Forecast-based monetary policy in Sweden 1992-98: a view from within

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Abstract

The use of explicit inflation targets has meant that monetary policy has become more transparent and also easier to evaluate. The analysis in this paper is based on forecasts by Sveriges Riksbank (the Central Bank of Sweden) on real output and inflation. Our purpose is to separate the effects on the interest rate instrument of (i) discretionary changes in the rule for monetary policy and (ii) judgments in forecasting. We first feed the Riksbank's forecasts into two different simple rules for interest rate policy. The differences between the interest rates implied by these benchmark rules and the actual policy rate are interpreted as measures of "policy shocks". Second, we compare the Riksbank's forecasts with alternative forecasts. Using a benchmark rule for the setting of the policy rate, we can use the differences between the forecasts to define measures of the effects of the Riksbank's "judgments" on its interest rate policy.

1. Introduction

In order to understand the effects of monetary policy, we have to be able to identify, among other things, movements in interest rates and monetary aggregates that are induced by changes in policy (as opposed to changes in other factors, eg money demand). Attempts to describe central banks' monetary policies have been undertaken by researchers using different methods. One common approach has been to use time-series models, such as vector autoregressions (VARs), to estimate "shocks" to interest rates using a minimum of a priori restrictions. Christiano et al (1998) provide a review of this literature. A quite different approach has been to single out specific episodes when monetary policy is believed to have been especially active and effective and to scrutinise both policy documents and macroeconomic data from those episodes. Although such studies can hardly provide strong statistical evidence, it is clear that careful studies of specific events can yield useful information about the design and effects of monetary policy. The study by Milton Friedman and Anna Schwartz (1963) is probably the most well known example. Christina and David Romer have applied a similar approach in a number of more recent studies (eg Romer and Romer (1989)).[2]

A serious evaluation of policy requires rather detailed information about policy objectives and rules and about the information policymakers have at their disposal when they make their decisions. This type of information is not readily available, either for external economists or economists at the central banks themselves. One reason for this is that policy decisions are made on the basis of many different kinds and sources of information, which in the policy process are weighed together in complicated and informal ways. Policy is to a large extent based on judgments and discretionary decisions. It is not

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[2] Both time-series approaches and Friedman-Schwartz-type studies have of course been criticised; see eg Rudebusch (1998) and Leeper (1997).

simply the result of model forecasts that are plugged into policy rules to which the central banks have committed themselves in advance.

During the last decade, however, many central banks have started to follow policies that have been characterised as "constrained discretion" (Bernanke and Mishkin (1997)). These central banks have defined explicit inflation targets and have also obtained increased independence to achieve their goals. This development has been associated with an increased demand for information about, and analyses of, monetary policy. It has also provided incentives for central bankers to explain their policies to the general public. Examples of this can be found in Australia, Canada, New Zealand, Sweden, the United Kingdom and the European monetary union, although the approaches to inflation targeting differ somewhat between these countries.

The use of explicit inflation targets has meant that monetary policy has become more transparent and also easier to evaluate. For instance, many of the inflation targeting central banks claim that their policies are forecast-based. If the forecasts are also actually published, then interesting insights into the central banks' reaction functions can be gained from investigating the effects of forecasts on policy. On the other hand, if there is a close relation between a published forecast and decisions on monetary policy, then policy considerations may also influence the forecast. A comparison of a central bank's forecasts with some alternative sets of forecasts may thus yield useful information about monetary policy.

In this paper we analyse monetary policy in Sweden during the first six years of the inflation targeting regime, 1992-98. More precisely, our purpose is to investigate if it is possible to describe this monetary policy in terms of a simple reaction function that relates the interest rate instrument to reasonable forecasts of macroeconomic conditions. We try to separate the effects on the interest rate of (i) discretionary changes in the rule for monetary policy and (ii) judgments in forecasting.

In undertaking our study we combine time-series methods with information from policy documents. Specifically, we look at the forecasts of inflation and GDP growth produced by the Riksbank in connection with its Inflation Reports 1992-98. Our study is (to our knowledge) unique in the sense that it constitutes a first attempt to comprehensively analyse actual real-time forecasts undertaken by an inflation targeting central bank. Given such forecasts, it is possible not only to evaluate the forecasts per se but also to relate them to the policy decisions that were actually made. We hope that this exercise is interesting not only for economists inside central banks, but also to market participants and politicians (who may want to evaluate and better understand monetary policy) and researchers (who may be interested in realistic estimates of "policy shocks").[3] We furthermore believe that analyses of this kind are important and necessary to support the mandate and the increased operational independence recently given to many central banks.

We first feed the Riksbank's forecasts into two different simple rules for interest rate policy - one forward-looking Taylor-type rule suggested by Rudebusch and Svensson (1999), the "RS rule", and another which seems to lie closer to the rule suggested by the Riksbank itself in its Inflation Reports, the "RB rule". The differences between the actual policy rates and the interest rates implied by these benchmark rules are interpreted as measures of "policy shocks". These reflect changes of the policy rate that, given the rules, are not motivated by the Riksbank's own forecasts.

Second, we compare the Riksbank's forecasts with alternative forecasts on which the bank could very well have chosen to base its monetary policy: real-time forecasts produced by a VAR model and by other analysts. Using a benchmark rule for the setting of the policy rate, we can then use the differences between the forecasts to define measures of the effects of the Riksbank's "judgments" on its interest rate policy. One of our measures of the impact of "judgments" is thus the calculated change in the policy rate that, given a policy rule, does not appear to be motivated by forecasts derived from a formal model-based approach (in our case a VAR). Our second measure is obtained through a similar calculation where forecasts by other institutions are substituted for the model-based forecasts. The latter measure presumably reflects not only judgmental adjustments of model forecasts, since other institutions' forecasts are not entirely model-based but are also affected by judgments. The differences between the Riksbank's forecasts and those of other institutions may also reflect "informational

[3] We think that our estimates of the effects of "judgments" and "policy shocks" come close to the "modest policy interventions" Leeper and Zha (1999) have in mind.

advantages" - or "disadvantages" - that the Riksbank may have, eg about the state of the economy or the effects of monetary policy.

