Does Inflation Targeting Increase Output Volatility? An International Comparison of Policymakers' Preferences and Outcomes

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Monetary policy regimes around the world changed dramatically over the decade of the 1990s. Central banks have become more transparent, more independent, more accountable, and (apparently) more successful. The biggest transformation has been the move away from focusing on intermediate objectives, such as money and exchange rates, and toward the direct targeting of inflation. In their survey of central banks worldwide, Fry and others (1999) find that in 1990 only four of seventy central banks had either an explicit monitoring range or an actual target for inflation. By 1998 that number had risen to forty out of seventy-seven.

This profound change in institutional structure has been accompanied by an equally impressive improvement in economic performance. Across the set of twenty-three industrialized and developing countries that we study here, average inflation fell from 8.7 percent per year for the five years ending in 1990 to an average of 3.5 percent per year for the most recent five years for which we have data. Over these same intervals, real growth in industrial production rose from 3.2 percent per year to 4.3 percent per year.

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The most interesting part of the story, however, concerns inflation targeting, which one might call the monetary policy framework of the 1990s. Included in our sample of twenty-three countries are nine that have targeted inflation explicitly, beginning, in nearly all cases, in the first few years of the decade. Table 1 shows that inflation in these countries fell by more than 7 percentage points on average, from 10.8 percent in the late 1980s to 3.4 percent in the latter part of the 1990s. The average reduction among nontargeting countries was 3.6 percent. To a very real extent, inflation targeting has achieved its primary objective: the lowering of inflation.

Table 1. Output Growth and Inflation and Their Variability before and after 1990 in Inflation-Targeting and Nontargeting Countries (percent per year)

	Average		*Standard deviation*[b]	
Country group	*Real output growth*[a]	*Inflation*	*Real output growth*	*Inflation*
1985-89				
All countries	3.21	8.65	9.08	10.44
All inflation targeters[c]	2.26	10.83	7.47	15.01
All nontargeters[d]	3.81	7.24	10.12	7.49
All EU countries	2.35	10.22	7.35	13.69
EU nontargeters	3.23	3.83	10.65	3.60
Non-EU nontargeters	4.86	13.38	9.17	14.51
1993-97				
All countries	4.28	3.53	7.22	3.68
All inflation targeters	4.80	3.41	6.92	3.31
All nontargeters	3.95	3.60	7.41	3.92
All EU countries	4.84	3.32	7.09	3.25
EU nontargeters	3.82	2.44	8.29	1.90
Non-EU nontargeters	4.18	5.68	5.83	7.55
Difference between 1985-89 and 1993-97				
All countries	1.08	−5.12	−1.87	−6.75
All inflation targeters	2.54	−7.42	−0.55	−11.70
All nontargeters	0.13	−3.64	−2.71	−3.57
All EU countries	2.49	−6.90	−0.26	−10.44
EU nontargeters	0.59	−1.38	−2.36	−1.69
Non-EU nontargeters	−0.68	−7.70	−3.35	−6.95

Source: See the appendix B for details

a. Output growth is measured by industrial production (quarterly data at an annual rate).

b. Average of standard deviations for all countries in the group. The standard deviation of real growth is computed as the deviation from the full sample trend. The standard deviation of inflation is computed as the deviation from 2 percent. Sample periods vary slightly by country.

c. The nine countries, as classified by Morandé and Schmidt-Hebbel (1999), where inflation targets are explicit and clearly dominate any other possible secondary target or objective: Australia, Canada, Chile, Finland, Israel, New Zealand, Spain, Sweden, and the United Kingdom.

d. Austria, Belgium, Denmark, France, Germany, Ireland, Italy, Japan, Korea, Mexico, Netherlands, Portugal, Switzerland, and the United States.

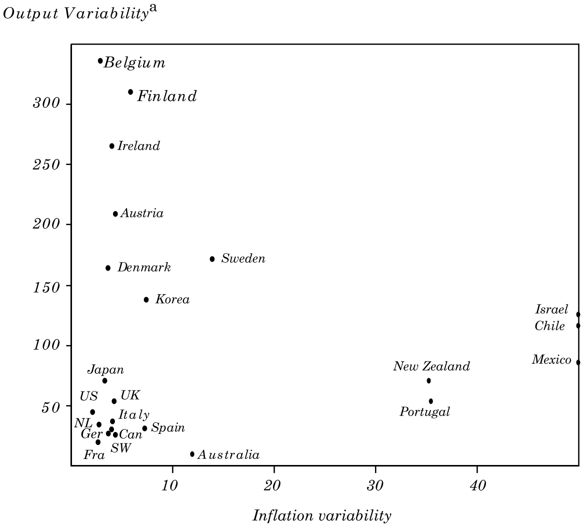
There are many ways to portray a shift in monetary regime. One is to note that, if the regime shift is real, it must represent a change in the preferences of the central bank. This means that, if we can use the outcomes of policy to infer the objectives of the policymaker, these objectives should have changed following the regime shift. More specifically, we might think of policymakers as choosing a point on a trade-off between output variability and inflation variability, assuming that such a trade-off exists. If there is a stable trade-off, a move to inflation targeting would be expected to result in a move along this frontier to a point where inflation is less variable and output more variable than they otherwise would have been. It is also possible that operating on the frontier is difficult, and that a shift in the policy framework could act as a commitment mechanism, increasing credibility and allowing policymakers to achieve better outcomes overall.

The breakdown of output and inflation statistics in table 1 supports the view that inflation-targeting countries have reduced inflation variability at the expense of an increase in output variability. Comparing the late 1980s with the mid-1990s, we see first that volatility in both output and inflation fell in all countries in our sample, suggesting that the 1990s were a relatively shock-free decade; thus overall performance has been better in all countries. That is, aggregate supply shocks, which move output and inflation in opposite directions and force monetary policymakers to make choices, may have been on average smaller (in absolute value) during the 1990s.[1] For this reason, it is important to compare inflation-targeting and nontargeting countries. The table shows that the standard deviation of inflation fell more for the targeters, and output variability fell less.

Figures 1 and 2 present the same information in a slightly different way. Figure 1 plots the variance of inflation (as measured by consumer prices) and the volatility of output (as measured by industrial production) about its trend for our sample of twenty-three countries. (Extremely high values of inflation or output variability are truncated.) These outcomes depend on many things, including a country's economic structure, its policy regime, and the pattern of shocks it has faced. Nevertheless, the pattern of inflation and output variability suggests the existence of a trade-off, because there seem to be groups of countries along concentric curves that move radially outward from the origin.

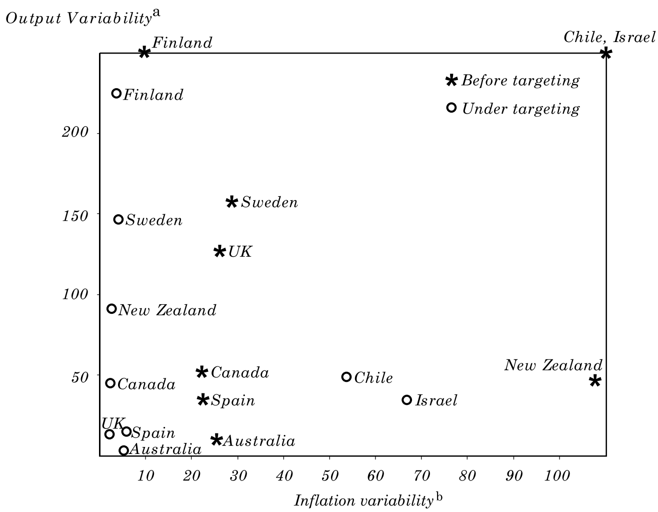
1. Fry and others (1999, p. 66) also make this point.

