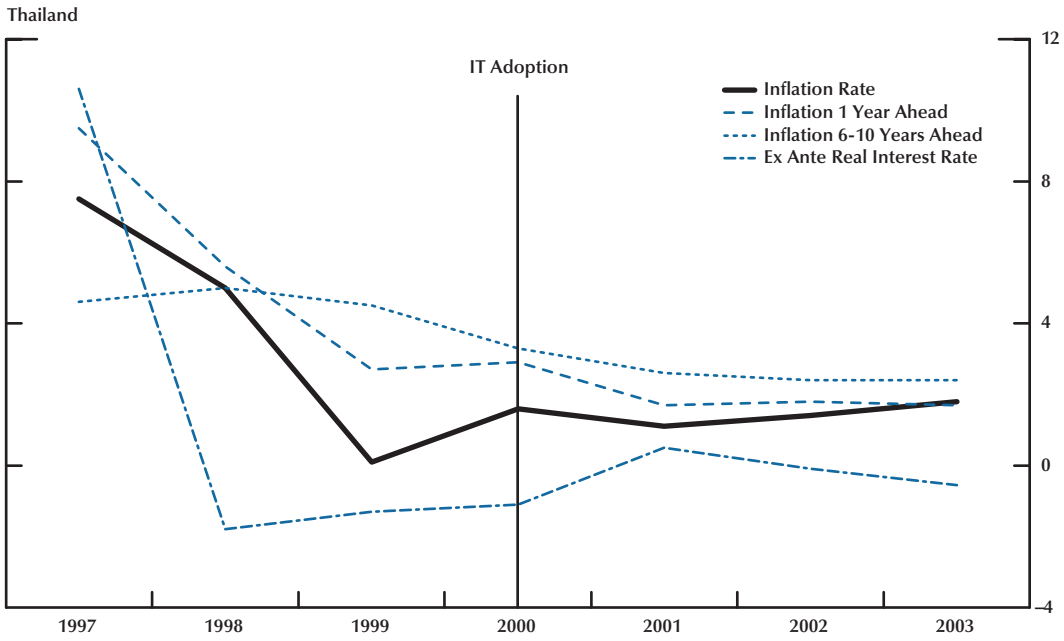


Figure 6 cont'd

Event Study: IT in EMEs



words, long-term inflation expectations did not change dramatically at the time of the adoption of IT. Consider Brazil: Inflation expectations were 2.4 percent at the end of 1998, when the *real* came under attack, down from nearly 6 percent in 1996. They were up to only 3.4 in 1999, when IT was introduced after the collapse of the currency, even though actual inflation jumped to 8.2 percent from 1.7 percent in the previous year. Inflation expectations continued to decline in 2000, down to 3.1 percent, with actual inflation still above that level, at 6.1 percent. Inflation expectations rose only slightly afterwards, up to 4.4 percent, well below actual inflation. The main point, therefore, is that inflation expectations in Brazil started to decline *before* the adoption of IT and continued to do so afterwards, edging up again 2 years later, but always remaining below actual inflation.

A similar path can be observed in other countries. In South Korea, inflation expectations have been declining since 1995, well before the adoption of IT, and continued to fall smoothly, at small decrements, through 2001, down 1 percent in total. Actual inflation rose only 1 percent after the financial crisis, in 1998, but dropped to 1.3 percent in 1999, well below long-term inflation expectations. In 2001, actual inflation was at a level consistent with long-term expectations. In Mexico, apart from 1998, inflation expectations dropped dramatically, from 10.4 percent in 1996 to 7.5 percent in 1999 and 3.4 percent in 2002. The introduction of IT does not seem to have affected significantly this downward trend in inflation expectations. Moreover, inflation expectations have been consistently below actual inflation, even immediately after the 1994-95 crisis, when the difference was almost 20 percent. At the end of 2002, long-term expectations were 2 percent below actual inflation. In Thailand, inflation expectations have declined since 1998, with a noticeable drop in 2000, when IT was adopted, but have been well above actual inflation since 1999. Finally, inflation expectations in Hungary were coming down before IT was introduced and actually rose the year of the adoption.[30] However, they remained stable, at around 3 percent in 2003, even though actual inflation rose almost 1 percentage point.

