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DOES INFLATION TARGETING INCREASE OUTPUT VOLATILITY? AN INTERNATIONAL COMPARISON OF POLICYMAKERS' PREFERENCES AND OUTCOMES

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ABSTRACT

Aggregate shocks that move output and inflation in opposite directions create a tradeoff between output and inflation variability, forcing central bankers to make a choice. Differences in the degree of accommodation of shocks lead to disparate variability outcomes, revealing national central banker's relative weight on output and inflation variability in their preferences. We use estimates of the structure of 23 industrialized and developing economies, including nine that target inflation explicitly, together with the realized output and inflation patterns in those countries, to infer the degree of policymakers' inflation variability aversion. Our results suggest that both countries that introduced inflation targeting, and non-targeting European Union countries approaching monetary union, increased their revealed aversion to inflation variability, and likely suffered most increases in output volatility as a result.

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1 Introduction

Throughout the world, monetary policy regimes have 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, toward the direct targeting of inflation. In their survey of the central banks in 77 countries, Fry, Julius, Mahadeva, Roger, and Sterne (1999) find that in 1990 only 4 of the (then 70) countries' central banks either had an explicit monitoring range or an actual target for inflation. By 1998, this number had risen to 40 (of 77).

This profound change in institutional structure has been accompanied by an equally impressive improvement in economic performance. Across the set of 23 industrialized and developing countries that we study here, average inflation fell from 8.65 percent per year for the five years ending in 1990 to an average of 3.53 percent for the most recent five years for which we have data. Over these same intervals, real growth (in industrial production) rose from 3.21 percent per year to 4.28 percent per year.

The most interesting part of the story, however, concerns inflation targeting, which we might call the monetary policy framework of the 1990s. Included in our sample of 23 countries are 9 that have targeted inflation explicitly, beginning in nearly all cases in the first few years of the decade. Looking at Table 1, we see that for these countries inflation fell by more than 7 percentage points on average, from 10.82 percent in the late 1980s to 3.41 percent in the latter part of the 1990s (Table 1). For the nontargeters, the average reduction is 3.6 percent. To a very real extent, inflation targeting has achieved its primary objective — the lowering of inflation.

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, then these objectives should have changed following the regime shift.

Table 1: Economic Performance Before and After 1990

1985 to 1989

	Average		Average St. Dev.	
	Real Growth	Inflation	Real Growth	Inflation
All countries	3.21	8.65	9.08	10.44
Inflation targeters	2.26	10.83	7.47	15.01
All nontargeters	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 to 1997

	Average		Average St. Dev.	
	Real Growth	Inflation	Real Growth	Inflation
All countries	4.28	3.53	7.22	3.68
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

	Average		Average St.Dev.	
	Real Growth	Inflation	Real Growth	Inflation
All countries	1.08	-5.12	-1.87	-6.75
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

Inflation-targeting countries are Australia, Canada, Chile, Finland, Israel, New Zealand, Spain, Sweden, and the United Kingdom. These are 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. Nontargeting countries are Austria, Belgium, Denmark, France, Germany, Ireland, Italy, Japan, Korea, Mexico, Netherlands, Portugal, Switzerland and the United States. The standard deviation of real growth is computed as the deviation from the full sample trend, using quarterly industrial production at an annual rate. The standard deviation of inflation is computed as the deviation from 2 percent. Sample periods vary slightly by country. See the appendix for details concerning the data.

More specifically, we might think of policymakers as choosing a point on an output-inflation variability trade-off, assuming that a trade-off between these two exists. If there is a stable trade-off, then 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 is more variable than it 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 to the mid-1990s, we see first that volatility in both output and inflation fell in all countries in our sample, suggesting that the 1990s have been relatively shock-free, and so 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) in the recent decade.[1] For this reason, it is the comparison of the targeting and nontargeting countries that is important. Here we see 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. In the first figure, we plot the variance of inflation (as measured by consumer prices) and the volatility of output about its trend (as measured by industrial production) for our sample of 23 countries.[2] These outcomes depend on many things, including a country's economic structure, its policy regime, and the actual pattern of shocks it has faced. Nevertheless, we note that the pattern 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 et al. (1999, p. 66) also make this point.
[2]Countries with extremely high inflation or output variability are truncated.

Figure 1: Output-Inflation Variability Trade-off
23 Countries, 1984 to 1997

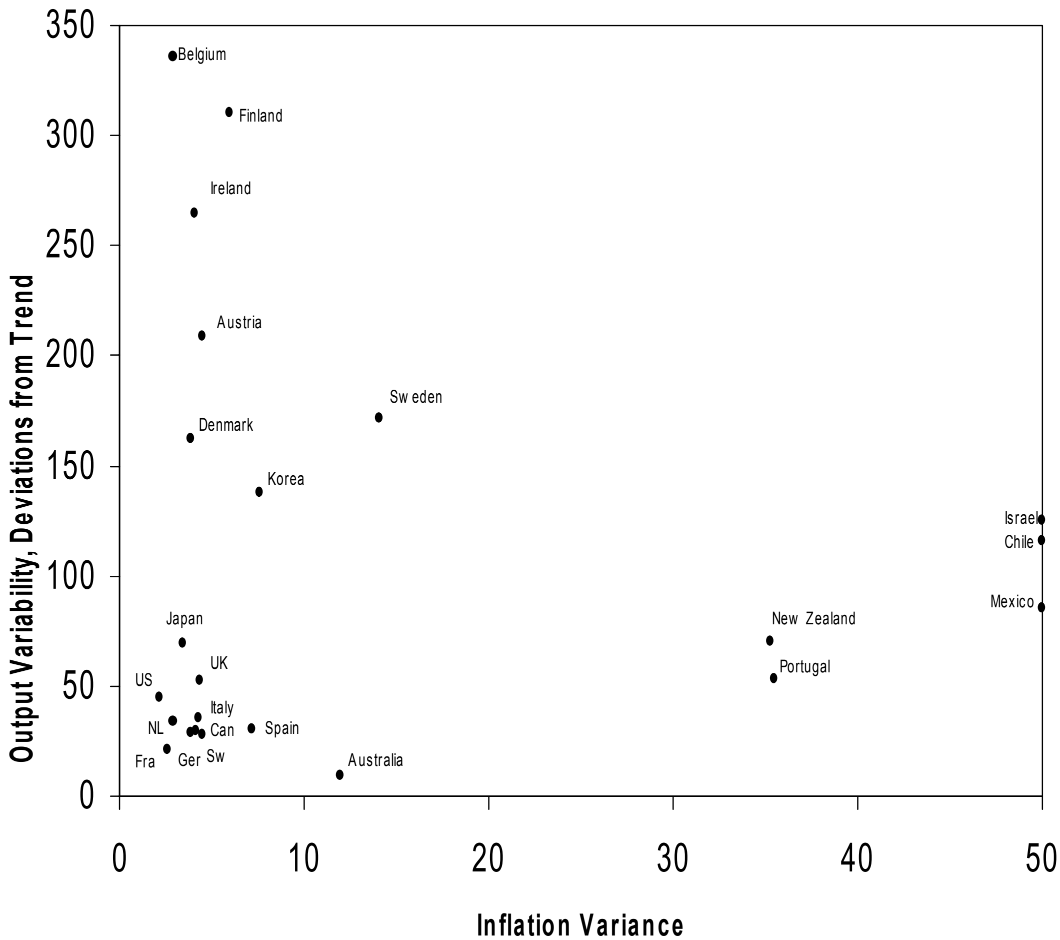


Figure 2: Output-Inflation Variability Trade-off
Inflation-Targeting Countries, before and after Implementation