Figure 1. Trade-off between Output and Inflation Variability in Twenty-Three Countries



Source: Authors' calculations.
a. Deviations from trend.

Figure 2. Trade-off between Output and Inflation Variability in Inflation-Targeting Countries, before and after Implementation



Source: Authors' calculations.
a. Deviations from trend.
b. Deviations from 2 percent per year.

Figure 2 reports the experience of the inflation-targeting countries. We examine the outcomes for five years before (indicated by asterisks) and five years after inflation targeting was implemented (indicated by circles). The figure shows the squared deviation of annual inflation from 2 percent, which we assume to be a likely long-run target. If a country were initially operating on a stationary inflation-output variability trade-off, the shift to inflation targeting would be expected to move the point on the plot upward (toward higher output variability) and to the left (toward lower inflation variability). This is the case, however, for only one of the nine countries we examine, New Zealand. For the remaining eight countries, performance suggests that the move to inflation targeting came with an overall improvement in efficiency.

Unfortunately, presenting the evidence in this way has a significant drawback. If, in the aggregate, the shocks hitting the economy decline between the two periods we compare, both inflation and output variability will fall, and the country's point on the plot will move toward the origin (downward and to the left). For this reason we must develop a more disciplined approach to the data, one based on an economic model.

The remainder of this paper pursues this approach, estimating the changes in policymakers' revealed preferences to see whether the outcomes in inflation-targeting countries are likely to have come from an increase in the weight attached to inflation variability in policymakers' objective function. We do this using the technique described in Cecchetti, McConnell, and Perez Quiros (1999), who note that if we assume policymakers are acting optimally, their actions reveal their objectives. The method is as follows. Beginning with a simple loss function that represents combinations of output and inflation variability, we can treat policy as a solution to a control problem in which the interest rate path is chosen so as to place the economy at the point on the variability frontier that minimizes this loss. In effect, we deduce from the data what policymakers' preference must be. The data are used to go backward. First, we estimate the structure of the economy in each country. This tells us the country's available frontier. From this and the actual output and inflation outcomes, we can estimate the relative weight that national central banks implicitly have placed on output and inflation variability in formulating their policies.

The remainder of the paper is in four sections. Section 1 presents a simple model that allows us to relate output and inflation outcomes, together with the economic structure, to a policymaker's preferences. Section 2 reports estimates of the structural vector autoregressions that give us the raw material we need to estimate preferences. Section 3 then reports estimates of the policymaker's implied objective function in a sample of twenty-three countries. Most important, we see how these objective functions vary across targeting and nontargeting countries and how they have changed over time. Our conclusion is that the targeting countries have, on average, moved along the available frontier in a way that reduces inflation variability significantly and increases output variability slightly from what they might otherwise have been. Interestingly, the same is true of the nontargeting EU countries, which necessarily increased their focus on inflation as they approached the start of monetary union on January 1, 1999.

1. Formulating the Policymaker's Problem

When making policy, central bankers consider large masses of information in an effort to meet what are often multiple objectives. It is impossible to describe the process in terms that are amenable to analytical study. To make any progress at all, we must begin with a number of assumptions that clearly result in a model that is unrealistic. Our hope is that our results capture some critical aspect of the problem actually being addressed.

We follow textbook analyses at the outset by assuming that a central banker's objectives can be written as a simple quadratic loss function.[2] That is, the policymaker seeks to minimize the discounted sum of squared deviations of output and prices from their target paths. The general form of such a loss function (measured over a medium-term horizon of three or four years) can be written as

$$L = \mathrm{E}\left[\alpha\left(\pi - \pi^*\right)^2 + \left(1 - \alpha\right)\left(y - y^*\right)^2\right], \tag{1}$$

where E denotes the mathematical expectation, π is inflation, y is the logarithm of aggregate output, π^* and y^* are the desired levels of inflation and output, and α is the relative weight given to squared

2. The model here was first presented in Cecchetti, McConnell, and Perez Quiros (1999) and is based on Cecchetti (1998).

deviations of output and inflation from their desired levels.[3] The parameter α is the crucial quantity of interest, and we will call it the policymaker's aversion to inflation variability.

Equation (1) immediately gives rise to several issues. First, the objective function is symmetrical, including only quadratic terms. The implication is that policymakers are equally averse to extremely positive and extremely negative events. This is surely not the case: we would expect policymakers to take action when the mean and the variance of forecast distributions are likely to stay the same but the probability of some extreme bad event increases. That is, even if the variance is unchanged, an increase in the probability of a severe economic downturn is likely to prompt action.

Also, the loss function includes only output and inflation and not exchange rates. The rationale for this is our belief that domestic inflation and output are the fundamental concerns of policymakers. The decision to focus on the exchange rate path in the formulation of policy is, in our view, the choice of an intermediate target. Policymakers are concerned not with the behavior of intermediate targets per se, but with the domestic inflation and growth outcomes produced by their use. Exchange rate targeting is analogous to monetary aggregate targeting. Both imply a certain behavior for output and inflation and an objective function such as equation (1).

Returning to the issues at hand, we contend that the policymaker's problem cannot be solved without knowledge of the dynamics of output and inflation and their relationship to the interest rate (r_t) instrument controlled by the policymaker. We write these in the following simple way:

$$y_t = \gamma\left(r_t - d_t\right) + s_t \, , \tag{2}$$

$$\pi_t = -\left(r_t - d_t\right) - \omega s_t \, , \tag{3}$$

where d_t and s_t are shocks to aggregate demand and aggregate supply, respectively. These are the fundamental sources of exogenous disturbances to the economy.[4] The parameter γ gives the ratio of the

3. This loss function can be written in a more complex, dynamic form in which a discount factor and a time horizon appear explicitly. In addition, we could add a term that makes changes in interest rates explicitly costly. These refinements do not add to the analysis here.

4. Equations (2) and (3) can be thought of as the time averages of the vector-moving-average representation of a structural vector autoregressive model. Thus our model, although apparently simple, does not restrict short-run dynamics.

responses of output and inflation to a policy shock and can be thought of as the inverse of the slope of the aggregate supply curve. The parameter ω is the slope of aggregate demand.

The relationship linking output, inflation, and interest rates can be described in many ways, most of them very complex. What is important for our purposes here, and is captured in equations (2) and (3), is the notion that two kinds of disturbances buffet the economy and require policy responses. The first—the aggregate demand shock—moves output and inflation in the same direction; the second—the aggregate supply shock—moves output and inflation in opposite directions. Policy can only move output and inflation in the same direction and so is analogous to an aggregate demand shock. It is the movements in aggregate supply that create the essential dilemma for policy, because they force a choice.