[30] For Colombia, we don't have inflation expectations for the year after the adoption of IT, but there is still a clear downward trend beginning in 1997. In Peru, the decline in long-term inflation expectations began before IT was introduced in 2002, but was very gradual. For the Czech Republic and Poland we don't have data available for the years before adoption of the IT. However, inflation expectations have been declining since the adoption of IT. Finally, we don't have any data available for Chile and Israel (the early adopters) or for the Philippines and South Africa.

Table 6

Relative Success in Hitting Inflation Targets (standard deviation from midpoint)

Country	Standard deviation
Brazil	5.4
Chile	1.9
Columbia	2.1
Czech Republic	3.1
Hungary	1.1
Israel	2.6
Mexico	2.1
Poland	2.7
South Africa	3.6
Korea	1.3
Thailand	0.7
Australia	1.7
Canada	1.2
New Zealand	1.6
Sweden	1.3
United Kingdom	0.9

NOTE: Inflation is measured as a quarterly, annualized rate. For Columbia, inflation deviations are based on CPI inflation, although the target is based on net inflation through 2001. In accordance with the target, inflation deviations for South Korea are based on CPI inflation through 1999 and on core inflation thereafter.

What about short-term inflation expectations? Is there any evidence that the introduction of IT lowered one-year-ahead expectations? The conclusion is similar to the case of long-term inflation expectations: There is no evidence of any dramatic reduction in short-term inflation expectations, neither for the year IT was introduced nor for the following year. There seems to be, instead, a gradual decline of these expectations over time, with differences on a country-by-country basis.[31]

[31] For example, in Brazil, in line with long-term inflation expectations, short-term expectations rose the year of the introduction of IT, declined the following year, and rose again in the next couple of years. In Hungary, short-term inflation expectations declined both the year IT was introduced and the following year. However, a downward trend was already evident in the previous three years. A similar story holds for Mexico, with short-term expectations gradually declining over time, well before the introduction of IT. In Korea and Thailand, short-term expectations actually rose the year IT was adopted and dropped significantly the year after. Interestingly, this was the only year of such an increase, with both the previous and the following three years showing declines.

In summary, the evidence from inflation expectations suggests that, while expectations declined when IT was introduced and continued to do so subsequently, the downward trend was evident even before the switch to IT, in line with the experience of industrial countries. This does not necessarily mean that IT was ineffective, as it is plausible that, in the absence of IT, "bad" monetary policies could have offset previous gains in reducing inflation.

An alternative way to evaluate the medium-term performance of IT in EMEs would be to calculate sacrifice ratios for these countries, along the line of similar studies for industrial countries. However, EMEs are characterized by rapid structural changes, making the estimate of potential output extremely difficult and maybe even unreliable. One possibility is to look at short-term ex ante real rates (shown in Figure 6 and Appendix Table A3). Consider Brazil, for example. Short-term real rates were very high before the introduction of IT, at almost 36 percent in 1998, came down to 13.4 percent in 1999, but remained around that level for the following three years. Monetary policy was very tight, and this makes it more difficult to evaluate the performance of IT as a monetary policy framework. In Mexico, short-term real rates were very high in 1998, but declined substantially the year IT was introduced, down to nearly 5 percent. After rising in 2000, they were around 1 percent in 2001 and 2002. In this case, it seems reasonable to conclude that the successful reduction of inflation cannot be entirely attributed to tight monetary policy, leaving some scope for crediting IT. This is even more evident in Korea, where short-term real rates dropped the year of the introduction of IT, from nearly 12 percent to 2.6 percent, and remained low afterward, and in Thailand, where real rates were negative even the two years before the introduction of IT. In summary, while in some countries real rates were very high when IT was introduced, in other countries real rates were low and inflation was still successfully reduced.

In EMEs the adoption of IT has been frequently associated with overshooting and undershooting of the targets. An alternative way to evaluate the medium-term performance of the IT framework in EMEs is to look at the frequency of overshooting and undershooting. Table 6 shows the standard deviation of inflation from the midpoint of the target range for each of the countries considered in Figure 5. Not surprisingly, industrial countries generally display a lower standard deviation than EMEs. Among

EMEs, Brazil is the worst performer, followed by South Africa, while South Korea and Thailand are the best performers, with standard deviations even lower than that of Australia. Possible explanations for the higher standard deviation of inflation in EMEs include the difficulty of controlling and forecasting inflation in the developing world, the larger shocks EMEs face, and the lower credibility central banks have in countries with a history of high inflation.