The paper is organised as follows: the Riksbank's forecasts from 1992-98 are presented in Section 2; Section 3 discusses the simple rules for the policy rate that serve as our benchmarks; in Section 4 we present our estimates of "policy shocks"; Section 5 compares the different sets of forecasts of the arguments that enter the simple rules and presents the effects of the Riksbank's "judgments"; Section 6, finally, gives conclusions and includes some suggestions for further research.

A quick summary of the results is as follows: (i) the Riksbank has followed a forecast-based policy rule quite closely, ie "policy shocks" in the sense of deviations from such a rule have been small; (ii) actual policy has been less activist, in particular in response to output fluctuations, than predicted by the theoretical RS rule; (iii) deviations between the Riksbank's forecasts and those of other institutions have been small; and (iv) "judgments" nevertheless seem quantitatively important, since there are large deviations between the Riksbank's forecasts and forecasts produced by a VAR model.

2. Forecasts vs outcomes

Not all central banks (even inflation targeters) publish their forecasts of inflation and other macroeconomic variables. In the case of the Riksbank approximate numerical inflation and GDP growth forecasts (for calendar years) started to emerge during 1996. Around the end of 1997 and the beginning of 1998 approximate annual inflation forecasts appeared on a quarterly basis. Numerical forecasts of inflation and GDP growth to one decimal place were introduced in the Inflation Reports in March 1998 and March 1999 respectively. The inflation and GDP growth forecasts made in 1992-96 were first published in connection with the Inflation Report in June 2000.

The Riksbank's forecasts for 1992-98 are reported in Figures 1 and 2 together with the actual outcomes for annual CPI inflation and GDP growth. To facilitate our discussion and analysis, the same data are also reported in Tables 1 and 2.[4] At each forecast occasion, forecasts of inflation and real GDP growth are produced for the current year and, at most, the two following calendar years.[5] The forecast occasions are quarterly. The actual outcomes of inflation and GDP growth each year *t* can thus be compared with at most 12 earlier forecasts of these figures - four forecasts per year from years $t-2$, $t-1$ and *t*. The actual development of consumer prices is reported by Statistics Sweden on a monthly basis and GDP figures on a quarterly basis.

Figure 1 shows that the Riksbank's inflation forecasts are systematically higher than the actual outcomes for the corresponding years. There is only one exception to this rule (the forecast for 1994 undertaken in April 1994). As can be seen from Figure 2, the same systematic pattern does not obtain for the Riksbank's forecasts of GDP growth.

Several further observations can be made in relation to Figures 1 and 2:

(i) *The Riksbank's inflation forecasts are conditioned on the assumption of an unchanged policy rate.* They are thus not intended to be optimal forecasts in a mean-squared-error sense.[6] It is not clear, however, that this can explain the systematic overpredictions. One reason is that the Riksbank's forecasts (like those of most other central banks) are largely determined by judgments. The conditioning of the forecast on a constant interest rate assumption is obviously extremely difficult without the use of a formal model. Thus, it cannot be ruled out that these forecasts have to some extent been implicitly conditioned on a policy rate that changes over time.

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[4] The months reported in these tables (and Table 5) refer to the dates of the final forecasts and hence do not always coincide with the months in which the Inflation Reports were published.

[5] Since 1998 the Riksbank also reports forecasts of CPI inflation on a monthly basis. Unpublished monthly forecasts of inflation are available from approximately mid-1997 only. The forecasts of GDP growth are, however, still only given on a calendar year basis.

[6] For a discussion of this principle, which is also followed by the Bank of England, see Goodhart (2000).

There is one property of the CPI index, however, which can perhaps explain, at least partly, the forecast errors when the forecast is conditioned on an unchanged interest rate. A lower short-term interest rate implies an autonomous negative effect on the housing cost component in the CPI, which - at least temporarily - puts downward pressure on the CPI. The initial effect of a more expansionary monetary policy, aimed at eventually raising inflation, may thus be a fall in the registered rate of inflation. How much of the forecast errors can be explained by such mechanisms cannot, however, be determined without an explicit structural model which also includes other channels between monetary policy and inflation.[7]

(ii) *The forecast errors become smaller as the forecast horizon is approached.* The typical pattern of inflation forecasts, apparent from Figure 1, is that they start at a higher level than the eventual outcome (often more than 1 percentage point higher) and then gradually converge to the outcome. For example, according to the figures in Table 3, two-years-ahead forecasts for inflation (eight steps ahead in the table) have a root mean-squared error (RMSE) that is almost twice as large as that for inflation forecasts with a one-year horizon (four steps ahead in the table).[8] On some occasions, however, the inflation forecast has temporarily moved in the "wrong" direction. Two of these (October 1994 and August 1997) were - as shown in Figure 3 - followed by increases in the policy rate. This suggests that expectations of higher inflation caused the Riksbank to deviate from the downward interest rate trend that characterised the sample period. That inflation eventually turned out to be lower than expected may of course partly have been the result of the temporary contractions in monetary policy. However, again, some model is needed to evaluate such propositions.[9]

(iii) *The forecasts of GDP growth are on average more accurate than the inflation forecasts.* This is somewhat surprising, since information about actual GDP growth becomes available with a considerable lag, approximately two quarters, and revisions occur frequently. That inflation forecast errors become smaller as the forecast horizon is approached is less surprising. New information about actual inflation becomes available on a monthly basis, with a lag of approximately two weeks, and the CPI figures are only subject to very small revisions on an annual basis.[10] This explains why GDP growth forecasts show less tendency to converge to the actual outcomes than inflation forecasts (cf Figure 2 and Table 3); but it does not explain why GDP growth forecasts have been more accurate than inflation forecasts.