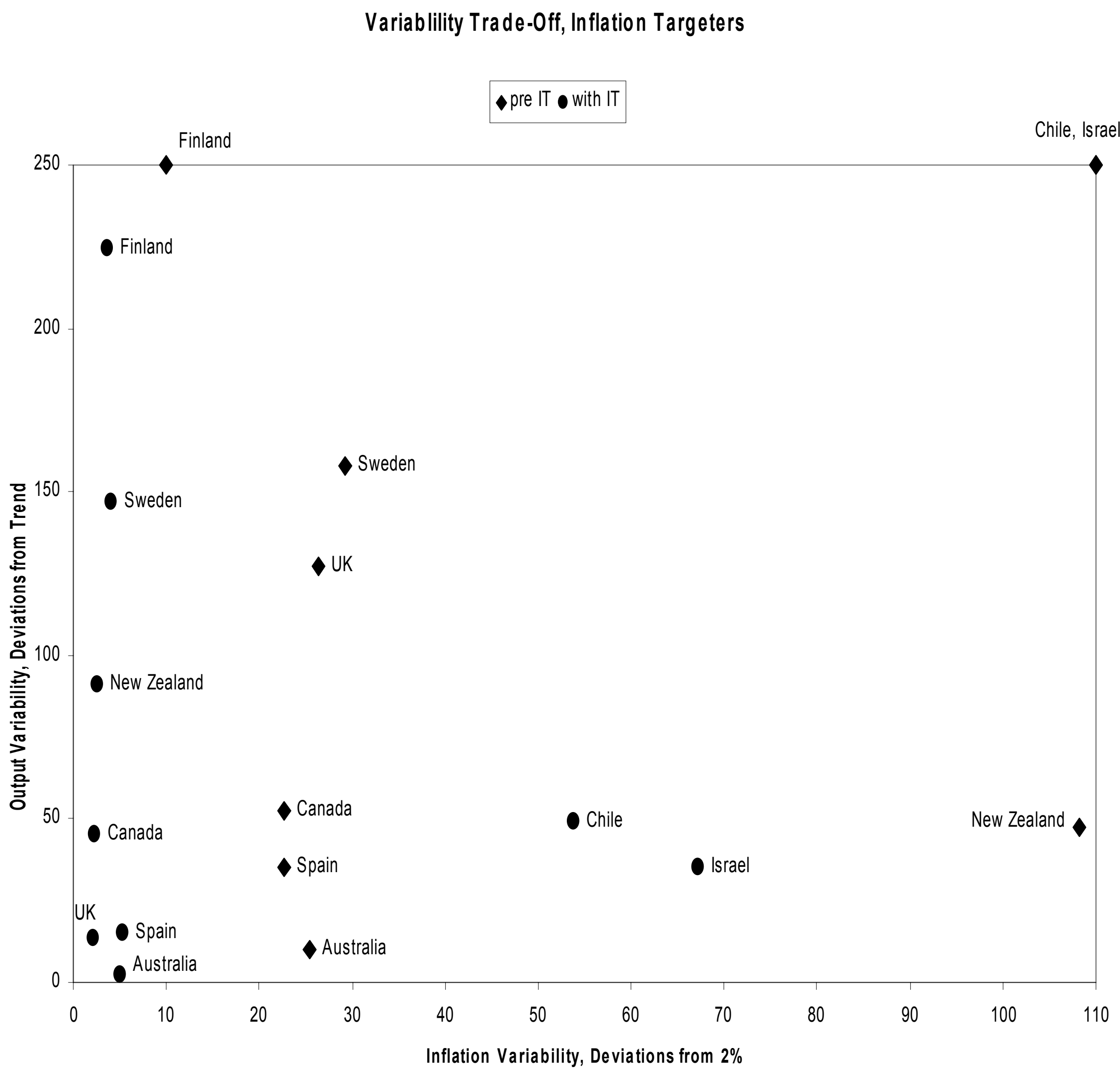


Figure 2 reports the experience of the inflation targeting countries. We examine the outcomes for 5 years before (indicated by solid diamonds) and 5 years after inflation targeting was implemented (indicated by solid circles). Here, we compute the squared deviation of inflation from 2 percent, which we assume to be near a likely long-run target. If a country is initially operating on a stationary inflation-output variability trade-off, then the shift to inflation targeting would be expected to move the point on the plot up (higher output variability) and to the left (lower inflation variability). This is the case for only 1 of the 9 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 the overall level of shocks hitting the economy declines between the two periods we compare, both inflation and output variability will fall, and a point on the plot will move toward the origin (down and to the left). For this reason, we must develop a more disciplined approach to the data, one based on an economic model.

In the remainder of this paper we pursue this approach, estimating the changes in policymakers' revealed preferences to see if 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, then their actions reveal their objectives. The method is as follows. Beginning with a simple loss function that represents trade-offs among 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 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 is used to go backwards. First, we estimate the structure of the economy in each country. This tells us the available frontier for each country. 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 the formulation of their policies.

The remainder of the paper is in four sections. In Section 2, we present a simple model that allows us to relate output and inflation outcomes, together with the economic structure, to a policymaker's preferences. Section 3 reports estimates of the structural vector autoregressions that give us the raw material we need to estimate preferences. The task of Section 4 is to report estimates of the policymaker's implied objective function in a sample of 23 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) above what it otherwise might have been. Interestingly, the same is true of the nontargeting European Union (EU) countries, who necessarily increased their focus on inflation as they approached the start of monetary union on January 1, 1999.

2 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 write down 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 central banker's objectives can be written as a simple quadratic loss function.[3] That is, the policymaker seeks to minimize the discounted sum of squared deviations of output and prices

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

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

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

where E denotes the mathematical expectation, π is inflation, y is the (log) of aggregate output, π^* and y^* are the desired levels of inflation and output, and α is the relative weight given to squared deviations of output and inflation from their desired levels.[4] The parameter α is the crucial quantity of interest, and we will call it the policymaker's aversion to inflation variability.