In conclusion, the record to date suggests that inflation targeters in emerging markets have been relatively successful in reducing inflation, although the record is still fairly short for most of the countries. It is still not completely obvious, however, the extent to which this reduction can be credited entirely to IT as a monetary policy framework. It might be the case that part of the success of IT in EMEs is attributable to the global downward trend in inflation rates. It remains also to be seen whether the fairly strong performance of these countries will be sustained over a longer horizon.

7. CONCLUSION

Our analysis of the past decade of experience for the industrial countries suggests that IT has played a role in anchoring inflation expectations and in reducing inflation persistence. Of course, because we have focused on reduced-form evidence, we have not addressed the extent to which certain country-specific factors may account for the differences we have documented across IT and non-IT economies. For example, many of the IT countries in our sample are small, open economies, which might be expected to have very different inflation dynamics from the large, mostly closed economies that dominate our non-IT sample.

Nevertheless, our results are broadly consistent with the implications of the expectations-augmented Phillips curve:

$$\pi_t = \hat{\pi}_{t+1} + \phi y_t + \varepsilon_t , \quad (3)$$

where $\hat{\pi}_{t+1}$ is the one-period-ahead forecast of inflation, y_t is the current output gap, and ε_t is an aggregate supply shock. When the central bank has an transparent and credible inflation target, π^*, then the private sector's inflation forecast corresponds to $\hat{\pi}_{t+j} = \pi^*$ at some reasonable forecast horizon, j. In this case, actual inflation will depend on expected output gaps over the next j periods and on the current aggregate supply shock. Thus, inflation will tend to exhibit relatively little intrinsic persistence in response to transitory supply shocks; the observed degree of inflation persistence may depend largely on the persistence of output gap fluctuations. As a result, under IT, a key challenge for the central bank may be to keep output close to potential by moving promptly to offset aggregate demand shocks.

In contrast, if the central bank's inflation objective is not transparent or credible, the private sector's rational forecast of medium-to-long-run inflation will depend on the recent behavior of actual inflation (cf. Erceg and Levin, 2003). For the simplest case in which $\hat{\pi}_{t+1} = \hat{\pi}_{t-1}$, it is evident that inflation will tend to exhibit a high degree of intrinsic persistence, even in response to temporary supply shocks or fluctuations in aggregate demand.[32]

Our investigation of the early experience with IT in EMEs confirms that—as in the industrial countries—the adoption of IT has generally not been associated with an instantaneous adjustment of inflation expectations. Furthermore, while most of these EMEs have succeeded in reducing average inflation to very low levels, the volatility of inflation has remained quite high, with relatively frequent overshooting and undershooting of the target bands. Such volatility is not necessarily surprising, given that most of the EMEs are small and highly sensitive to global economic fluctuations. Thus, additional research and experience will be helpful in fine-tuning the implementation of IT and ensuring its positive contribution to macroeconomic stability.

REFERENCES

Agenor, Pierre-Richard. "Monetary Policy under Flexible Exchange Rates: An Introduction to Inflation Targeting." Unpublished manuscript, 2000.

Akaike, H. "Information Theory and an Extension of the Maximum Likelihood Principal," in B.N. Petrov and F. Csaki, eds., *Second International Symposium on Information Theory*. Budapest: Akademia Kiado, 1973, pp. 267-81.

Almeida, Alavro and Goodhart, Charles A.E. "Does the Adoption of Inflation Targets Affect Central Bank Behaviour?" Unpublished manuscript, 1998.

Amato, Jeffrey D. and Gerlach, Stefan. "Inflation Targeting in Emerging Market and Transition Economies: Lessons after a Decade." *European Economic Review*, April 2002, *46*(4-5), pp. 781-90.

[32] See also Orphanides and Williams (forthcoming).

Ammer, John and Freeman, Richard T. "Inflation Targeting in the 1990s: The Experiences of New Zealand, Canada, and the United Kingdom." *Journal of Economics and Business*, May 1995, *47*(2), pp. 165-92.

Andrews, Donald W.K. and Chen, Hong-Yuan. "Approximately Median-Unbiased Estimation of Autoregressive Models." *Journal of Business and Economic Statistics*, April 1994, *12*(1), pp. 187-204.