(iv) *There was a regime shift in Swedish monetary policy in 1992-93*, from an exchange rate target to an explicit inflation target. Such changes make forecasting even more difficult than it is under more stable circumstances. That inflation was lower than expected during the 1990s is furthermore something that was experienced in many other countries.[11] It can be noted, however, that there is no tendency for the inflation forecasts to become more accurate over time, something one might perhaps have expected, if forecasters learn about the effects of the regime shift over time. As shown in Table 1, the RMSEs were eg much smaller for the forecasts of inflation of 1994 and 1995 than for the forecasts of 1996-98. The reason is that the first forecasts for 1994 and 1995 started at a level much closer to the eventual outcome than the corresponding forecasts for 1996-98. Another way to express the same thing is to say that actual inflation has come down quite dramatically, but forecasts have not responded to that development to the same degree. The RMSEs for forecasts of

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[7] One such model has been presented by Apel and Jansson (1999). This model suggests that a 1 percentage point increase in the nominal interest rate (three-month Treasury bill rate) on average is associated with an initial 0.2 percentage point increase in inflation.

[8] Note that the number of available forecasts for a particular horizon is sometimes very small. Hence, the RMSEs of Table 3 need to be interpreted with great care.

[9] If the assumption about a constant interest rate can explain part of the forecast errors, then the differences between the Riksbank's inflation forecasts and those of other institutions should contain information about future interest rate changes. In the Inflation Report from June 2000 it is argued that this is indeed the case.

[10] Revisions of the official Swedish data on *monthly* CPI are prohibited by law. The annual consumer price change used by the Riksbank to guide its monetary policy is, however, not exactly identical to the annual change of the official CPI. The measures of annual inflation take account of the fact that the composition of the CPI changes over time. The index used by the Riksbank is, however, also published by Statistics Sweden.

[11] This can, for example, be seen in the large international database of Consensus Forecasts.

GDP growth have, on the other hand, become smaller over time. The RMSE was much larger for the forecasts of GDP growth of 1994 and 1995 than 1997 and 1998 (Table 2).

3. Simple rules for monetary policy

3.1 The case for simple rules

Central banks with explicit inflation targets (and some without) repeatedly stress that their interest rate policy has to be forward-looking and pre-emptive. One reason for this is that it is believed that the effects of changes in monetary policy (or at least some of the effects) occur with a considerable lag. But even if the central bank could already control inflation perfectly in the short run, policy might have to be forward-looking for other reasons. High ambitions to stabilise inflation in the short run would imply considerable volatility in short-term nominal interest rates, which presumably would be transmitted into high volatility in real variables such as GDP growth and unemployment (see eg Svensson (2000)). In practice, monetary policy is characterised by interest rate smoothing, which may reflect that central banks, in addition to price stability, are concerned with financial stability, or real stability, or both.

It is quite common for central banks with an explicit inflation target also to indicate that they aim to close the gap between the inflation target and the inflation forecast at a certain forecast horizon, typically around two years. This principle, or rule of thumb, can be interpreted in two different ways. The inflation forecast two years ahead may be an *optimal intermediate target* for monetary policy if it takes two years before a change in the interest rate can have any significant effect on inflation. This is the case in Svensson's (1999) model of an inflation targeting central bank. Alternatively, one may view a rule-of-thumb relation between the interest rate and the inflation forecast as a *simple rule* that the central bank has to follow (in order to be transparent and accountable, for instance). The central bank's problem is then to find what the forecast horizon of such a suboptimal rule should be, given its preferences for inflation stabilisation (and possibly other objectives). Such models of inflation targeting have been analysed by eg Amato and Laubach (1999), Batini and Haldane (1999), Batini and Nelson (1999) and Leitemo (1999). Numerical examples suggest that neither very short nor very long forecast horizons are desirable, but that the optimal horizon may very well be around two years.

Another guide to understanding the links between forecasts and monetary policy has been offered by Rudebusch and Svensson (1999). They compare different simple rules and calculate the "social loss" associated with them under different assumptions about the central bank's preferences for price, output and interest rate stability (given certain assumptions about crucial relations in the economy). Their analysis suggests that forward-looking Taylor-type rules (Taylor (1993)) of the following form are quite robust, in the sense that they perform relatively well under different objective functions:[12]

$$i_t^* = \alpha_0 + \alpha_1[E(\pi_{t+s,t+s-j}|I_t;\ i_{t-1}) - \pi^*] + \alpha_2 E(y_{t+h,t+h-i} - y^P_{t+h,t+h-i}|I_t;\ i_{t-1}) + \alpha_3 i_{t-1}, \quad (1)$$

where i_t^* denotes a benchmark level of the short-term interest rate that is the central bank's policy rate; $E(\pi_{t+s,t+s-j}|I_t;\ i_{t-1})$ is the forecast of inflation between $(t+s)$ and $(t+s-j)$, conditional on the information available at time *t* and on the assumption of an unchanged interest rate; and $E(y_{t+h,t+h-i} - y^P_{t+h,t+h-i}|I_t;\ i_{t-1})$ is the corresponding conditional forecast of the level of the "output gap" (ie the deviation between (log) actual and potential output) accumulated between periods $(t+h)$ and $(t+h-i)$. The parameter π^* is the central bank's (constant) inflation target. Note that information lags may imply that actual values in *t* and (conditionally) expected values at *t* are not the same. The information set I_t may thus not include all information on the outcome of all variables in period *t* and earlier.

[12] For a different view, see the paper by Levin et al (1999), where the practice of forecast-based rules is questioned.