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

We also note that 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 not concerned 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

[4] This loss function can be written in a more complex, dynamic form in which a discount factor and an 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.

be solved without knowledge of the dynamics of the 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:

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

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

and d_t and s_t are aggregate demand and aggregate supply shocks. These are the fundamental sources of exogenous disturbances to the economy.[5] The parameter γ gives the ratio of the 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.

Note that 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 what is captured in equations 2 and 3, is the notion that there are two kinds of disturbances that buffet the economy and require policy responses. The first type of shock — the aggregate demand shock — moves output and inflation in the same direction; the second type of shock — the aggregate supply shock — moves output and inflation in opposite directions. Policy is capable only of moving output and inflation in the same direction, and so is analogous to an aggregate demand shock. It is the aggregate supply movements 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

[5] 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, while apparently simple, does not restrict short-run dynamics.

shocks is a simple linear rule. We write this as

$$r_t = ad_t + bs_t. \tag{4}$$

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 one. 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).[6]

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.[7] 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 variance of output and inflation in the same proportion.[8] As a result, we can derive the following ratio:

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

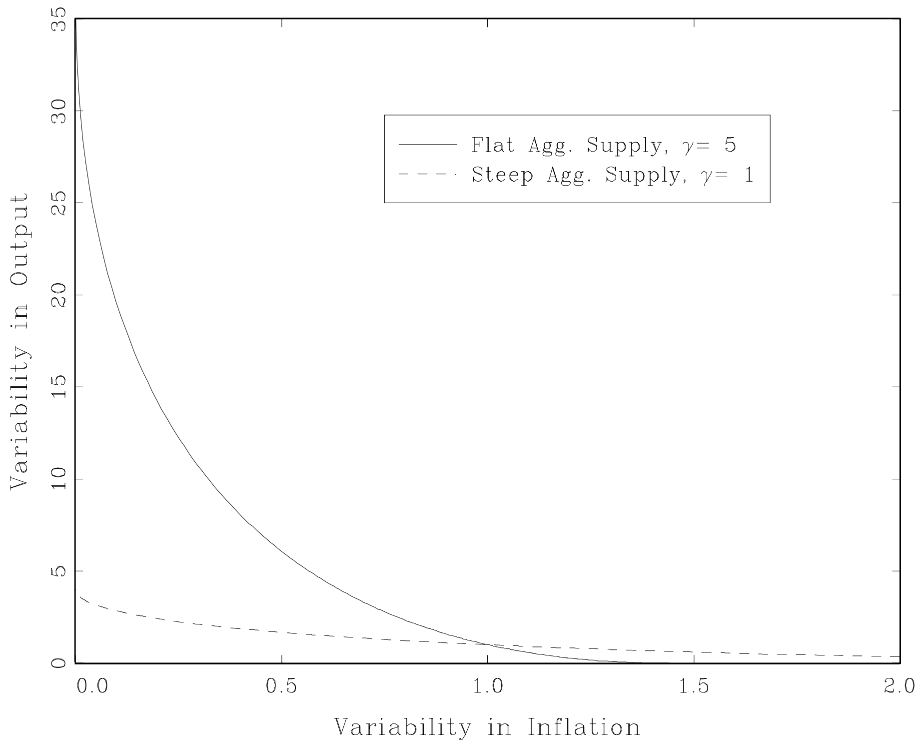
This expression has several interesting properties. First, we note that when $\alpha = 0$ (the policymaker cares only about output variability), $\sigma_y^2/\sigma_\pi^2 = 0$. Likewise, for $\alpha = 1$ (the policymakers cares only about inflation variability), $\sigma_y^2/\sigma_\pi^2 = \infty$. Significantly, varying α between zero and one allows us to trace out the entire output-inflation variability frontier, the shape of which is related to the slope of the aggregate supply

[6]The resulting expression is given by $b^* = [-\alpha\omega + (1-\alpha)\gamma]/[\alpha + (1-\alpha)\gamma^2]$. We also note that it would be possible to rewrite the rule (4) in the form used by Taylor (1993). To accomplish this, simply note that, using the expressions (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.

[7]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 footnote 6.

[8]This means that the variability frontier as drawn in Figures 1 and 2 of the introduction does shift with the variance of supply shocks, making those pictures more difficult to interpret.

Figure 3: Examples of the Inflation-Output Variability Trade-off



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 ($\gamma = 5$), while the dashed line depicts the frontier for a country with a steeper aggregate supply curve ($\gamma = 1$) (recall that γ is the inverse of the slope of the aggregate supply curve).[9] 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 3, and the ratio of the variance of output and inflation, which we will obtain from the

[9]Table 3 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, Korea, Japan, Israel, Mexico, New Zealand, Spain, and the U.S.

data. With these two quantities in hand, we can compute an estimate of α.

3 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.[10] We choose to apply the methodology used by Ehrmann (1998) 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 23 countries, including 9 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.[11] In practice, these last requirements are extremely difficult to meet.

Methodologically, our approach is based on the structural VAR (vector autoregression) techniques devised by King, Plosser, Stock, and Watson (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, and 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 and model specifications are described in detail in the appendix. Here we simply report the results.

Figure 4 plots the responses of output (the solid lines) and inflation (the dashed lines) to an interest rate increase of 100 basis points for the 23 countries in our

[10] See the references in Cecchetti (forthcoming) for a representative sample.

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

Figure 4
Response of Output and Inflation to a 100-Basis-Point
Interest Rate Increase