Ball, Laurence and Sheridan, Niahm. "Does Inflation Targeting Matter?" in Ben S. Bernanke and Michael Woodford, eds., *The Inflation Targeting Debate*. Chicago: University of Chicago Press (forthcoming).

Barsky, Robert B. "The Fisher Hypothesis and the Forecastability and Persistence of Inflation." *Journal of Monetary Economics*, January 1987, *19*(1), pp. 3-24.

Batini, Nicoletta. "Euro Area Inflation Persistence." Working Paper No. 201, European Central Bank, 2002.

Benati, Luca. "Investigating Inflation Persistence Across Monetary Regimes." Unpublished manuscript, Bank of England, 2002.

Benati, Luca. "Evolving Post-World War II U.K. Economic Performance." Unpublished manuscript, Bank of England, 2003.

Bernanke, Ben S.; Laubach, Thomas; Mishkin, Frederic and Posen, Adam S. *Inflation Targeting: Lessons from the International Experience*. Princeton, NJ: Princeton University Press, 1999.

Bernanke, Ben S. and Kuttner, Kenneth N. "What Explains the Stock Market's Reaction to Federal Reserve Policy?" Staff Report No. 174, Federal Reserve Bank of New York, 2003.

Bernanke, Ben S. and Mishkin, Frederic. "Inflation Targeting: A New Framework for Monetary Policy?" *Journal of Economic Perspectives*, Spring 1997, *11*(2), pp. 97-116.

Blejer, Mario I.; Ize, Alain; Leone, Alfredo M. and Werlang, Sergio. *Inflation Targeting in Practice: Strategic and Operational Issues and Application to Emerging Market Economies*. Washington, DC: International Monetary Fund, 2000; www.imf.org/external/pubs/ft/seminar/2000/targets/strach1.pdf.

Bonfim, Antulio N. "Monetary Policy and the Yield Curve." Finance and Economics Discussion Series Paper No. 2003-15, Board of Governors of the Federal Reserve System, 2003.

Brainard, William C. and Perry, George. "Making Policy in a Changing World," in G. Perry and J. Tobin, eds., *Economic Events, Ideas, and Policies: The 1960s and After*. Washington, DC: Brookings Institution Press, 2000.

Calderon, César A. and Schmidt-Hebbel, Klaus. "Macroeconomic Policies and Performance in Latin America." Working Paper No. 217, Central Bank of Chile, 2003.

Casteleijn, Anton J.H. "South Africa's Monetary Policy Framework." Working paper, Reserve Bank of South Africa, 2001.

Castelnuovo, Efrem; Nicoletti-Altimari, Sergio and Palenzuela, Diego. "Definition of Price Stability, Range and Point Inflation Targets: The Anchoring of Long-Term Inflation Expectations," in O. Issing, ed., *Background Studies for the ECB's Evaluation of Its Monetary Policy Strategy*. Frankfurt-am-Main, Germany: European Central Bank, 2003.

Cecchetti, Stephen G. and Ehrmann, Michael. "Does Inflation Targeting Increase Output Volatility? An International Comparison of Policymakers' Preferences and Outcomes." NBER Working Paper 7426, National Bureau of Economic Research, 1999.

Cogley, Timothy and Sargent, Thomas J. "Evolving Post-World War II U.S. Inflation Dynamics," in B.S. Bernanke and K. Rogoff, eds., *NBER Macroeconomics Annual 2001*. *16*(1). Cambridge, MA: MIT Press, 2002, pp. 331-72.

Cogley, Timothy and Sargent, Thomas J. "Drifts and Volatilities: Monetary Policies and Outcomes in the Postwar U.S." Working paper, 2003.

Corbo, Vittorio and Schmidt-Hebbel, Klaus. "Inflation Targeting in Latin America." Working Paper No. 105, Central Bank of Chile, 2001.

Corbo, Vittorio; Landerretche, Oscar and Schmidt-Hebbel, Klaus. "Assessing Inflation Targeting after a Decade of World Experience." Working Paper No. 51, Austrian National Bank, 2001.

Cukierman, Alex; Miller, Geoffrey P. and Neyapti, Bilin. "Central Bank Reform, Liberalization and Inflation in Transition Economies—An International Perspective."

Journal of Monetary Economics, May 2002, *49*(2), pp. 237-64.