We will use (1) as one benchmark interest rate rule for our analysis of Swedish monetary policy. This is justified not only by the results reported by Rudebusch and Svensson (1999), but also because rules of this type seem to be able to describe monetary policy in other countries where price stabilisation has been an important goal (cf Clarida et al (1998, 1999)).[13] We will use coefficients suggested by Rudebusch and Svensson (1999) to define a benchmark rule which we label the "RS rule".[14] There is, however, no self-evident first candidate for a simple rule and sensitivity analyses are of course needed. In particular, it may be interesting to compare the actual interest rate also with a rule that puts zero weight on the output gap, since the Riksbank has repeatedly stressed that its interest rate decisions are mainly based on an assessment of future inflation. Concerns for output stabilisation have not been expressed as often, although it has been explicitly declared that certain temporary deviations from the inflation target may be accepted if a more aggressive monetary policy would imply unacceptably large swings in interest rates and real economic activity; see eg Berg (1999), Heikensten and Vredin (1998) and Heikensten (1999). How much weight the Riksbank has put on output stabilisation in practice is thus an open question. We will therefore derive data-based estimates of the coefficients in (1) that capture the empirical relation between the Riksbank's forecasts and its policy rate. This version of (1) is labelled the "RB rule".

3.2 Defining the arguments in the simple rule

Irrespective of whether we want to define the coefficients of (1) on theoretical or empirical grounds, we first have to define the forecasting horizons *s* and *h* and the time spans of the forecasted inflation rate $(s-j)$ and output gap $(h-i)$. The time spans must be equal to one year, since the forecasts that we have access to cover only the annual frequency (and the inflation target is defined in terms of annual inflation). The maximum forecast horizon in Tables 1 and 2 is 12 quarters, so with *t* denoting quarters, $s \leq 12$ and $h \leq 12$. In the Inflation Reports, the Riksbank declares that the forecast horizon which governs monetary policy lies 12 to 24 months ahead, which suggests that $4 \leq s \leq 8$. In our applications, we have to use a time-varying forecast horizon, because forecasts are made quarterly but only for annual inflation rates. The inflation forecasts by the Riksbank which we feed into the benchmark rule are underlined in Table 1. The benchmark interest rate is thus calculated using only a subset of the available inflation forecasts. We do this partly to make our analysis easier to perform and explain, but also because a simple rule with a forecast horizon of about six to eight quarters seems reasonable in view of actual statements made by central bankers.[15]

The choice of the value of *h* is more difficult, but given the standard view on the transmission mechanism of monetary policy it seems reasonable that $h < s$. We have chosen to base our benchmark rules on the current output gap.[16] It still has to be forecasted, however, since neither the level of potential GDP nor that of current GDP can be observed within the current quarter. The former is unobservable and the latter is reported with a considerable lag. Another problem is that we do not have access to forecasts of the output gap, but only of the growth rates of GDP. Taking the first difference of (1), we obtain:

$$\Delta i_t^* = \alpha_1 \Delta_t E(\pi_{t+s,t+s-j} | I_t;\ i_{t-1}) + \alpha_2 \Delta_t E(y_{t+h,t+h-i} - y^P_{t+h,t+h-i} | I_t;\ i_{t-1}) + \alpha_3 \Delta i_{t-1}, \quad (2)$$

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[13] It may be argued that an "optimal" reaction function for a central bank in an open economy should include more arguments than (1), eg exchange rate shocks (see eg Svensson (2000) and Walsh (1999)). On the other hand, one reason why central banks may want to stick to some simple rule is that the "optimal" rule is not feasible. In practice, rules like (1) can be supported by official policy statements and also seem to capture actual monetary policy quite well.

[14] Since (1) has been used and advocated by many researchers, it would perhaps have been more appropriate to use eg the label "FT rule" instead (forward-looking Taylor-type rule). To our knowledge, however, no one has presented such convincing normative arguments for (1) as Rudebusch and Svensson (1999). Furthermore, our choices of coefficient values and lag lengths have also been directly inspired by these authors.

[15] For discussions about problems that policymakers face in practice when trying to implement forecast-based inflation targeting, see eg Heikensten (1999) and Apel et al (1999). Certain problems discussed in those papers, eg whether the inflation target should be defined in terms of CPI inflation or some measure of "core" (or "underlying") inflation, are absolutely crucial for evaluations of monetary policy, but nevertheless beyond the scope of the present paper.

[16] The "top-performing" rules in Rudebusch and Svensson's (1999) analyses use $s = 8$ and $h = 0$.

where Δ_t means that first differences are taken with respect to subscript *t*. If we thus are willing to make assumptions about the forecasted growth of potential output and approximate the change in the forecast of (log) GDP with the forecast of the change in (log) GDP, then we can feed the forecasts of current GDP growth and of the change in the inflation forecast (between two successive forecast occasions) into (2) and calculate the *change* in the benchmark interest rate. The forecasts of GDP growth that we use are underlined in Table 2.

Furthermore, we do not have time-series observations of inflation and GDP growth forecasts made by the Riksbank each quarter, but only the forecasts made on the 21 occasions reported in Tables 1 and 2. This makes it hard to decide what measures of Δi_t^* and Δi_{t-1} we should use. Consider eg the forecasts of GDP growth 1998 and inflation 2000 made in May 1998. Should we use the simple rule to calculate what the benchmark interest rate change Δi_t^* should be between 4 June and 3 June 1998, since the Inflation Report was published on 4 June? Or should we look at the interest rate change between the May forecast and the immediately preceding forecast in February the same year, ie for the period between, say, mid-May 1998 and mid-February 1998? In the former case, the lagged interest rate change in rule (2) should (perhaps) be the change between 3 June and 2 June, whereas in the latter case the change between mid-February 1998 and mid-November 1997 may seem a natural measure of Δi_{t-1}. We have chosen to divide the time period that the sample spans into 21 shorter periods that together cover all interest rate changes made during the whole sample period. Each forecast round is thus assumed to be associated, via the simple rule, with interest rate changes made from the day halfway back to the previous forecast round and up until halfway towards the next forecast round. For instance, the forecasts from May 1998 are used to calculate a benchmark interest rate change between 1 April 1998 and 15 July 1998. The lagged interest rate change in this case is the change between 1 January 1998 and 30 March 1998.[17]

3.3 The RS rule

The first benchmark rule we will look at sets $\alpha_1 = 1.5$, $\alpha_2 = 0.5$ and $\alpha_3 = 0.6$. This is (almost) the best simple rule reported by Rudebusch and Svensson (1999) in their Table 3; in this case the central bank's loss function, which is used to define the optimal policy, puts equal weight on inflation and output stabilisation and the weight on interest rate smoothing is half as large.