The fact that the policymaker's objectives are assumed to be a simple function of the variances of output and inflation, and that the structure of the economy is assumed to be linear, means that the optimal policy response to demand and supply shocks is a simple linear rule. We write this as

$$r_t = \mathrm{a}d_t + \mathrm{b}s_t \,. \tag{4}$$

It is now straightforward to solve for the rule. The result is that policy offsets aggregate demand shocks one for one, and so a is equal to 1. As expected, the response to supply shocks is more complex, because they create a trade-off for policy. The extent of the reaction depends on the economic structure as measured by the slopes of the aggregate demand (ω) and aggregate supply curves (γ), as well as the policymaker's aversion to inflation variability (α).[5]

The optimal policy has several implications for the variability of output and inflation. First, both depend only on the variance of aggregate supply shocks, not on the variance of demand shocks.[6] This follows immediately from the fact that the optimal policy rule dictates that demand shocks be offset completely by interest rate moves. Second, changes in the volatility of aggregate supply shocks shift the

5. The resulting expression is given by $b^* = [-\alpha\omega + (1-\alpha)\gamma]/[\alpha + (1-\alpha)\gamma^2]$. It would be possible to rewrite equation (4) in the form used by Taylor (1993). To accomplish this, simply note that, using equations (2) and (3), the supply shock s_t can be written in terms of output, y_t, and inflation, π_t. Simple substitution would then allow us to rewrite the policy rule in terms of output and inflation directly—the form of a Taylor rule.

6. The resulting expressions are $\sigma_y^2 = (1-\gamma b^*)^2\,\sigma_s^2$ and $\sigma_\pi^2 = (\omega + b^*)^2\,\sigma_s^2$, where σ_s^2 is the variance of the supply shocks and b^* is the optimal reaction to s_t given in note 5.

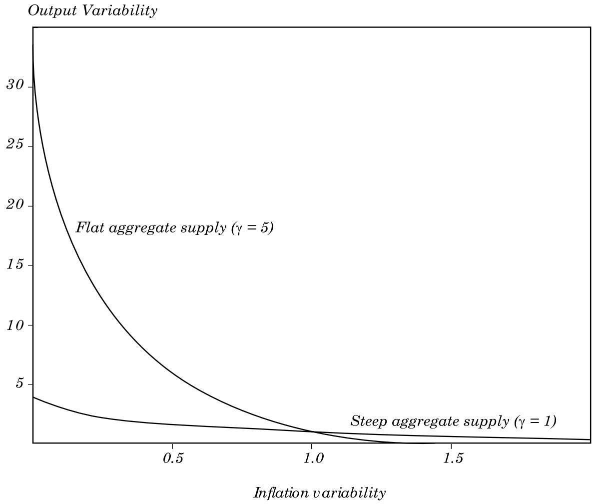
variance of output and inflation in the same proportion.[7] As a result, we can derive the following ratio:

$$\frac{\sigma_y^2}{\sigma_\pi^2} = \left[\frac{\alpha}{\gamma\left(1-\alpha\right)} \right]^2. \tag{5}$$

This expression has several interesting properties. First, we note that when $\alpha = 0$ (that is, the policymaker cares only about output variability), $\sigma^2_y / \sigma^2_\pi = 0$. Likewise, for $\alpha = 1$ (the policymakers cares only about inflation variability), $\sigma^2_y / \sigma^2_\pi = \infty$. Significantly, varying α between 0 and 1 allows us to trace out the entire output-inflation variability frontier, the shape of which is related to the slope of the aggregate supply curve ($1/\gamma$) and is unaffected by the slope of the aggregate demand curve (ω) and the variance of aggregate supply shocks.

Figure 3 plots two representative frontiers to show how the slope depends on γ. The solid line plots a frontier for a country with a relatively flat aggregate supply curve ($\gamma = 5$), whereas the dashed line depicts the frontier for a country with a steeper aggregate supply

Figure 3. Representative Frontiers of the Trade-off between Inflation and Output Variability



Source: Authors' calculations.

7. This means that the variability frontier as drawn in figures 1 and 2 does shift with the variance of supply shocks, making those figures more difficult to interpret.

curve ($\gamma = 1$).[8] The implication is that if a country faces a relatively flat aggregate supply curve, reductions in inflation variability will be accompanied by relatively large increases in output variability, making inflation targeting more difficult.

We will use equation (5) to estimate the policymaker's revealed aversion to inflation variability, α. First, however, we need to know γ, which we will estimate in section 2, and the ratio of the variances of output and inflation, which we will obtain from the data. With these two quantities in hand, we can estimate α.

2. Measuring the Impact of Policy

The next task is to measure the impact of policy on output and inflation. That is, we need to identify and estimate a model that allows us to measure the monetary transmission mechanism. Numerous studies report such estimates for various sets of countries.[9] We choose to apply the methodology used by Ehrmann (2000), in his study of European countries, to a broader cross section of countries. This approach yields a series of estimates, all based on the same methodology, for a set of twenty-three countries, including nine that target inflation explicitly. Also, the estimated models can be carefully tested for structural stability and adjusted to ensure that they are stable over the samples for which we estimate them. It is also important that our models yield a complete set of responses to the shocks we identify and that these models conform to our priors with regard to the type of shock being identified.[10] In practice, these last requirements are extremely difficult to meet.

Methodologically, our approach is based on the structural vector autoregression (VAR) techniques devised by King and others (1991) to identify monetary shocks from a combination of long-run and short-run restrictions. For each country the model has either four or five variables, including output, inflation, an interest rate, and (with the exception of Japan, Switzerland, and the United States) an exchange rate. When a fifth variable is present, it is either a monetary aggregate, a second interest rate, or a commodity price index. The methods

8. Table 3 below reports the estimates of γ for the countries we study. The case of $\gamma = 5$ is close to that of Australia, France, Germany, Italy, and Switzerland. The second case, $\gamma = 1$, is close to that of Chile, Denmark, Israel, Korea, Japan, Mexico, New Zealand, Spain, and the United States.

9. See the references in Cecchetti (2001) for a representative sample.

10. In particular, it is important for our purposes that all shocks in the system, and not just the money shock, produce plausible impulse response functions.

and model specifications are described in detail in the appendixes A and B. Here we simply report the results.

Figure 4 plots the responses of output and inflation to an interest rate increase of 100 basis points for the twenty-three countries in our sample. For purposes of comparison, we have plotted all the results on the same vertical scale. The patterns vary quite dramatically, with the interest rate changes eliciting a much larger response in Germany and Switzerland, for example, than in Israel or Mexico.

Figure 4. Responses of Output and Inflation to a 100-Basis Point Interest Rate Increase in Twenty-Three Countries