Dueker, Michael J. and Fischer, Andreas. "Do Inflation Targets Redefine Central Bank Inflation Preferences? Results from an Indicator Model," in K. Alders, K. Koedijk and C. Winder, eds., *Monetary Policy in a Converging Europe*. Amsterdam: Kluwer Academic Publishers, 1996.

Erceg, Christopher J. and Levin, Andrew T. "Imperfect Credibility and Inflation Persistence." *Journal of Monetary Economics*, May 2003, *50*(4), pp. 915-44.

Evans, Martin and Wachtel, Paul. "Inflation Regimes and the Sources of Inflation Uncertainty. " *Journal of Money, Credit, and Banking*, August 1993, *25*(3), pp. 475-511.

Fraga, Arminio; Goldfajn, Ilan and Minella, Andre. "Inflation Targeting in Emerging Market Economies," in M. Gertler and K. Rogoff, eds., *NBER Macroeconomics Annual 2003*. Volume 18. Cambridge, MA: MIT Press (forthcoming).

Franses, Philip H. and Haldrup, Hans. "The Effects of Additive Outliers on Tests for Unit Roots and Cointegration." *Journal of Business and Economic Statistics*, October 1994, *12*(4), pp. 471-78.

Fuhrer, Jeffrey and Moore, George R. "Inflation Persistence." *Quarterly Journal of Economics*, February 1995, *110*(1), pp. 127-59.

Gavin, William T. "Inflation Targeting: Why It Works and How to Make It Work Better?" *Business Economics*, April 2004, *39*(2), pp. 30-37.

Gertler, Mark. Comment on L. Ball and N. Sheridan, "Does Inflation Targeting Matter?" in Ben S. Bernanke and Michael Woodford, eds., *The Inflation Targeting Debate*. Chicago: University of Chicago Press (forthcoming).

Goodfriend, Marvin. "Inflation Targeting in the United States?" in Ben S. Bernanke and Michael Woodford, eds., *The Inflation Targeting Debate*. Chicago: University of Chicago Press (forthcoming).

Gurkaynak, Refet S.; Sack, Brian and Swanson, Eric. "The Excess Sensitivity of Long-Term Interest Rates: Evidence and Implications for Macroeconomic Models." Finance and Economic Discussion Series Paper No. 2003-50, Board of Governors of the Federal Reserve System, 2003.

Hansen, Bruce E. "The Grid Bootstrap and the Autoregressive Model." *The Review of Economics and Statistics*, 1999, *81*(4), pp. 594-607.

Johnson, David R. "The Effect of Inflation Targeting on the Behavior of Expected Inflation: Evidence from an 11 Country Panel." *Journal of Monetary Economics*, November 2002, *49*(8), pp.1493-1519.

Johnson, David R. "The Effect of Inflation Targets on the Level of Expected Inflation in Five Countries." *Review of Economics and Statistics*, November 2003, *55*(4), pp. 1076-81.

Jonas, Jiri and Mishkin, Frederic S. "Inflation Targeting in Transition Economies: Experience and Prospects." NBER Working Paper No. 9667, National Bureau of Economic Research, 2003.

Kim, Chang-Jin; Nelson, Charles R. and Piger, Jeremy. "The Less-Volatile U.S. Economy: A Bayesian Investigation of Timing, Breadth, and Potential Explanations." *Journal of Business and Economic Statistics*, January 2003, *22*(10), pp. 80-93.

Kohn, Donald.L. Comment on M. Goodfriend, "Inflation Targeting in the United States?" in Ben S. Bernanke and Michael Woodford, eds., *The Inflation Targeting Debate*. Chicago: University of Chicago Press (forthcoming).

Kozicki, Sharon and Tinsley, P.A. "Term Structure Views of Monetary Policy under Alternative Models of Agent Expectations." *Journal of Economic Dynamics and Control*, January 2001a, *25*(1/2), pp. 149-84.

Kozicki, Sharon and Tinsley, P.A. "Shifting Endpoints in the Term Structure of Interest Rates." *Journal of Monetary Economics*, June 2001b, *47*(3), pp. 613-52.

Kuttner, Kenneth N. and Posen, Adam S. "Does Talk Matter After All? Inflation Targeting and Central Bank Behavior." Federal Reserve Bank of New York, Staff Report No. 88, 1999.