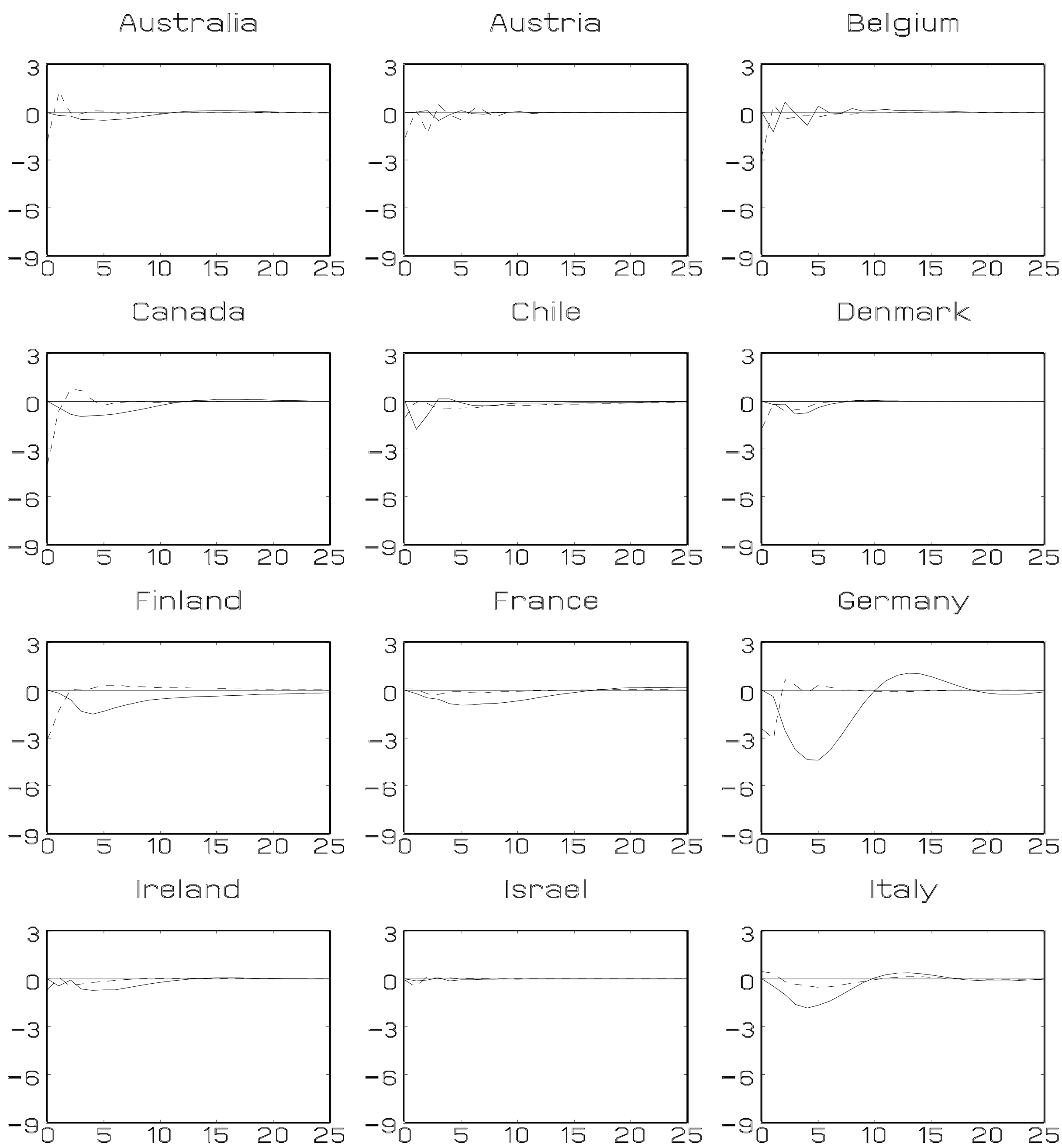


Figure 4
Continued

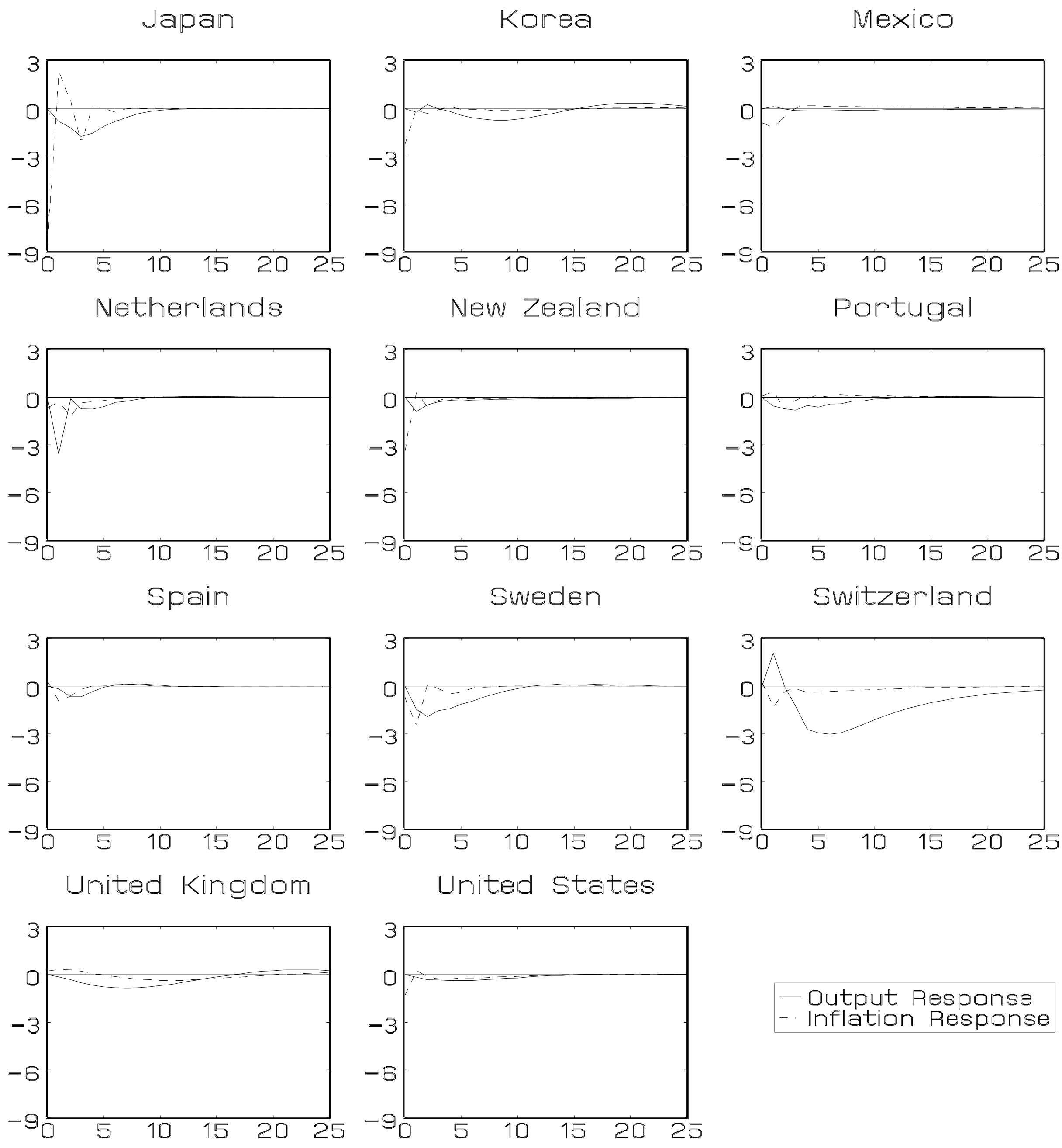


Table 2: The Impulse Response Functions

Country	Maximum Impact		Sacrifice	Inverse Aggregate
	Output	Inflation	Ratio	Supply Slope (γ)
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	-1.53	-2.02	4.00	2.46

The sacrifice ratio is computed as the cumulative output loss per percentage point reduction in inflation over a horizon of 12 quarters. The inverse aggregate supply slope is the 12-quarter average of the impact of policy innovations on output, divided by the 12-quarter average impact on inflation. See the appendix for details of the estimation of the models. The average for the "Other Countries" excludes Portugal.

sample. For the purpose of comparison, we have plotted all of 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 than in Israel or Mexico. Table 2 summarizes the results from the figures. 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, and an estimate of the sacrifice ratio. The sacrifice ratio is the cumulative percentage loss in output for a 1-percentage point reduction in inflation. Here we compute the sacrifice ratio over a horizon of 12 quarters.