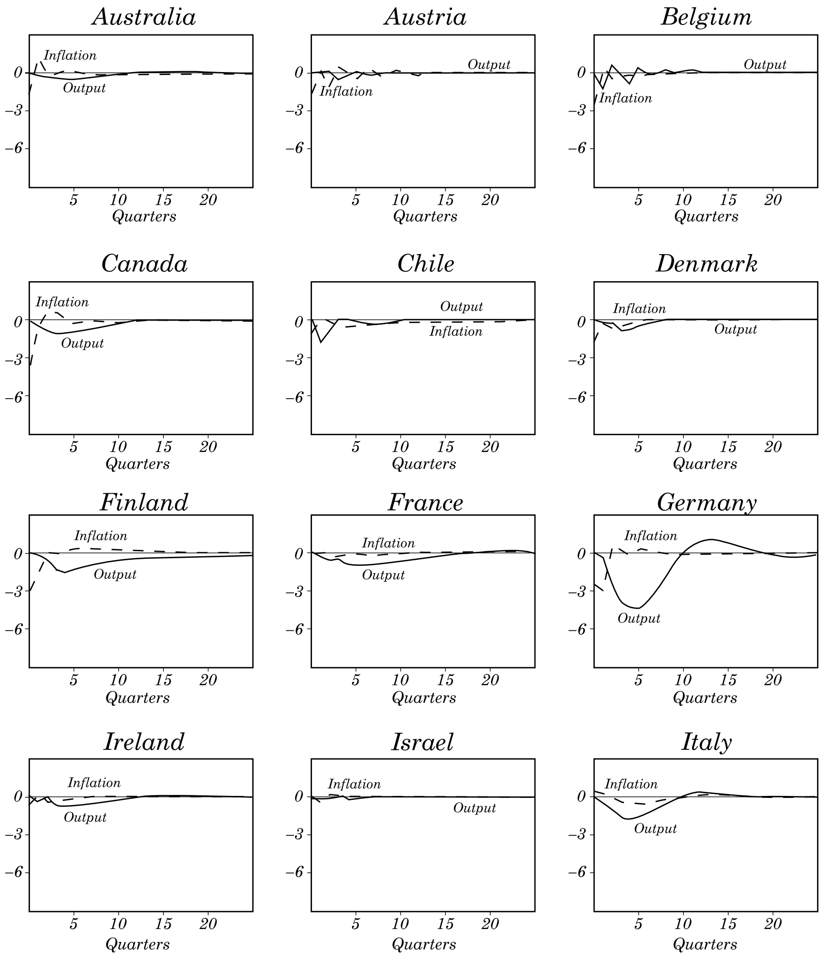
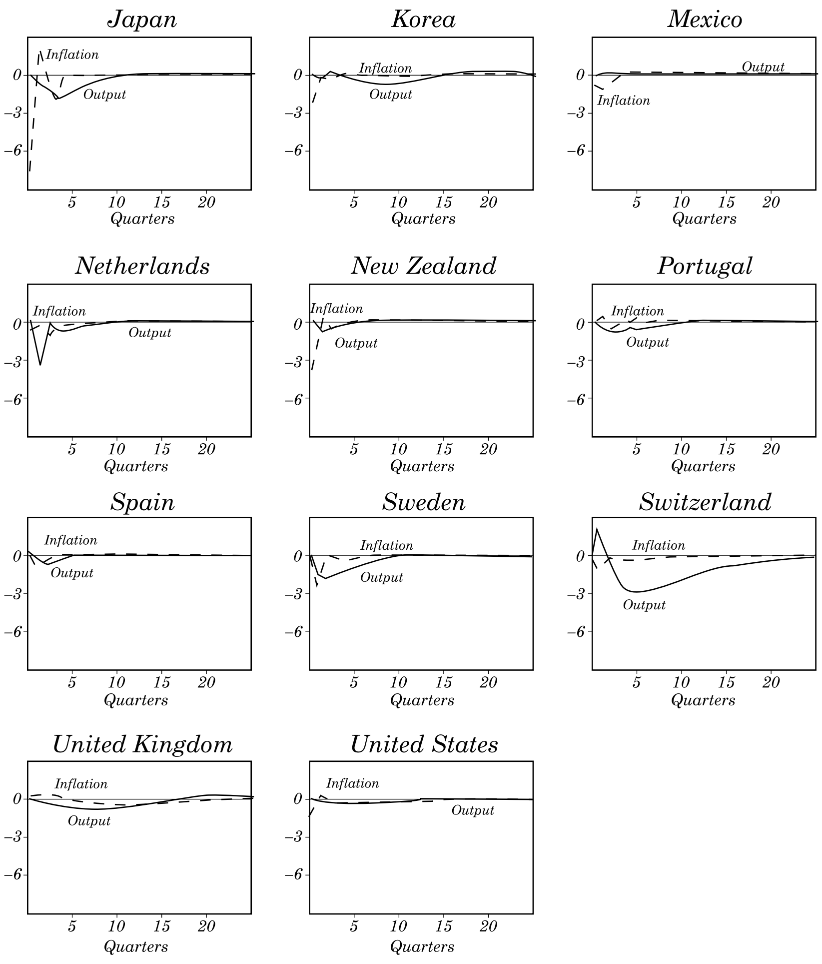


Figure 4. (continued)



Source: Authors' calculations.

Table 2 summarizes the results from the figure. For each country the table also reports estimates of the sacrifice ratio and an estimate of the inverse slope of the aggregate supply curve (γ), which we need to infer the policymaker's preferences. The sacrifice ratio is the cumulative percentage loss in output for a 1-percentage-point reduction in inflation. Here we report the sacrifice ratio over a horizon of twelve quarters.

Table 2. Impulse Response Functions in Inflation-Targeting and Nontargeting Countries

Country	*Maximum impact*		*Sacrifice ratio*[a]	*Inverse aggregate supply slope* (γ)[b]
	On output	*On inflation*		
Inflation-targeting countries				
Australia	–0.48	–1.78	7.90	4.65
Canada	–0.96	–3.96	3.11	1.80
Chile	–1.78	–1.03	1.79	0.84
Finland	–1.51	–3.05	5.92	3.76
Israel	–0.11	–0.51	2.90	1.42
New Zealand	–0.93	–3.41	1.36	0.67
Spain	–0.68	–0.95	3.29	1.22
Sweden	–1.92	–2.58	4.68	2.35
United Kingdom	–0.84	–0.36	18.17	13.76
Average	–1.02	–1.96	5.46	3.38
Other countries				
Austria	–0.51	–1.58	0.40	0.22
Belgium	–1.21	–2.72	0.66	0.13
Denmark	–0.80	–1.68	1.52	0.70
France	–0.93	–0.28	8.65	6.15
Germany	–4.39	–3.05	10.37	5.72
Ireland	–0.73	–0.67	4.62	2.83
Italy	–1.82	–0.52	9.27	4.89
Japan	–1.76	–8.41	2.14	1.09
Korea	–0.73	–2.29	1.38	1.35
Mexico	–0.15	–1.19	0.83	0.69
Netherlands	–3.56	–1.23	4.76	2.03
Portugal	–0.82	–0.90	230.2	122.55
Switzerland	–3.04	–1.34	5.65	5.08
United States	–0.36	–1.30	1.75	1.10
Average[c]	–1.53	–2.02	4.00	2.46

Source: Authors' calculations.
a. Computed as the cumulative output loss per percentage-point reduction in inflation over a horizon of twelve quarters.
b. Twelve-quarter average of the impact of policy innovations on output, divided by the twelve-quarter average impact on inflation. See appendixes A and B for details.
c. Excludes Portugal.

The numbers appear to be both reasonable and similar across the targeting and nontargeting countries. With the exception of those for Portugal, all of the numbers are plausible. For the remaining countries the sacrifice ratio ranges from 0.4 for Austria to 18.2 for the United Kingdom. The estimate of γ has a similar variation, from 13.8 for the United Kingdom to 0.1 for Belgium (again ignoring Portugal). Although there is modest evidence that interest rate increases yield a bigger output response and a smaller implied sacrifice ratio in the inflation-targeting countries, the results are far from conclusive.