Kuttner, Kenneth N. and Posen, Adam S. "Beyond Bipolar: A Three-Dimensional Assessment of Monetary Frameworks." *International Journal of Finance and Economics*, October 2001, *6*(4), pp. 369-87.

Laubach, Thomas and Posen, Adam S. "Some Comparative Evidence on the Effectiveness of Inflation Targeting." Research Paper No. 9714, Federal Reserve Bank of New York, 1997.

Leiderman, Leonardo and Svensson, Lars E.O., eds. *Inflation Targets*. London: Centre for Economic Policy Research, 1995.

Levin, Andrew T. and Piger, Jeremy. "Is Inflation Persistence Intrinsic In Industrial Economies?" Working Paper No. 2002-023, Federal Reserve Bank of St. Louis, 2002.

Masson, Paul R.; Savastano, Miguel A. and Sharma, Sunhil. "The Scope for Inflation Targeting in Developing Countries." IMF Working Paper No. 130, International Monetary Fund, 1997.

Mishkin, Frederic S. "Inflation Targeting in Emerging-Market Countries." *American Economic Review*, May 2000, *90*(2), pp. 105-09.

Mishkin, Frederic S. and Savastano, Miguel A. "Monetary Policy Strategies for Emerging Market Countries: Lessons from Latin America." Unpublished manuscript, Columbia University, 2002.

Mishkin, Frederic S. and Schmidt-Hebbel, Klaus. "One Decade of Inflation Targeting in the World: What Do We Know and What Do We Need to Know?" in N. Loayza and R. Soto, eds., *A Decade of Inflation Targeting in the World*. Santiago: Central Bank of Chile, 2001, pp. 117-219.

Neumann, Manfred J.M. and von Hagen, Jurgen. "Does Inflation Targeting Matter?" Federal Reserve Bank of St. Louis *Review*, July/August 2002, *84*(4), pp. 127-48.

Orphanides, Athanasios and Williams, John C. "Imperfect Knowledge, Inflation Expectations, and Monetary Policy," in Ben S. Bernanke and Michael Woodford, eds., *The Inflation Targeting Debate*. Chicago: University of Chicago Press (forthcoming).

Pivetta, Frederic and Reis, Ricardo A.M.R. "The Persistence of Inflation in the United States." Unpublished manuscript, Harvard University, 2001.

Ravenna, Frederic. "The Impact of Inflation Targeting in Canada: A Structural Analysis." Job Market Paper, New York University, 2000.

Schaechter, Andrea; Stone, Mark R. and Zelmer, Mark D. "Adopting Inflation Targeting: Practical Issues for Emerging Market Countries." IMF Occasional Paper No. 202, International Monetary Fund, 2000.

Siklos, Pierre L. "Inflation-Target Design: Changing Inflation Performance and Persistence in Industrial Countries." Federal Reserve Bank of St. Louis *Review*, March/April 1999, *81*(2), pp. 47-57.

Stock, James H. "Confidence Intervals for the Largest Autoregressive Root in U.S. Macroeconomic Time Series." *Journal of Monetary Economics*, December 1991, *28*(3), pp. 435-59.

Stock, James H. Comment on T. Cogley and T.J. Sargent, "Evolving Post-World War II U.S. Inflation Dynamics," in B.S. Bernanke and K. Rogoff, eds., *NBER Macroeconomics Annual 2001*. *16*(1). Cambridge, MA: MIT Press, 2002, pp. 379-87.

Stock, James and Watson, Mark W. "Has the Business Cycle Changed? Evidence and Explanations." Federal Reserve Bank of Kansas City *Economic Review* (forthcoming).

Svensson, Lars E.O. and Woodford, Michael. "Implementing Optimal Policy through Inflation-Forecast Targeting," in Ben S. Bernanke and Michael Woodford, eds., *The Inflation Targeting Debate*. Chicago: University of Chicago Press (forthcoming).

Taylor, John B. "Low Inflation, Pass-Through, and the Pricing Power of Firms." *European Economic Review*, 2000, *44*(7), pp. 1389-1408.

van Dijk, Dick; Osborn, Denise R. and Sensier, Marianne. "Changes in the Variability of the Business Cycle in the G7 Countries." Centre for Growth and Business Cycle Research Discussion Paper No. 0316, School of Economics, University of Manchester, 2002.