The numbers appear to be both reasonable and similar across the targeting and nontargeting countries. With the exception of Portugal, all of the numbers are plausible. For the remaining countries, the sacrifice ratio ranges from 0.4 for Austria to 10.4 for Germany. The estimate of γ has a similar variation, from 13.7 for the United Kingdom to 0.13 for Belgium (again ignoring Portugal). While 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.

4 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 the desired measure of output variability 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. In Table 3 we report results for two assumptions about the desired level of inflation: (1) it is equivalent to average inflation in the sample or (2) it is a fixed level of 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 α's are quite large, suggesting that many of these countries have taken the goal of inflation stability very seriously over this period. When desired inflation is assumed to be 2 percent, 14 of the 23 countries have estimated α's of 0.70 or higher, and half of these exceed 0.9.[12] 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 of the countries 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 compute the value of α for five-year moving windows. Throughout, we assume that desired inflation is 2 percent, and that the estimate of γ is unchanged.[13] On each graph we include a horizontal line for the value of α computed from the 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.

The results in the figures are quite striking. For 7 of the 9 inflation-targeting countries, the estimate of the aversion to inflation variability rises substantially either *prior* to or immediately following the time the targeting regime is implemented (Figure 5).

[12]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_y^2/σ_π^2. For any given value of σ_y^2/σ_π^2, 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.

[13]As noted in Section 3, 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 effect our results, as this simply serves to scale the level of α, not affecting the changes.

Table 3: Full Sample Results

Country	Aversion to Inflation Variability, α	
	$y^* = trend$, $\pi^* = \overline{\pi}$	$y^* = trend$, $\pi^* = 2\%$
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	0.75	0.73

Figure 5
Five-Year Rolling Sample Estimates of Inflation Variability Aversion, Inflation-Targeting Countries

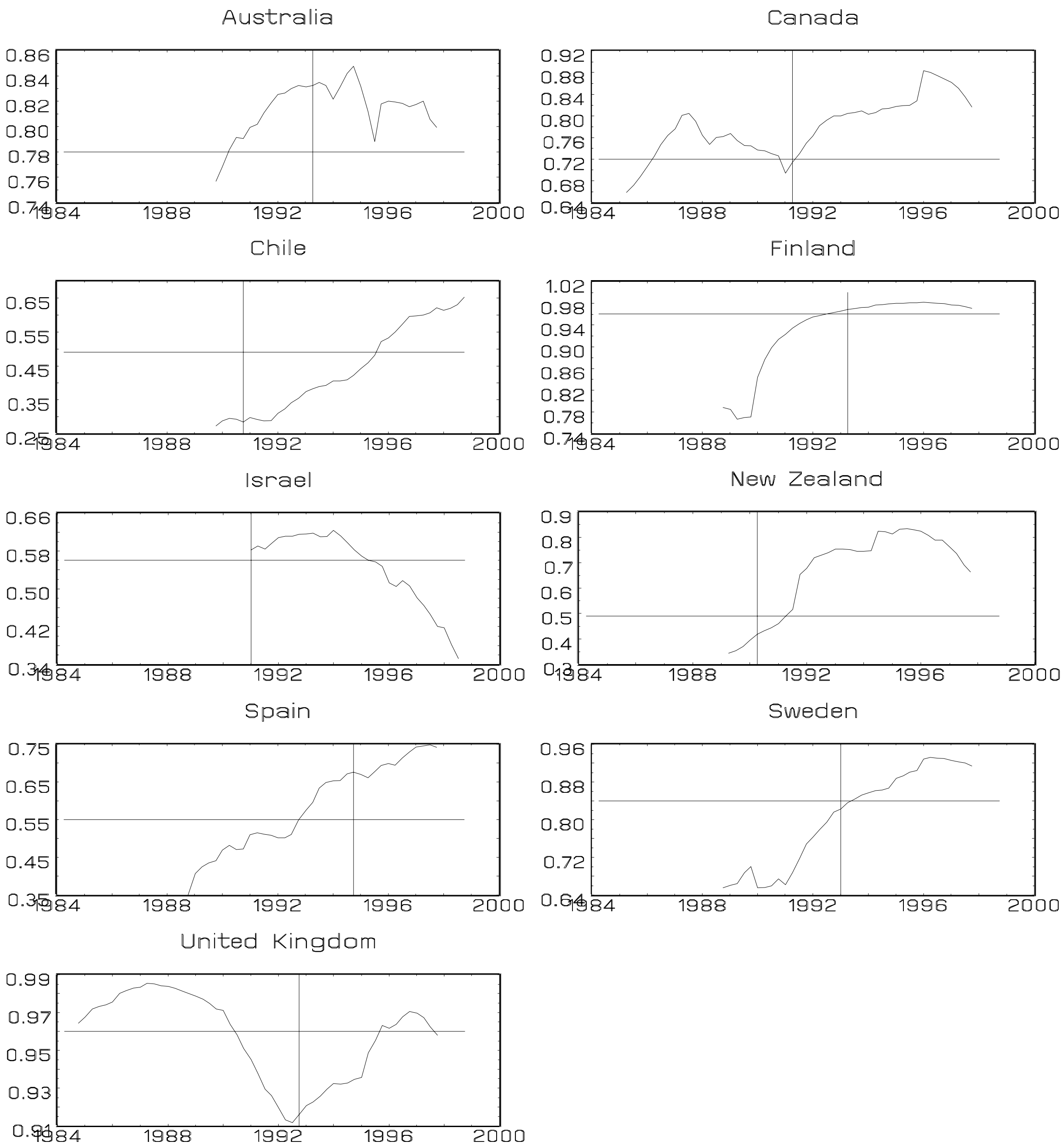


Figure 6
Five-Year Rolling Sample Estimates of Inflation Variability Aversion,
Other EU Countries