3. Policymakers' Aversion to Inflation Variability

We are now ready to estimate policymakers' aversion to inflation variability (α). Equation (5), together with estimates of the aggregate supply slope and the ratio of the variance of output and inflation, yields an estimate of α. In calculating the ratio of inflation volatility to output volatility, we must make an assumption about the paths of desired inflation and output, π^* and y^* in equation (1). Throughout the analysis we take desired output to be the actual trend in the sample. This assumption tends to minimize the estimated "variance" of output, and so measures of α will be higher than they otherwise would be. Table 3 reports results for two assumptions about the desired level of inflation: that it is equivalent to average inflation in the sample, and that it is fixed at 2 percent. The results for the second assumption are always higher, because the use of the sample mean inflation reduces the squared deviations.

The first thing to notice about the results is that most of the αs are quite large, suggesting that many of these countries took the goal of inflation stability very seriously over this period. When desired inflation is assumed to be 2 percent, fourteen of the twenty-three countries have estimated αs of higher than 0.70, and half of these exceed 0.9.[11] The only country that appears not to be averse to inflation variability at all is Mexico, with an estimated α of 0.08. Beyond this, the average for the inflation-targeting countries is no different from that for the nontargeting countries.

The estimates in table 3 are interesting, but since they are computed over the full samples for which data are available, they do not allow us to infer the effects of changes to inflation targeting. For this reason we now shift to computing estimates of α using subsamples of the data. Figures 5 through 7 plot the results of an exercise in which we computed the value of α for five-year moving windows. Throughout we assume that desired inflation is 2 percent and that the estimate of

11. As noted in Cecchetti, McConnell, and Perez Quiros (1999), the use of industrial production to measure output is likely to produce values of α for these countries that are upper bounds on the true value. We would expect that a shift to GDP, which is nearly uniformly less volatile, would raise our estimate of the absolute value of γ and reduce our estimate of σ^2_y/σ^2_π. For any given value of σ^2_y/σ^2_π, a higher γ will imply a higher value of α, since the slope of the output-inflation variability frontier at that point will be steeper. Thus both of these effects serve to raise the value of α relative to what we would obtain using GDP.

γ is unchanged.[12] On each graph we include a horizontal line for the value of α computed from using the full sample, as reported in table 4. For the inflation-targeting countries in figure 5, the vertical line represents the date at which the new regime was introduced.

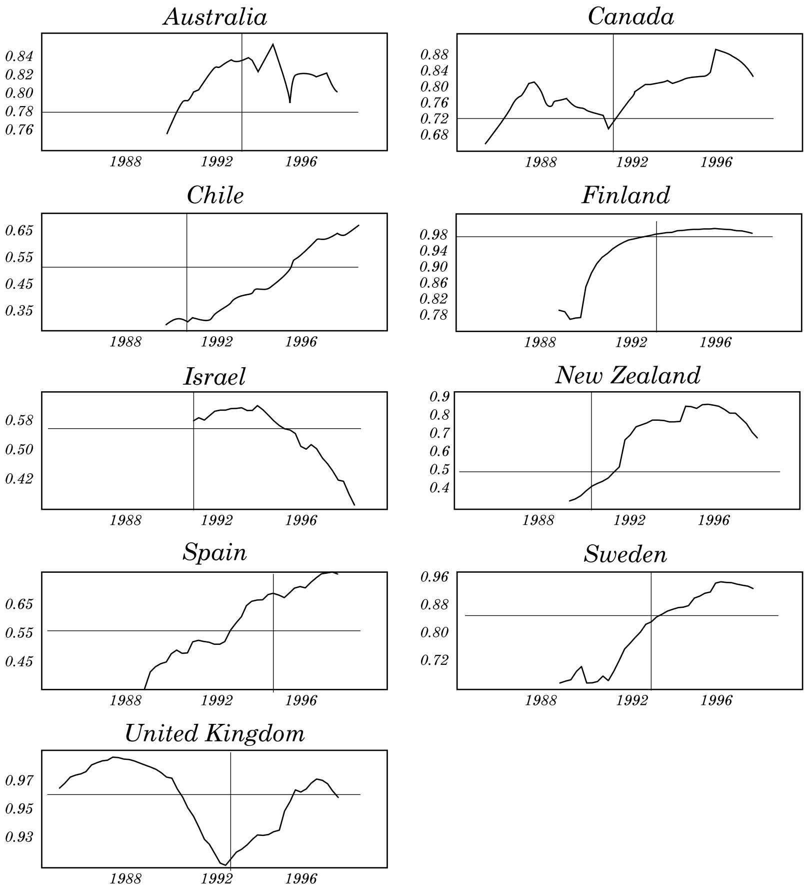
Table 3. Estimated Aversion to Inflation Variability in Inflation-Targeting and Nontargeting Countries

	Aversion to inflation variability (α)	
Country	*Assuming desired output = trend output, and desired inflation = average inflation*	*Assuming desired output = trend output, and desired inflation = 2 percent per year*
Inflation-targeting countries		
Australia	0.81	0.78
Canada	0.75	0.72
Chile	0.55	0.49
Finland	0.96	0.96
Israel	0.72	0.56
New Zealand	0.53	0.49
Spain	0.67	0.55
Sweden	0.86	0.84
United Kingdom	0.97	0.96
Average	0.76	0.71
Other countries		
Austria	0.50	0.49
Belgium	0.43	0.43
Denmark	0.61	0.59
France	0.95	0.94
Germany	0.94	0.93
Ireland	0.94	0.93
Italy	0.91	0.85
Japan	0.84	0.83
Korea	0.79	0.71
Mexico	0.12	0.08
Netherlands	0.84	0.84
Portugal	0.99	0.99
Switzerland	0.92	0.92
United States	0.74	0.70
Average[c]	0.75	0.73

Source: Authors' calculations.

12. As noted in section 2, we took care to examine each of our structural models for stability, and so we are reasonably confident that we have obtained stable estimates of the aggregate supply slope. Even so, small changes in γ would not affect our results, as this simply serves to scale the level of α, not affecting the changes.

Figure 5. Five-Year Rolling Sample Estimates of Aversion to Inflation Variability in Inflation-Targeting Countries



Source: Authors' calculations.

The results in the figures are quite striking. For seven of the nine inflation-targeting countries, the estimate of the aversion to inflation variability rises substantially either *before* or immediately after the targeting regime is implemented (figure 5). The exceptions are Israel, where the estimate of α falls following implementation, and the United Kingdom, where there is no material change.