Appendix

Table A1

AIC Lag Selection

Country	Lag choice—core CPI	Lag choice—total CPI
IT countries		
Australia	1	1
Canada	1	1
New Zealand	1	1
Sweden	1	1
United Kingdom	1	1
Non-IT countries		
Denmark	2	1
Euro area	2	4
France	1	3
Germany	3	3
Italy	1	1
Netherlands	1	1
Japan	2	3
United States	4	4

Table A2

Alternative Persistence Estimates for Inflation

	Core CPI		Total CPI	
Country	Median unbiased	Upper 95th percentile	Median unbiased	Upper 95th percentile
IT countries				
Australia	0.77	1.05	0.59	0.85
Canada	0.45	0.73	0.12	0.46
New Zealand	0.43	0.72	0.44	0.73
Sweden	0.44	0.7	0.28	0.58
United Kingdom	0.5	0.77	0.34	0.64
Non-IT countries				
Denmark	0.48	1.07	–0.05	0.28
Euro area	0.88	1.08	0.76	1.24
France	0.79	1.06	0.76	1.24
Germany	0.74	1.09	0.65	1.17
Italy	0.91	1.07	0.89	1.07
Netherlands	0.53	0.79	0.6	0.89
Japan	0.81	1.10	0.5	1.14
United States	1.03	1.16	0.36	0.87

NOTE: For each country in the sample, this table records the median unbiased estimate and the upper bound of the two-sided 90 percent confidence interval for the sum of the autoregressive coefficients of core and total CPI inflation, estimated over 1994:Q1–2003:Q3. Estimates were computed based on Hansen (1999), using equation (2).

Table A3

Event Study: IT in EMEs

	Years from IT Adoption						
	–3	–2	–1	0	1	2	3
Brazil				**1999**			
π_t	10.8	5.2	1.7	8.2	6.1	7.4	10.6
$\hat{\pi}_t^{(s)}$	8.9	4.6	1.3	5.6	4.8	5.4	7.9
$\hat{\pi}_t^{(l)}$	5.7	4.0	2.4	3.4	3.1	3.7	4.4
$\hat{r}_t$	15.3	31.2	35.9	13.4	11.6	13.7	13.4
Hungary				**2001**			
π_t	11.0	10.6	10.2	7.1	4.8	5.6	NA
$\hat{\pi}_t^{(s)}$	11.4	8.6	7.5	6.2	5.0	5.5	NA
$\hat{\pi}_t^{(l)}$	5.8	3.2	2.7	3.7	2.9	3.0	NA
$\hat{r}_t$	6.3	6.4	3.5	4.1	4.0	7.0	NA
Korea				**1998**			
π_t	4.4	4.9	4.9	5.9	1.3	2.9	3.0
$\hat{\pi}_t^{(s)}$	5.0	4.6	4.6	4.9	3.3	3.2	2.7
$\hat{\pi}_t^{(l)}$	4.1	3.7	3.9	3.6	3.4	3.2	3.1
$\hat{r}_t$	NA	8.8	11.7	2.6	–0.1	2.0	0.8
Mexico				**1999**			
π_t	28.0	17.1	17.2	13.5	8.7	5.1	5.3
$\hat{\pi}_t^{(s)}$	17.5	12.7	15.4	11.5	7.8	5.5	4.1
$\hat{\pi}_t^{(l)}$	10.4	7.3	9.4	7.5	5.5	3.7	3.4
$\hat{r}_t$	9.2	4.7	13.1	4.8	6.3	1.3	1.2
Thailand				**2000**			
π_t	7.5	5.0	0.1	1.6	1.1	1.4	1.8
$\hat{\pi}_t^{(s)}$	9.5	5.6	2.7	2.9	1.7	1.8	1.7
$\hat{\pi}_t^{(l)}$	4.6	5.0	4.5	3.3	2.6	2.4	2.4
$\hat{r}_t$	10.6	–1.8	–1.3	–1.1	0.5	–0.1	–0.5

NOTE: For the years surrounding the switch to IT, this table shows the inflation rate (π_t); expected inflation one year in the future ($\hat{\pi}_t^{(s)}$); expected inflation six to ten years in the future ($\hat{\pi}_t^{(l)}$); and the ex-ante real interest rate, $\hat{r}_t$, measured as the policy rate less $\hat{\pi}_t^{(s)}$. All variables are measured in the fourth quarter of the given year.