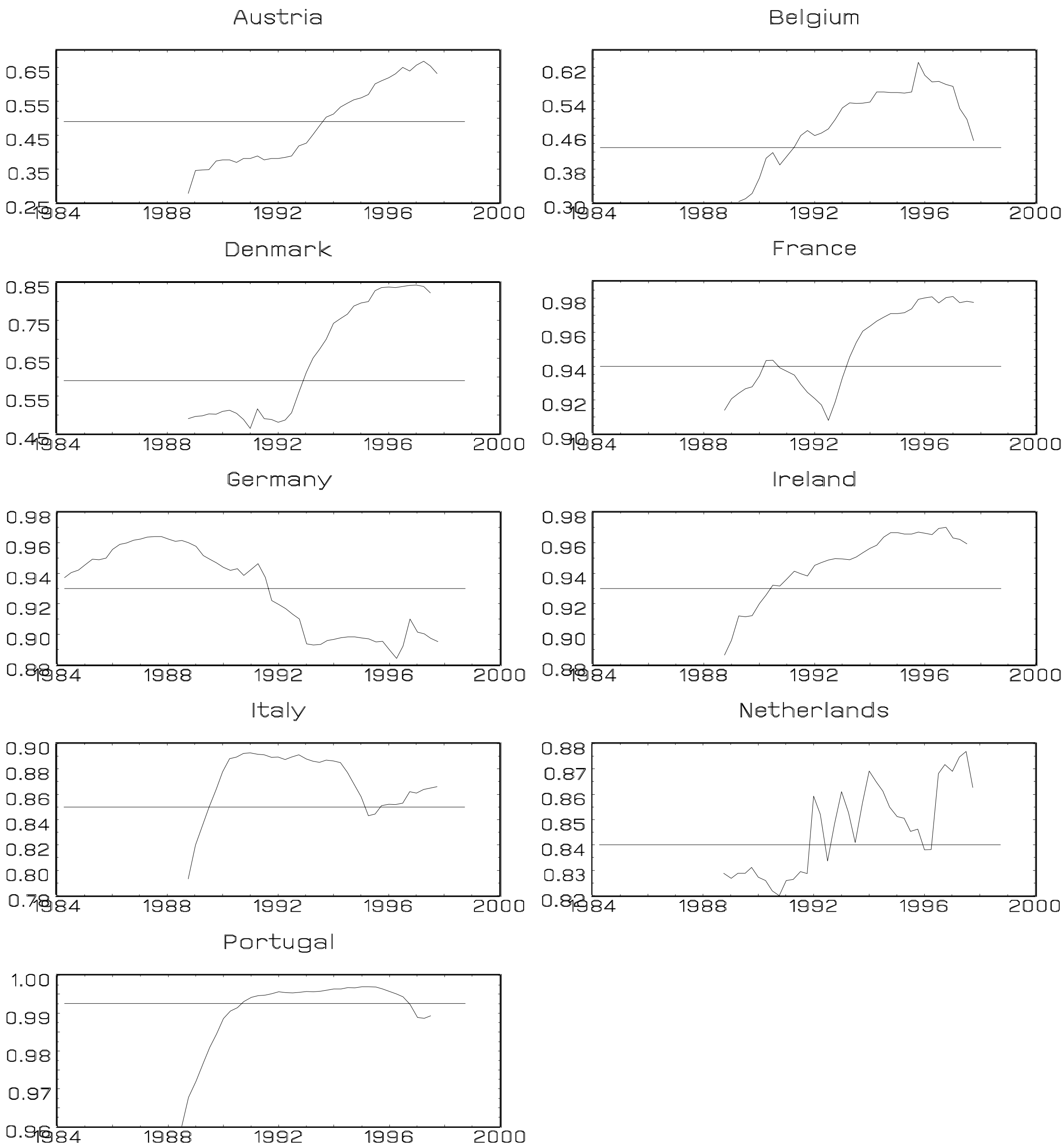


Figure 7
Five-Year Rolling Sample Estimates of Inflation Variability Aversion,
Other Countries

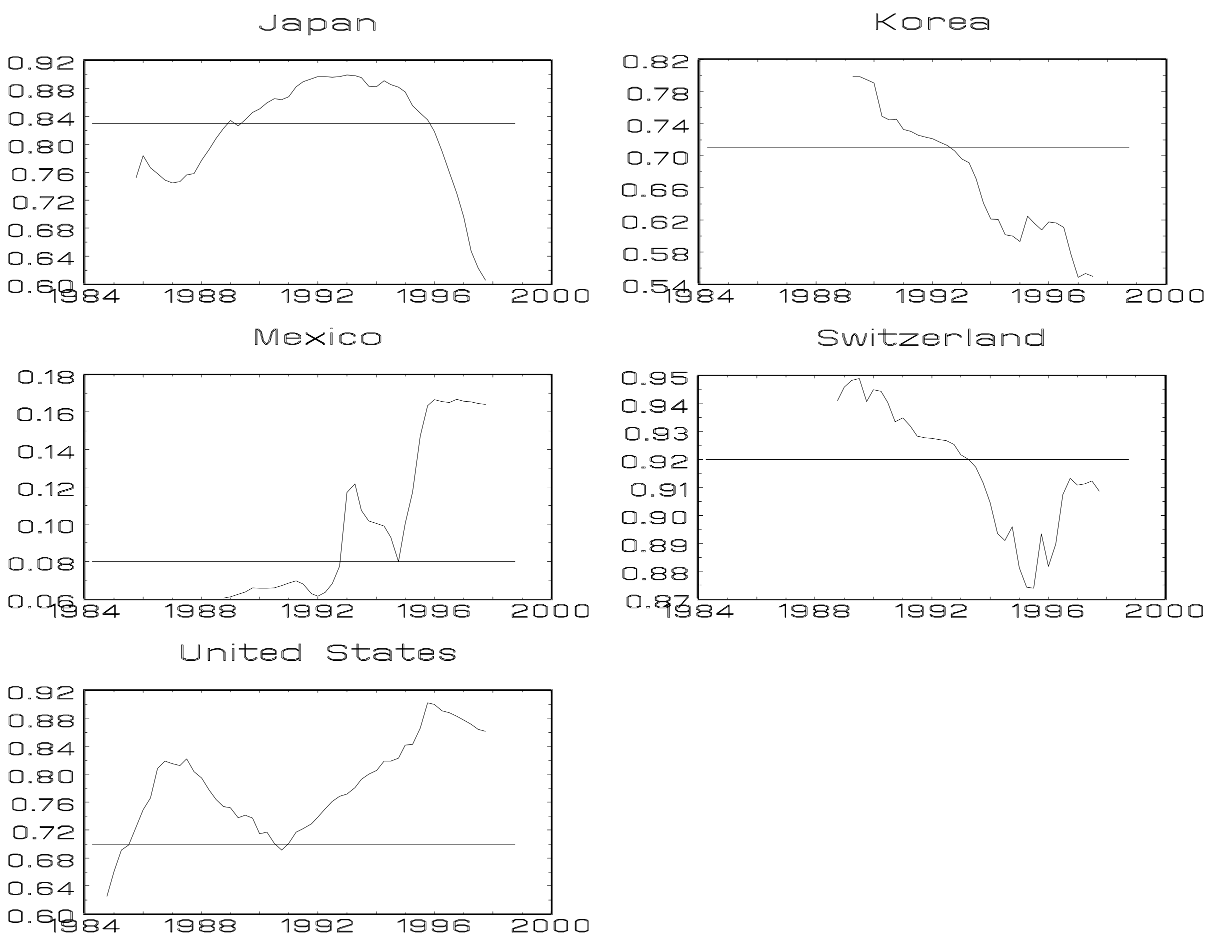


Table 4: Shift in Implied Weight Attached to Inflation Variability for Inflation-Targeting Countries