Table 4. Shift in Implied Weight Attached to Inflation Variability in Inflation-Targeting Countries

Country	*Aversion to inflation variability in full sample period*	*Date of shift to inflation targeting*	*Aversion to inflation variability*	
			Before shift[a]	*After shift*[b]
Australia	0.78	1993Q2	0.83	0.80
Canada	0.72	1991Q2	0.73	0.87
Chile	0.49	1990Q4	0.27	0.52
Finland	0.96	1993Q2	0.96	0.97
Israel	0.56	1991Q1	0.58	0.51
New Zealand	0.49	1990Q2	0.34	0.83
Spain	0.55	1994Q4	0.65	0.74
Sweden	0.84	1993Q1	0.76	0.91
United Kingdom	0.99	1992Q4	0.93	0.96
Average	0.71	1992Q1	0.67	0.79

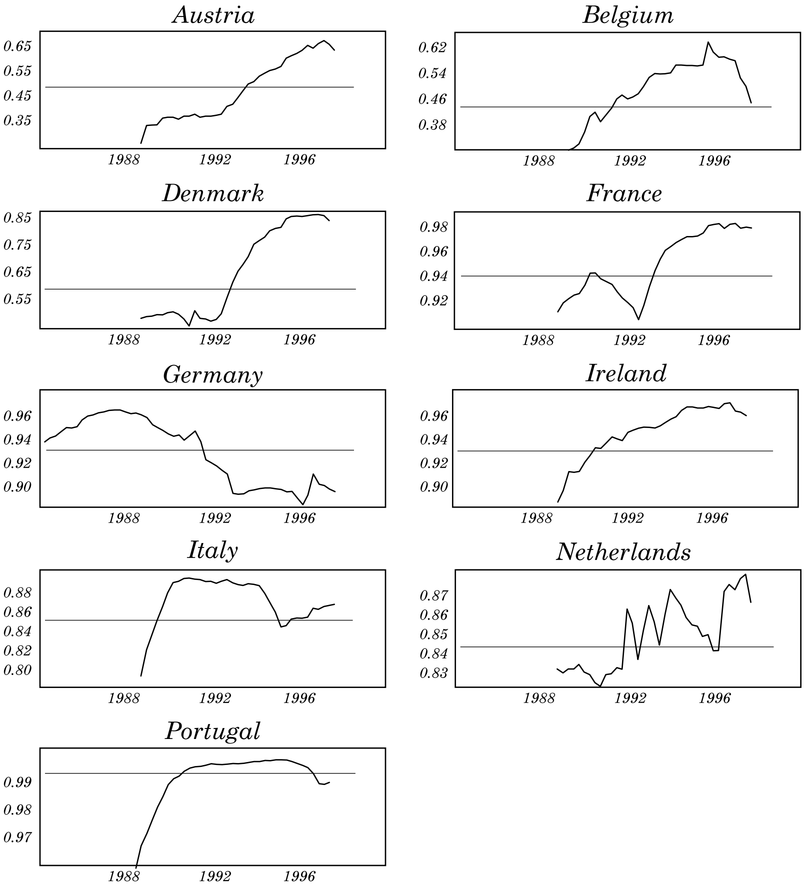
Source: Authors' calculations.
a. Five years ending one year before the shift to explicit inflation targeting.
b. Five years following the shift to explicit inflation targeting, or the last five-year period for which data are available.

Of the nine EU countries that did not explicitly target inflation in the 1990s, all but one show an increase in the estimate of α beginning in the early 1990s similar to the increase for the inflation targeters (figure 6). Interestingly, the exception is Germany. We surmise that, in preparation for monetary union, the countries of the European Union were forced to behave more like inflation-targeting countries throughout the 1990s. Germany, however, softened its previous hard-line view toward inflation, both because of the implications of unification with the former East Germany and as a compromise in the direction of its future colleagues in monetary union.

For the remaining five countries in our data set, the results are mixed (figure 7). The estimates of the aversion to inflation variability for the United States and Mexico rise, but the estimates for the other countries show declines of varying degrees.

Table 4 complements figure 5, reporting the aversion to inflation variability for five-year periods before and after the explicit announcement of a move to inflation targeting. Of the nine countries in the sample, seven show an increase in the estimate of α. For the other two there are modest declines.

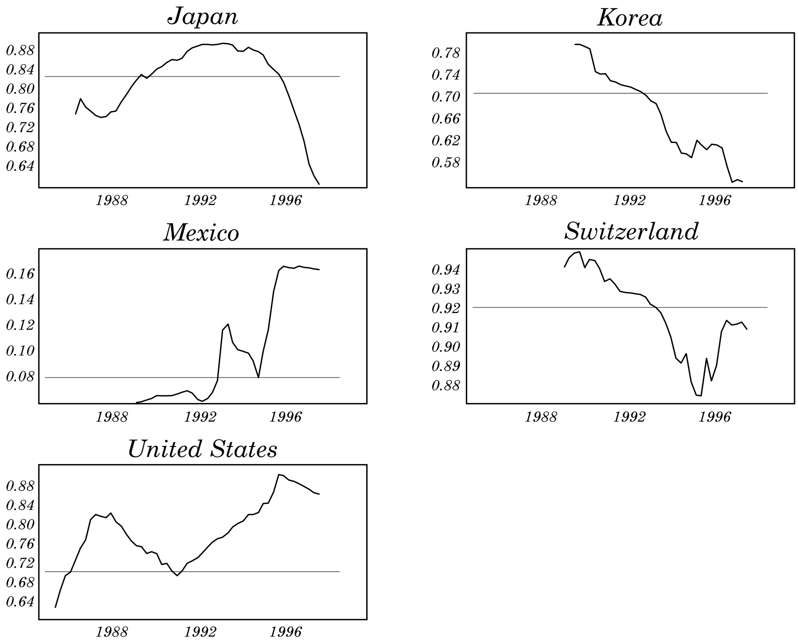
Figure 6. Five-Year Rolling Sample Estimates of Aversion to Inflation Variability in Other EU Countries



Source: Authors' calculations.

We conducted one final test to determine whether the changes in the inflation-targeting countries can in fact be ascribed to the targeting regime. For this test we used the remaining fourteen countries in our sample as a control and examined the values of α as they changed from 1990 to the end of the available sample. The results, reported in table 5, show that, over the full sample for which we have data, the values of α are highest in the nontargeting EU countries.

Figure 7. Five-Year Rolling Sample Estimates of Aversion to Inflation Variability in Other Countries



Source: Authors' calculations.

Table 5. Changes in Average Aversion to Inflation Variability in Inflation-Targeting and Nontargeting Countries

Country group [a]	*Full sample period*	*1984-89*	*Last 5 years*
All countries	0.72	0.69	0.76
All inflation targeters	0.71	0.63	0.76
All nontargeters	0.73	0.72	0.75
EU nontargeters	0.78	0.75	0.83
Non-EU nontargeters	0.65	0.67	0.62

Source: Authors' calculations.
a. Non-EU nontargeters are Japan, Korea, Mexico, Switzerland, and the United States. Other groups are defined as in table 1.

The principal finding, however, is that the inflation-targeting countries show a significant increase, from an average of 0.63 to an average of 0.76. In addition, the nontargeting EU countries show an increase in α from 0.75 to 0.83. The non-EU nontargeting countries show a modest decrease.[13]

4. Conclusions

This paper asks whether inflation targeting increases the volatility of output. Most macroeconomists assume that in the presence of aggregate supply shocks—short-run disturbances that move output and inflation in opposite directions—monetary policy must allow either output or inflation to move away from its desired long-run level. In other words, there is a variability trade-off. One interpretation of a move to inflation targeting is that the preferences of monetary policymakers have changed, with many central banks exhibiting increasing aversion to inflation variability and decreasing aversion to output variability. It is natural to conclude that the outcome should be higher output volatility than would otherwise have occurred.

We estimated the change in the preferences of monetary policymakers in a cross section of twenty-three countries, including nine that target inflation explicitly. We found evidence that in all countries, whether they target inflation or not, aversion to inflation variability increased during the decade of the 1990s. Furthermore, we conclude that the inflation targeters increased their aversion to inflation volatility by more than the nontargeters, although the difference is modest.

13. A simple regression of the change in α on dummy variables for inflation-targeting and EU nontargeting countries shows that these declines are statistically significant at the 5 percent level for the targeters, and at the 10 percent level for the nontargeting EU countries.