In the calibration of the benchmark interest rate implied by the RS rule, the Riksbank's forecast of the potential growth of output has been set to 2.2% per year. We have no data on the assumptions about the potential growth of output that should be associated with the inflation and GDP forecasts in Table 1 and Table 2, and hence are forced to make a guess. We know that the potential growth of output has typically been assumed to lie in the interval 1.5-2.5%, and that the figure 2.2% has been used at least some of the time.

3.4 The RB rule

As noted in the introduction, the purpose of this paper is not to find the rule which best captures the Riksbank's actual policy in the period 1992-98. If, however, the RS rule is very far from the Riksbank's own desired rule, then the use of (2) as a benchmark rule would be quite meaningless. This has led us to investigate how well (2) empirically tracks the actual policy rate changes.

Using the data on inflation and GDP growth forecasts underlined in Tables 1 and 2 respectively and the definition of Δi discussed above, we get the following ordinary least-squares regression:

$$\Delta \hat{i}_t = \underset{(0.29)}{0.81}\,\Delta_t E(\pi_{t+s,t+s-j}|I_t;\ i_{t-1}) + \underset{(0.14)}{0.05}\,\Delta_t E(y_{t+h,t+h-i}|I_t;\ i_{t-1}) + \underset{(0.21)}{0.62}\,\Delta i_{t-1} - \underset{(0.35)}{0.09},$$
$$R^2 = 0.65, \qquad \sigma = 0.53, \tag{3}$$

[17] Alternatively, we could have calculated a benchmark interest rate change for each day, month or quarter, by assuming that the forecasts which enter the simple rule are the most recent forecasts. This is something we recommend for future work.

wherei the numbers within parentheses are standard errors, R^2 is the multiple coefficient of determination and σ is the standard error of regression.

The residual diagnostics indicate that the error terms are close to white noise.[18] Hence, the arguments on the right-hand side of (3) seem on average to have good explanatory power for the systematic changes in the policy rate over the sample period.

Some features of (3) are especially noteworthy. First, the coefficient on GDP growth is not significantly different from zero. When we compare the residuals from (3) with the "policy shocks" implied by the theoretical RS rule (rule (2) using the coefficient values given in Section 3.3) we see that the theoretical rule produces particularly large shocks for the first two observations in our sample (see Section 4 below). One may of course argue that the Riksbank's policy may have changed during the sample period, eg because a particularly contractionary policy was needed in the beginning of the new regime to establish credibility for the inflation target. The full-sample estimates are compared with various subsample estimates in Table 4. We have deleted observations both from the beginning of the sample and from the end. All results (even (3)) must of course be interpreted with great care, because of the limited number of observations that are available to us (at most 18). There are no significant differences between the coefficient estimates from any of the subsamples and those reported from the analysis of the full sample. Still, it can be noted that the point estimates of the coefficient on the output gap increase steadily as more and more observations from the beginning of the sample are deleted. It may be tempting to conclude that the Riksbank was a more "strict" inflation targeter in the beginning of the new regime and has become more "flexible" over the years; but the statistical evidence from this small sample only provides weak support for this hypothesis.

Another interesting result is that the point estimates of the intercept are roughly consistent with the argument that the constant in (3) approximates $-\alpha_2 \Delta y^P$ with $\Delta y^P = 2.2$, as assumed in Section 3.3.[19] For instance, for the full sample with an estimate of $\alpha_2 = 0.05$ and an assumption of $\Delta y^P = 2.2$ the implied value of the constant is –0.11, while the empirical estimate is –0.09. For the sample using observations 9-19, the estimate of α_2 is 0.49 and the implied value of the constant is –1.08, while the empirical estimate is -1.16. If the true coefficient for the output gap in the Riksbank's policy rule is zero, then the constant in (3) should also be zero. The estimates are indeed not significantly different from zero.

These empirical results strengthen our belief that forward-looking Taylor-type rules serve as a useful benchmark for a study of Swedish monetary policy. The particular form (2), in combination with the coefficient values given in Section 3.3 (the RS rule), can be questioned, however. A rule which restricts the coefficient on GDP growth to zero seems to be at least as relevant a benchmark (in view of the Riksbank's own statements about its reaction function combined with the evidence from (3)). Estimating (2) upon restricting the reaction coefficient on the output component to zero gives:[20]

$$\begin{aligned} \Delta\hat{i}_t &= \underset{(0.28)}{0.81}\,\Delta_t E(\pi_{t+s,t+s-j} | I_t;\ i_{t-1}) + \underset{(0.14)}{0.67}\,\Delta i_{t-1} + \underset{(0.14)}{0.02}, \\ R^2 &= 0.65, \qquad \sigma = 0.51. \end{aligned} \tag{4}$$

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[18] $F_{AR}(2,\ 12) = 5.3 \quad (0.02)$, $\chi^2_{NORM}(2) = 3.1 \quad (0.21)$, $F_{ARCH}(1,\ 12) = 0.2 \quad (0.67)$, $F_H(6,\ 7) = 0.6 \quad (0.74)$, $F_{HC}(9,\ 4) = 0.4 \quad (0.90)$. F_{AR} is an *F* test against serial correlation of order two; χ^2_{NORM} is a normality test; F_{ARCH} tests for conditional heteroscedasticity of order one; F_H and F_{HC} are *F* tests for heteroscedasticity with and without regressor-cross products respectively (see Doornik and Hendry (1997) for further details). Numbers within parentheses are *p* values.