Country	Full Sample	Date of Shift to π Target	α Prior to the Shift	α After the Shift
Australia	0.78	1993:2	0.83	0.80
Canada	0.72	1991:2	0.73	0.87
Chile	0.49	1990:4	0.27	0.52
Finland	0.96	1993:2	0.96	0.97
Israel	0.56	1991:1	0.58	0.51
New Zealand	0.49	1990:2	0.34	0.83
Spain	0.55	1994:4	0.65	0.74
Sweden	0.84	1993:1	0.76	0.91
United Kingdom	0.99	1992:4	0.93	0.96
Average	0.71	1992:1	0.67	0.79

"α prior to shift" is the α for the five-years ending one year before the date of the shift to explicit inflation targeting. "α after the shift" is the α for the five years following the shift, or the last available five-year period when data are not available.

The exceptions are Israel, where the estimate of α falls following implementation, and the United Kingdom where there is no discernible pattern.

Of the 9 EU countries that have not explicitly targeted 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 conclude that in preparation for monetary union, the countries of the EU were forced to behave more like inflation-targeting countries throughout the 1990s. Germany, however, softened its previous hardline view toward inflation, both because of the implications of unification and as a compromise in the direction of its future EMU colleagues.

For the remaining 5 countries in our data set, the results are mixed (Figure 7). While the estimates of the aversion to inflation variability for the United States and Mexico rise, the estimates for the other countries show declines of varying degree.

Table 4 complements Figure 5, reporting the aversion to inflation variability for

Table 5: Changes in Average Level of Inflation Volatility Aversion

	Full Sample	1984-1989	Last 5 Years
All countries	0.72	0.69	0.76
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

Inflation-targeting countries are Australia, Canada, Chile, Finland, Israel, New Zealand, Spain, Sweden, and the United Kingdom. European Union nontargeters are Austria, Belgium, Denmark, France, Germany, Ireland, Italy, Netherlands, and Portugal. The remaining countries are Japan, Korea, Mexico, Switzerland and the United States.

five-year periods before and after the explicit announcement of a move to inflation targeting. Of the 9 countries in the sample, 6 show an increase in the estimate of α. For the other 3, there are modest declines.

We now conduct one final test to determine whether the changes in the inflation-targeting countries can in fact be ascribed to the targeting regime itself. For this test, we use the remaining 14 countries in our sample as a control and examine 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 "EU Nontargeting" countries. The principal finding, however, is that inflation-targeting countries show a significant average increase, from an average of 0.63 to an average of 0.76. In addition, the other EU countries show an increase in α from 0.75 to 0.83. The countries in neither category show a modest decrease.[14]

[14] A simple regression of the change in α on dummy variables for inflation-targeting and EU nontargeters 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.

5 Conclusions

This paper asks if inflation targeting increases output volatility. 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 long-run desired levels. 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 estimate the change in the preferences of monetary policymakers in a cross-section of 23 countries, including 9 that target inflation explicitly. We find 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.

Appendix

A1: Estimation and Identification Strategy

To estimate the structural responses of each economy to a monetary policy shock, we use structural vector autoregressions (SVARs). A detailed discussion of our methodology can be found in Ehrmann (1998), so we provide only a quick overview of the estimation strategy. We apply a procedure set forth in King, Plosser, Stock, and Watson (1991).[15] The KPSW identification strategy is based on the implications of the cointegrating relations, in a multivariate system. Complete identification of an n-variable structural system requires $\left[\frac{n(n-1)}{2}\right]$ 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 $\left[\frac{k(k-1)}{2}\right]$ additional restrictions. The KPSW methodology 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 $\left[\frac{m(m-1)}{2}\right]$ 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.

A2: The Models

Appendix 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

[15] For the analytical derivation of the KPSW procedure, see there or Warne (1993).

addition, for all countries but the United States, Japan, and Switzerland, 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 the U.S. or German monetary policy setting), commodity prices as a leading indicator for inflation[16] 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 break-point (N down) Chow tests, both on 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 models are stable and well specified, for most countries the samples are restricted to 1984-97. In some cases, the results of the stability tests led us to make the sample period shorter. To make sure we do not distort 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 systems as a whole for serial correlation, non-normality, heteroskedasticity and autoregressive conditional heteroskedasticity (ARCH).[17]

[16]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.

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

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. Appendix Table A2 reports the full list of dummy variables included for each of the countries we study.

Table A1: Model Specification

Country	Variables	Coint Rank	Lags	Sample Size
Australia	OECD-MEI short-term interest rate, industrial production (sa), CPI inflation, Aus. dollar/Yen exchange rate, IMF commodity price index	3	2	85:I-97:IV
Austria	3-month money market rate, industrial production, CPI inflation, Schilling/DM exchange rate, German short-term rate	2	2	84:I-97:I
Belgium	3-month t-bill rate, industrial production, CPI-inflation, Franc/DM exchange rate, German short-term rate	3	2	84:III-97:IV
Canada	OECD-MEI short-term interest rate, industrial production (sa), CPI inflation, Canadian Dollar/U.S.$ exchange rate, real M3	2	2	80:III-97:IV
Chile[1]	30-to-90 day deposit rate, industrial production (sa), CPI inflation, Peso/U.S.$ exchange rate, U.S. short-term interest rate	3	2	85:I-98:IV
Denmark	3-month interbank market rate, industrial production (sa), CPI inflation, Krone/DM exchange rate	2	2	84:I-97:III
Finland	call money rate, industrial production, CPI inflation, Markka/U.S.$ exchange rate	2	2	84:I-97:IV
France	3-month money market rate, industrial production, CPI inflation, Franc/DM exchange rate, long-term rate on govt. bonds	3	2	84:I-97:IV
Germany	3-month money market rate, industrial production (sa), CPI inflation, DM/$ exchange rate, IMF commodity price index	3	2	79:III-97:IV
Ireland	3-month t-bill rate, industrial production, CPI inflation, Punt/DM and Punt/sterling exchange rates	3	2	84:I-97:III
Israel	Short-term t-bill rate, industrial production (sa), CPI inflation, Shekel/US$ exchange rate, real money	3	2	86:II-98:III
Italy	3-month t-bill rate, industrial production, CPI inflation, Lira/DM exchange rate, IMF commodity price index	3	2	84:I-97:IV
Japan	OECD-MEI short-term interest rate, industrial production (sa), CPI inflation, real M3	2	2	81:I-97:IV