APPENDIX A

Estimation and Identification Strategy

To estimate the structural responses of each economy to a monetary policy shock, we used structural vector autoregressions (SVARs). A detailed discussion of our methodology can be found in Ehrmann (2000), so we provide here only a quick overview of the estimation strategy. We apply a procedure set forth in King and others (1991).[14] Their identification strategy is based on the implications of the cointegrating relations, in a multivariate system. Complete identification of an n–variable structural system requires $[n(n-1)/2]$ restrictions. In a system with m cointegrating relations there will be k common trends, where $k = n - m$, and thus k shocks that are assumed to have long-term effects on the variables in the system (and are therefore interpretable as supply shocks). This structural assumption imposes $k*m$ of the necessary restrictions. For complete identification of the effects of supply shocks we need $[k(k-1)/2]$ additional restrictions. The methodology of King and others employs a triangular specification, allowing the first shock to have a contemporaneous effect on all the dependent variables, the second on the last $n-1$, and so on. In order to identify the transitory shocks (interpretable as demand shocks), we need a set of additional $[m(m-1)/2]$ restrictions. We again use a triangular specification, and we identify the monetary policy shock by assuming that it has no contemporaneous (within-quarter) effect on output.

14. For the analytical derivation of their procedure, see King and others (1991) or Warne (1993).

Appendix B

The Models

Table A1 contains detailed descriptions of each model. Briefly, for each country our model consists of four or five variables. For each country we include a short-term interest rate (the policy variable) as well as a measure of output and a measure of inflation (the quantities in the policymaker's objective function). In addition, for all countries but Japan, Switzerland, and the United States, we add the exchange rate of the national currency against the currency of a large trading partner. In the case of the members of the European Exchange Rate Mechanism, this is the exchange rate with the deutsche mark. For the remaining countries it is either the Japanese yen or the U.S. dollar exchange rate. When a four-variable system creates puzzling responses, a fifth variable is chosen from a pool of candidates: long-term interest rates, U.S. or German short-term interest rates (for countries strongly influenced by U.S. or German monetary policy, respectively), commodity prices as a leading indicator for inflation,[15] or monetary aggregates. All data are quarterly at annual rates and seasonally adjusted using deterministic dummy variables.

The models are tested for structural breaks with the help of one-step Chow tests and breakpoint (*N* down) Chow tests, both at the equation and the vector level. Especially for some European countries, the tests reveal structural breaks around 1984, coinciding with the emergence of the "hard" European Monetary System. To ensure that the models are stable and well specified, for most countries the sample period is restricted to 1984-97. In some cases the results of the stability tests led us to shorten the sample period. To avoid distorting the evidence, we thus have to accept small samples.

The lag length for the reduced-form vector autoregressions is found using the London School of Economics general-to-specific modeling strategy. In all cases a lag length of at most two is sufficient. We perform a number of additional diagnostic tests to ensure that the models are well specified. We test the residuals of both the individual equations and the

15. Since they are determined in auction markets, commodity prices react much faster to news about future inflation than do industrial or consumer prices. Econometric evidence supports their value as leading indicators of inflation (Boughton and Branson, 1991). Christiano, Eichenbaum, and Evans (1996) discuss the usefulness of commodity prices in estimating the responses of output and inflation to monetary policy shocks.

systems as a whole for serial correlation, nonnormality, heteroskedasticity, and autoregressive conditional heteroskedasticity.[16]

In most cases we must introduce dummy variables for our models to pass this battery of stringent specification tests. This is especially true of the tests for normality of the residuals. We introduce dummy variables in periods where indirect taxes are increased, under the presumption that central banks do not generally tighten policy at these times, even though measured inflation is normally observed to rise. We also include dummy variables at the times of the 1992-93 and 1995 exchange rate crises, when many countries' central banks changed their behavior drastically, albeit briefly. Finally, dummy variables are put into the models at times of extraordinary national events, such as labor strikes. Table A2 reports the full list of dummy variables included for each of the countries we study.

Table A1. Specification of the Model

Country	*Variables*	*Cointegration rank*	*Lags*	*Sample period*
Australia	OECD-MEI short-term interest rate, industrial production (seasonally adjusted), CPI inflation, Australian dollar-yen exchange rate, IMF commodity price index	3	2	1985Q1-1997Q4
Austria	Three-month money market rate, industrial production, CPI inflation, Schilling-DM exchange rate, German short-term interest rate	2	2	1984Q1-1997Q1
Belgium	Three-month treasury bill rate, industrial production, CPI inflation, Belgian franc-DM exchange rate, German short-term interest rate	3	2	1984Q3-1997Q4
Canada	OECD-MEI short-term interest rate, industrial production (seasonally adjusted), CPI inflation, Canadian dollar-U.S.dollar exchange rate, real M3	2	2	1980Q3-1997Q4
Chile[a]	Thirty-to-ninety-day deposit rate, industrial production (seasonally adjusted), CPI inflation, Peso-U.S.dollar exchange rate, U.S. short-term interest rate	3	2	1985Q1-1998Q4

16. For a detailed description of the tests, see the help function in PcFIML9.0; the test statistics are available from the authors upon request.

Table A1. (continued)

Country	*Variables*	*Cointegration rank*	*Lags*	*Sample period*
Denmark	Three-month interbank market rate, industrial production (seasonally adjusted), CPI inflation, Krone-DM exchange rate	2	2	1984Q1-1997Q3
Finland	Call money rate, industrial production, CPI inflation, Markka-U.S. dollar exchange rate	2	2	1984Q1-1997Q4
France	Three-month money market rate, industrial production, CPI inflation, French franc-DM exchange rate, long-term rate on government bonds	3	2	1984Q1-1997Q4
Germany	Three-month money market rate, industrial production (seasonally adjusted), CPI inflation, DM-U.S. dollar exchange rate, IMF commodity price index	3	2	1979Q3-1997Q4
Ireland	Three-month treasury bill rate, industrial production, CPI inflation, Punt-DM and Punt-Sterling exchange rates	3	2	1984Q1-1997Q3
Israel	Short-term treasury bill rate, industrial production (seasonally adjusted), CPI inflation, Shekel-U.S. dollar exchange rate, real money	3	2	1986Q2-1998Q3
Italy	Three-month treasury bill rate, industrial production, CPI inflation, Lira-DM exchange rate, IMF commodity price index	3	2	1984Q1-1997Q4
Japan	OECD-MEI short-term interest rate, industrial production (seasonally adjusted), CPI inflation, real M3	2	2	1981Q1-1997Q4
Korea	Daily money market rate, industrial production (seasonally adjusted), CPI inflation, Won-U.S. dollar exchange rate	2	2	1984Q3-1997Q3
Mexico	OECD-MEI short-term interest rate, industrial production (seasonally adjusted), CPI inflation, Peso-U.S. dollar exchange rate, IMF commodity price index	3	2	1984Q1-1997Q4
Netherlands	Three-month interbank market rate, industrial production, CPI inflation, Guilder-DM exchange rate, German short-term interest rate	3	2	1984Q1-1997Q4
New Zealand	OECD-MEI short-term interest rate, industrial production, CPI inflation, New Zealand dollar-U.S. dollar exchange rate	2	2	1984Q3-1997Q4
Portugal	Five-day money market rate, industrial production, CPI inflation, Escudo-DM exchange rate, German short-term interest rate	3	2	1983Q4-1997Q3