[19] This argument is based on the assumption that α_0 in (1) is indeed constant. It has been argued that it should vary with eg changes in the equilibrium real interest rate (see Hall (2000)).

[20] The residual diagnostics are similar to those obtained using the unconstrained specification and are for expository convenience not reproduced here.

In the next section we will use this empirical rule, which we label the RB rule, as another benchmark, besides the theoretical RS rule which is based on coefficient values adapted from Rudebusch and Svensson (1999).[21]

4. "Policy shocks"

The differences between the actual change in the interest rate and the change predicted by the simple benchmark rules - the theoretical RS rule (rule (2) using the coefficient values from Section 3.3) and the empirical RB rule (4) - may be interpreted as different measures of "policy shocks" created by discretionary deviations from the rules. Formally, let $\Delta i_t^* | (s, f)$ be the policy rate change computed conditional on rule *s* and forecasts *f*. The "policy shocks" then are $\Delta i_t - \Delta i_t^* | (s_{RB}, f_{RB})$ and $\Delta i_t - \Delta i_t^* | (s_{RS}, f_{RB})$ for the RB and RS rule respectively. Here, s_{RB} and s_{RS} denote the RB and RS rules respectively and f_{RB} the Riksbank's forecasts of inflation and output growth.

The actual policy rate is compared with the rates implied by the benchmark rules in Figure 4. The difference between the thick solid line (the actual rate) and the dotted line is the "policy shock" compared with the RS rule, while the difference between the thick and thin solid lines is the "policy shock" using the RB rule as the benchmark. In order to understand this figure, it is useful to consider eg the increase in the interest rate between 15 June and 30 November 1995 (ie the increase in the interest rate which we associate with the forecasts made in October 1995). During this period the policy rate was raised by 0.25 percentage points, from 8.66% to 8.91%. Had the Riksbank followed its own simple RB rule (4) exactly, it would have raised the interest rate by 8 basis points more, to 8.99%. If the Riksbank had instead followed the theoretical RS rule then it would have raised the interest rate by another 16 basis points, to 9.15%. In this case there thus seems to have been a negative "policy shock" to the interest rate, irrespective of our choice of benchmark rule.

The deviations between the actual interest rate and the benchmark rates, in most cases (all except two), have the same sign for both benchmark rules. The deviations from the estimated RB rule are of course, on average, smaller than the deviations from the theoretical RS rule. The differences between the two estimates of "policy shocks" are nevertheless surprisingly small, in view of the fact that the RS rule has been defined without any reference to how monetary policy in Sweden has actually been conducted. As noted already in Section 3 above, the differences between the RS and RB rules are larger at the beginning of the sample than towards the end.

Another interesting result is that although the RS rule often suggests a change in the policy rate in the same direction as the actual change, it implies a more aggressive policy than the one actually followed. The Riksbank has thus chosen a smoother path for the policy rate than it would have chosen had it followed the theoretical RS rule. There are, however, some exceptions to this pattern, in particular the decreases of the policy rate during the first half of 1996; here the Riksbank lowered the interest rate by more than the simple RS rule implies.

An interesting topic for future work is to look at the "policy shocks" more carefully, to see if they can be systematically related to other macro variables, or if they can be understood through the official explanations of policy given in eg the Riksbank's Inflation Reports.[22]

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[21] As noted above, there may be reasons to also restrict the constant in the RB rule (4) to zero. However, because the coefficient estimate is very close to zero this restriction is of no empirical importance.

[22] This would thus follow Romer and Romer's (1989) and Leeper's (1997) analyses of monetary policy in the United States.

5. Alternative forecasts and the Riksbank's "judgments"

There are several reasons why the forecasts published by central banks may differ from those made by other analysts or derived directly from models. One reason is that it cannot be ruled out, of course, that there is an element of policymaking involved also in the construction of the forecasts (as opposed to reacting differently to *given* forecasts). Another is that a central bank may hold the view that it has an "informational advantage" (over both other analysts and models), eg in its understanding of the effects of monetary policy. Relative to purely model-based forecasts, it may also be the case that professional forecasters believe that they can do better by making use of special information that is difficult to incorporate in standard macro forecasting models, eg high-frequency information from survey data or financial markets.

In order to shed light on the nature of judgments made at the forecasting stage, we will now compare the Riksbank's forecasts with two alternative sets of forecasts on which the bank could very well have chosen to base policy. One set is derived from a VAR model (the purely model-based alternative), the other simply consists of averages (medians) of other Swedish institutions' forecasts. Below, we start out by briefly describing the VAR model. We then turn to some practical problems that need to be addressed when undertaking and interpreting ex post forecasting. After having compared the various forecasts using standard measures of forecasting accuracy, we feed them into the benchmark rules and translate the differences in forecasts into differences in policy rate changes. These are our two measures of the Riksbank's "judgments".

5.1 Constructions of alternative forecasts

The VAR model that we consider is a version of the open economy quarterly VAR proposed by Jacobson et al (2000).[23] The model is a seven-variable VAR with four lags. The endogenous variables are: the Swedish CPI; Swedish real GDP; the short-term (three-month) nominal Treasury bill rates for Sweden and Germany; a foreign CPI; foreign real GDP; and a nominal effective exchange rate. To handle various deterministic breaks and regime shifts in Sweden and foreign countries, the model is augmented by a set of dummy variables.