Table A1: Model Specification - continued

Country	Variables	Coint Rank	Lags	Sample Size
Korea	Daily money-market rate, industrial production (sa), CPI inflation, Won/U.S.$ exchange rate	2	2	84:III-97:III
Mexico	OECD-MEI short-term interest rate, industrial production (sa), CPI inflation, Peso/U.S.$ exchange rate, IMF commodity price index	3	2	84:I-97:IV
Nether-lands	3-month interbank market rate, industrial production, CPI inflation, Guilder/DM exchange rate, German short-term rate	3	2	84:I-97:IV
New Zealand	OECD-MEI short-term interest rate, industrial production, CPI inflation, NZ dollar/U.S.$ exchange rate	2	2	84:III-97:IV
Portugal	5 day money-market rate, industrial production, CPI inflation, Escudo/DM exchange rate, German short-term rate	3	2	83:IV-97:III
Spain	3-month money market rate, industrial production, CPI inflation, Peseta/DM exchange rate, real ALP[2]	2	2	84:I-97:IV
Sweden	3-month t-bill rate, industrial production, CPI inflation, Krona/U.S.$ exchange rate, long-term rate (9 year govt. bonds)	3	2	84:I-97:IV
Switzer-land	OECD-MEI short-term interest rate, industrial production (sa), CPI inflation, real M3	2	2	84:I-97:IV
United Kingdom	3-month t-bill rate, industrial production, RPIX-inflation,[3] Sterling/DM exchange rate, IMF commodity price index	3	1	80:I-97:IV
US	OECD-MEI short-term interest rate, industrial production (sa), CPI inflation, IMF commodity price index	2	2	80:I-97:IV

Notes for Table A1:

Data for Austria, Belgium, Denmark, Finland, France, Germany, Ireland, Italy, 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. Data for Chile are from International Monetary Fund's International Financial Statistics (deposit rate), the Central Bank of Chile's WWW-homepage (inflation), and from DRI (industrial production, exchange rate); Israeli data are taken from DRI (exchange rate, industrial production, and inflation) and from IFS (interest rate, money). Korea's data are taken from IFS (money-market rate, industrial production) and DRI (inflation and exchange rates).

[1] 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.

[2] ALP is a monetary measure of active liquidity in private hands. It is defined as a broader aggregate than M3. To construct real ALP, the natural logarithm of the CPI is subtracted from the natural logarithm of ALP.

[3] Retail prices on all items excluding 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 have to be excluded from the price index.

Table A2: Dummies

Country	Dummies
Australia	None
Austria	For the inflation equation: increase of VAT 1986:I, 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 Austrian CB in 1986:I, which followed a period of massive capital outflows, CB 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 ERM-exchange-rate bands to 15%. Industrial production: output decline in 1987:I. The Belgium CB linked the decline to efforts to trim the public deficit and therefore did not take any corrective steps. Inflation: In 1986:I, inflation fell drastically, a decline too sharp to be explained by the monetary policy framework alone. Indeed, lower fuel prices are mentioned by the Belgian CB as a reason for the marked improvement in the inflation performance.
Canada	Exchange rate: 1992/93 exchange-rate crisis. Interest rate: in 1981:IV and 1994:II 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 1988:III, VAT and fuel prices fell, whereas in 1990 both were increased. System: in 1992:I, money growth exploded to a 55 percent annual rate.
Denmark	Exchange rate and interest rate: 1992/93 exchange-rate crisis. Inflation: Increase in indirect taxes in 1986.
Finland	Exchange rate and interest rate: 1992/93 exchange-rate crisis. Industrial production: recession 1990 to 1994.
France	None
Germany	Interest rate: stock market crash 1987, in the aftermath of which the Bundesbank loosened its monetary policy stance until 1988:III in order to offset some of the consequences of the crash on the real economy. Industrial production: strike in 1984:II. Inflation: first round of rent rises in East Germany 1992:I. Linear trend, restricted to lie in the cointegration space.

Table A2: Dummies - continued

Country	Dummies
Ireland	Interest rate: speculative crises 1986 and 1992. Inflation: increase in excise duties, removal of food subsidies and other taxation measures to reduce the Irish budget deficit 1987:I. Exchange rate: crises 1992 and 1995.
Israel	Exchange rate: devaluations in 1987:I, 1989:II and 1991:II.
Italy	Exchange rate and interest rate: Crises 1992/93 and 1995. Inflation: jump in 1990.
Japan	Interest rate: focus of monetary policy on exchange rate after Plaza Accord leads to a tightening of the policy stance in 1985:IV; inflation: increase in consumption tax 1997:II.
Korea	Inflation: acceleration in 1990:II. Exchange rate: acceleration of depreciation in 1996:III.
Mexico	Interest rate: tight monetary policy stance in the "Pact of Economic Solidarity" reduces inflation by over 100 percentage points in 1988. Industrial production: 1986 oil shock, 1994 steep increase in the growth rate coinciding with the start of NAFTA. Exchange rate: 1994/95 exchange-rate crisis.
Nether-lands	Industrial production: After a cut in VAT, a fall in security contributions and nominal wage increases, households' disposable income rose by 5% in real terms in 1989, leading to a steep increase in private consumption and industrial production.
New Zealand	Exchange rate: 20% devaluation in 1984:III, wide swings after the float in March 1985. Inflation: indirect tax increases in 1985:I, 1986:IV and 1989:III.
Portugal	Exchange rate: speculative attacks 1992/93.
Spain	Exchange rate: speculative attacks 1993 and 1995. Massive interest rate increase in the Bank of Spain lending rate 1987. After an overshooting of ALP by nearly 100% with respect to its target and after an increasing government deficit that 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% in December 1986 to 20.5% in May 1987. Inflation: Introduction of VAT in 1986:I. Linear trend, restricted to lie in the cointegration space.

Table A2: Dummies - continued

Country	Dummies
Sweden	Exchange rate and interest rate: crisis 1992/93. The CB of Sweden increased its marginal lending rate to 500% in September 1992. Inflation: tax reform 1990:I, where the VAT base was widened substantially, and the subsequent VAT change in 1991.
Switzer-land	Interest rate: after the stock market crash in 1987, the CB lowered interest rates to the lowest level since 1979.
UK	Industrial production: miners' strike in 1984. Exchange rate: currency crisis 1992. Interest rate: In 1985:I, 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 towards exchange-rate goals. Linear trend, restricted to lie in the cointegration space.
US	Interest rate: high volatility of short-term rates at the beginning of the Volcker era. Linear trend, restricted to lie in the cointegration space.

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