Table A1. (continued)

Country	Variables	Cointegration rank	Lags	Sample period
Spain	Three-month money market rate, industrial production, CPI inflation, Peseta-DM exchange rate, real ALP[b]	2	2	1984Q1-1997Q4
Sweden	Three-month treasury bill rate, industrial production, CPI inflation, Krona-U.S. dollar exchange rate, interest rate on nine-year government bonds	3	2	1984Q1-1997Q4
Switzerland	OECD-MEI short-term interest rate, industrial production (seasonally adjusted), CPI inflation, real M3	2	2	1984Q1-1997Q4
United Kingdom	Three-month treasury bill rate, industrial production, RPIX inflation,[c] Sterling-DM exchange rate, IMF commodity price index	3	1	1980Q1-1997Q4
United States	OECD-MEI short-term interest rate, industrial production (seasonally adjusted), CPI inflation, IMF commodity price index	2	2	1980Q1-1997Q4

Sources: Data for Austria, Belgium, Denmark, Finland, France, Germany, Ireland, Italy, the Netherlands, Portugal, Spain, Sweden, and the United Kingdom are from Datastream; those for Australia, Canada, Japan, Mexico, New Zealand, Switzerland, and the United States are taken from the OECD Main Economic Indicators (MEI). Data for Chile are from International Monetary Fund, *International Financial Statistics* (the deposit rate), the Central Bank of Chile's World Wide Web site (inflation), and DRI (industrial production and the exchange rate); Israeli data are from DRI (exchange rate, industrial production, and inflation) and from *International Financial Statistics* (interest rate and money); data for Korea are from *International Financial Statistics* (money market rate and industrial production) and DRI (inflation and exchange rates).
a. The model for Chile looks at parts of the transmission mechanism only, because the interest rate in use is a deposit rate. This assumes that the transmission from monetary policy shocks to the deposit rate has already taken place.
b. ALP is a monetary measure of active liquidity in private hands. It is a broader aggregate than M3. To construct real ALP, the natural logarithm of the consumer price index (CPI) is subtracted from the natural logarithm of ALP.
c. RPIX is a measure of retail prices on all items except mortgage interest. Because the U.K. CPI includes mortgage interest payments, CPI inflation is biased upward following an interest rate increase. To avoid a price puzzle, the interest payments must be excluded from the price index.

Table A2. Dummy Variables

Country	Dummy variables
Australia	None
Austria	For the inflation equation: increase in the value-added tax in 1986Q1 and of indirect taxes in 1996 (in order to achieve the Maastricht criteria). For the industrial production equation: general economic downturn in 1992. For the interest rate equation: tightening by the central bank in 1986 Q1, which followed a period of massive capital outflows, central bank interventions, and reserve losses
Belgium	Exchange rate and interest rate equations: exchange rate crisis in 1993 (restricted to lie in the cointegration space). The Belgian franc came under downward pressure with the widening of the exchange rate bands in the Exchange Rate Mechanism to 15 percent. Industrial production: output decline in 1987Q1; the central bank linked

Table A2. (continued)

Country	*Dummy variables*
	the decline to efforts to trim the public deficit and therefore did not take any corrective steps. Inflation: in 1986Q1 inflation fell too sharply to be explained by the monetary policy framework alone. Indeed, lower fuel prices are mentioned by the central bank as a reason for the marked improvement in inflation performance
Canada	Exchange rate: exchange rate crisis in 1992-93. Interest rate: in 1981Q4 and 1994Q2, strong influence of U.S. interest rate changes; since U.S. interest rates do not enter as a separate variable, these influences have to be dummied out here
Chile	Inflation: in 1988Q3 the value-added tax and fuel prices fell, whereas in 1990 both were increased. System: in 1992Q1, money growth exploded to a 55 percent annual rate
Denmark	Exchange rate and interest rate: exchange rate crisis in 1992-93. Inflation: increase in indirect taxes in 1986
Finland	Exchange rate and interest rate: exchange rate crisis in 1992-93. Industrial production: recession from 1990 to 1994
France	None
Germany	Interest rate: stock market crash in 1987, in the aftermath of which the Bundesbank loosened its monetary policy stance until 1988Q3 to offset some of the consequences of the crash on the real economy. Industrial production: strike in 1984Q2. Inflation: first round of rent rises in East Germany 1992Q1; linear trend, restricted to lie in the cointegration space
Ireland	Interest rate: speculative crises in 1986 and 1992. Inflation: increase in excise duties, removal of food subsidies and other taxation measures to reduce the budget deficit in 1987Q1. Exchange rate: crises in 1992 and 1995
Israel	Exchange rate: devaluations in 1987Q1, 1989Q2, and 1991Q2
Italy	Exchange rate and interest rate: crises in 1992-93 and 1995. Inflation: jump in 1990
Japan	Interest rate: focus of monetary policy on exchange rate after the 1985 Plaza Accord leads to a tightening of the policy stance in 1985Q4. Inflation: increase in consumption tax in 1997Q2
Korea	Inflation: acceleration in 1990Q2. Exchange rate: acceleration of depreciation in 1996Q3
Mexico	Interest rate: tight monetary policy stance under the Economic Solidarity Pact reduces inflation by over 100 percentage points in 1988. Industrial production: oil shock in 1986, steep increase in the growth rate in 1994 coinciding with the coming into force of the North American Free Trade Agreement. Exchange rate: crisis in 1994-95
Netherlands	Industrial production: after a cut in the value-added tax, a fall in social security contributions, and nominal wage increases, households' disposable income rose by 5 percent in real terms in 1989, leading to a steep increase in private consumption and industrial production

Table A2. (continued)

Country	*Dummy variables*
New Zealand	Exchange rate: 20 percent devaluation in 1984Q3, wide swings after the float in March 1985. Inflation: indirect tax increases in 1985Q1, 1986Q4, and 1989Q3
Portugal	Exchange rate: speculative attacks in 1992-93
Spain	Exchange rate: speculative attacks in 1993 and 1995. Massive interest rate increase in the Bank of Spain lending rate in 1987. After an overshooting of ALP by nearly 100 percent with respect to its target, and after an increasing government deficit had to be financed by the Bank of Spain, driving liquidity up even further, the Bank of Spain increased its lending rate from 11.5 percent in December 1986 to 20.5 percent in May 1987. Inflation: value-added tax introduced in 1986Q1; linear trend, restricted to lie in the cointegration space
Sweden	Exchange rate and interest rate: crisis in 1992-93. The central bank increased its marginal lending rate to 500 percent in September 1992. Inflation: tax reform in 1990Q1 widened the value-added tax base substantially; subsequent change in the value-added tax in 1991
Switzerland	Interest rate: after the stock market crash in 1987, the central bank lowered interest rates to their lowest level since 1979
United Kingdom	Industrial production: miners' strike in 1984. Exchange rate: currency crisis in1992. Interest rate: in 1985Q1 the Bank of England drastically increased interest rates after an exchange rate depreciation to indicate that it was in earnest about the newly declared change in orientation toward exchange rate goals; linear trend, restricted to lie in the cointegration space
United States	Interest rate: high volatility of short-term rates at the beginning of Paul Volcker's chairmanship of the Federal Reserve; linear trend, restricted to lie in the cointegration space

Source: Authors' construction.

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