We do not believe that this VAR framework necessarily constitutes the best possible forecasting tool for Swedish inflation and GDP growth.[24] Rather, we wish to derive some model forecasts of inflation and GDP growth that the Riksbank could very well have made, as alternatives to the actual judgmental forecasts. Our ambition has been to identify some simple empirical model with reasonable statistical properties that contains approximately the sort of information that policymakers and other analysts use when discussing monetary policy. The evaluation of the statistical properties of the VAR model undertaken by Jacobson et al (2000) shows that the model fulfils the criterion of being reasonably specified from a statistical point of view (see Tables 1 and 3 in their paper).

The specification of the VAR model implies that the real exchange rate and the short-term interest rate differential are stationary (I(0)). In addition, the foreign variables are not driven by three independent trends but share common trends and thus are cointegrated.

There are some important practical problems involved in ex post forecasting. A first problem is related to the input data that are used when deriving the forecasts. It is well known that published data on many macro variables are frequently revised and that the "final observation" on a particular series is often only available after a considerable lag, which may sometimes be several years. This means that the real-time forecasts of the Riksbank are sometimes not conditioned on the observations on macro variables available today but rather on preliminary figures that were later revised. A completely realistic real-time scenario would hence require the use of (some) macro series that are revised over time. While this is possible in principle, if one is willing to carefully reconstruct all revisions that were undertaken and recursively update the database that is used in the econometric analysis, the revisions

[23] A detailed description of the data is given in Jacobson et al (2000). Estimations are undertaken using PcFIML version 9.0. The full sample length of our updated data set is 1970:1-1998:4.

[24] It seems that the forecasting performance of VARs may be improved by imposing Bayesian prior restrictions on estimated parameters; see Robertson and Tallman (1999) for a recent review and Villani (1999) for an analysis of the VAR model that we explore.

in the case of Swedish data do not appear to be of such a magnitude that such a cumbersome approach is warranted (at least not as concerns the revisions undertaken during the sample period that we consider). Our analyses will thus be based on the most current observations on the variables that are available.[25]

While data revisions in our case do not seem to be quantitatively important, there is still the problem that data on many macro variables are available only after a considerable time lag. This publication lag implies that a forecast of a certain variable made at, say, time *t*, may not be based on information up to and including *t* but rather on $(t-k)$. The problem becomes particularly ticklish since for our VAR model the value of *k* is not the same for all variables. In particular, for interest rates and exchange rates the publication lag is zero, for consumer prices it is almost zero, whereas quarterly GDP is published with a lag of approximately two quarters. The approach that has been chosen here - and which is summarised in Table 5 - is to make the simplifying assumption that inflation forecasts from the VAR model always make use of more recent information on all variables than the GDP growth forecasts from the same model. The model-based forecasts of inflation have an informational advantage over the Riksbank's inflation forecasts in that they use more information than was actually available in real time. In the case of forecasts of the growth rate of GDP, the opposite holds true.

A third issue that deserves comment concerns the updating of the parameters in the cointegration space. The cointegration matrix depends on two estimated parameters (in the normalised cointegration relation between the foreign variables). The updating (re-estimation) procedure that we have chosen implies that these parameters are recursively re-estimated with an interval lag of approximately four forecasts (see Table 5). Looking at the details of the estimations (not shown to save space) it can be seen that the estimates of the parameters in the cointegration space only vary very little over time.[26] This indicates that the exact design of the updating procedure for the cointegration space is probably not very important, but we still believe that our recursive interval-lag procedure is rather reasonable as a description of a situation forecasters would face in practice.

The issue of the real-time use of the deterministic dummy variables is presumably more important. The problem concerns one particular dummy variable that represents the introduction of the floating exchange rate, inflation targeting regime in Sweden in 1992:4. This dummy variable deserves special mention because its dating implies that it will become effective *during* the forecasting sample period. The procedure adopted in our exercises assumes that the hypothetical real-time model forecaster would immediately have interpreted the float of the Swedish krona in the fourth quarter of 1992 as a permanent "exogenous" policy regime shift to his VAR model.

The medians of forecasts by other analysts are computed as follows: for each month in which the Riksbank has produced new forecasts, the medians of the latest available forecasts (including forecasts made that same month) from nine other Swedish institutions have been calculated. The institutions that are included are: the Ministry of Finance; the Wholesale & Retail Research Institute (Handelns Utredningsinstitut); the National Institute of Economic Research (Konjunkturinstitutet); the Federation of County Councils (Landstingsförbundet); the Trade Union Confederation (Landsorganisationen, LO); Handelsbanken; Nordbanken; SE-banken; and Sparbanken (the latter four are commercial banks).

5.2 Comparisons of the different forecasts

In Figures 5 and 6 Sveriges Riksbank's forecasts (RB) are depicted along with the forecasts from the VAR model, the medians of the other institutions' forecasts and actual outcomes.[27,28] In addition, the

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[25] During the summer of 1999 Statistics Sweden undertook a more fundamental revision of the Swedish national accounts system (the new system is called SNA93/ESA95). Since the forecasts from the Riksbank used in this paper are all conditional on the data available before this revision, our calculations and analyses throughout are based on data according to the earlier system of national accounts (called SNA68).

[26] Details of these results are available from the authors upon request.

[27] Details on how the alternative forecasts have been constructed are available from the authors upon request.

[28] Note that the dates on the horizontal axes in Figures 5 and 6 refer to the year for which the forecasts have been made. For instance, the three data points for the Riksbank inflation forecast for 1998 (the dotted (RB) line) show the three "two-years-ahead" forecasts of inflation 1998 made in June 1996-February 1997.

bottom lines of Table 3 summarise the overall forecasting accuracy of the different forecasts using RMSEs.

Looking first at the forecasts of inflation (Figure 5) it can be seen that all two-years-ahead forecasts persistently overpredict inflation over the four years of the sample period. The Riksbank's forecasts are quite close to the medians of the forecasts from other institutions and, accordingly, their RMSEs are also similar. The forecasts from the VAR model are not very different either, if we look at forecasts for 1996 (ie forecasts made in October 1994) and onwards. The initial forecasts from the VAR model display very large differences to the other two sets of forecasts, however. The VAR model first (December 1992) severely underestimates inflation two years ahead, then overestimates it by an even larger margin. Indeed, if one excludes the first two forecasts for 1994, then the RMSE for the VAR forecasts decreases to approximately 2.01 whereas the RMSE for the Riksbank's forecasts increases to 2.02 (the corresponding numbers if one also excludes the forecasts for 1995 are 2.11 and 2.41 respectively). The VAR forecasts thus appear to have a quicker "error correction mechanism" than the Riksbank's forecasts, but perform very badly in the beginning of the sample period.

The forecasts of GDP growth are displayed in Figure 6. In contrast to the inflation forecasts, there is no clear bias tendency for these forecasts. In general, the prediction errors are much smaller than for the inflation forecasts, which may be related to the fact that we look at current-year forecasts as opposed to two-years-ahead forecasts in the case of inflation. From Table 3, it can again be seen that the VAR model overall performs worse than the Riksbank's forecasts and that the performance of the other institutions' forecasts is similar.

In conclusion, the judgmental forecasts made by the Riksbank (possibly with the aid of forecasting models) have been rather successful compared with forecasts generated by the VAR model. Although there have been systematic overpredictions of inflation by the Riksbank, the forecasts are very close to the medians of other institutions' forecasts. More interestingly, the forecast errors could have been even larger if VAR models had been used, at least in the early period after the shift to the inflation targeting regime. The performance of the VAR model, however, improves over time, and in some cases even becomes better than the judgmental forecasts towards the end of the sample period. These results are perhaps not so surprising. In 1993 and 1994 the inflation targeting regime was still quite young and thus backward-looking model-based forecasts (like VAR forecasts) tended to be too heavily influenced by the previously higher average inflation rate. Policymakers and other forecasters therefore had reasons to use their own judgments to adjust the models' forecasts. Recently, however, it seems as if model-based forecasts have adjusted more rapidly to the large decline in inflation while the judgments have had a larger bias towards higher inflation.[29] One lesson from this is perhaps that model-based forecasts can be expected to be less biased than judgmental forecasts in stable (or at least less unstable) environments, while judgments should be particularly useful after regime shifts.[30]

5.3 The effects of "judgments" on the interest rate

Equipped with a set of alternative (real-time) forecasts we are able to estimate the effects of the Riksbank's "judgments" on its interest rate policy. We do this by feeding the three sets of forecasts - the Riksbank's, the other institutions' and the VAR model's - into the RB rule used in Sections 3 and 4. Algebraically, we compute $\Delta i_t^* \left| (s_{RB}, f_{RB}) - \Delta i_t^* \right| (s_{RB}, f_{ALT})$, where f_{ALT} is either the VAR forecast or the median forecast from other analysts of inflation and output growth. The different pictures of the effects of "judgments" that we get by plotting these quantities are presented in Figure 7.

The estimates of the effects of "judgments" differ both in size and sign depending on whether we choose to contrast the Riksbank's forecasts with model-based (VAR) forecasts or the medians of other

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[29] It must of course be remembered that our model forecasts are conditioned on a regime-shift dummy in 1992:4. Furthermore, there are more general reasons for interpreting the comparisons between the Riksbank's forecasts and the alternative forecasts with care. As emphasised previously, the Riksbank's forecasts are intended to be conditioned on the assumption of an unchanged interest rate. But, as also noted above (see Section 2), this difference may not be quantitatively important in practice.

[30] We have experimented with alternative specifications of the VAR model and also made comparisons with a simple random-walk model. These models have typically produced larger forecast errors (and larger estimates of the influence of "judgments") than the VAR model presented here.

institutions' forecasts. Even abstracting from the first two observations in our sample - when the VAR model produced extreme forecasts - the estimates of the Riksbank's "judgments" are much larger if the VAR model is used as a norm than if we make the comparisons with other institutions' forecasts. The differences between the Riksbank's forecasts and the medians of other institutions' seldom correspond to interest rate effects larger than 0.5 percentage points. Compared to the VAR model's forecasts, however, the effects of the Riksbank's judgmental forecasts are more often close to, and sometimes even larger than, 1 percentage point.

It is likely that the use of the medians of other institutions' forecasts involves an underestimation of the effects of "judgments" in forecasting, since individual institutions' forecasts presumably deviate more from the Riksbank's forecasts than the medians. It is less obvious that the comparison with the VAR model involves an overestimation of the Riksbank's "judgments". As noted above, the VAR model's forecasts are quite close to the Riksbank's, except during the early part of the sample, and both sets of forecasts involve systematic overestimations of inflation two years ahead. It is conceivable that a VAR model with better forecasting properties could have been constructed. If so, our estimates of the Riksbank's "judgments" could very well have been larger.

Comparing Figures 4 and 7, our results suggest that the *quantitative* effects of "judgments" may be at least as important as the effects of "policy shocks".[31] There does not, however, appear to be any systematic relation between the ***signs*** of the effects of "policy shocks" and "judgments".[32] Sometimes these different aspects of policymaking seem to affect the interest rate in the same direction, but just as often their effects seem to go in opposite directions.

6. Conclusions

We have found that, for the first six years of the floating exchange rate, inflation targeting regime, it is possible to describe Swedish monetary policy quite well by a forward-looking Taylor-type rule. According to the estimated "RB rule" there has been a significant response by the Riksbank to its own inflation forecasts. On the other hand, interest rate policy does not seem to have been significantly affected by the Riksbank's forecasts of GDP growth (at least not on average). Nevertheless, the size of the deviations from the theoretical "RS rule", suggested by Rudebusch and Svensson (1999), which puts some weight on the output gap, does not seem particularly large either. It is also noteworthy that the signs of the estimated "policy shocks" are the same, irrespective of whether we use the RB rule or the RS rule as a benchmark, and that the size of the "policy shocks" has decreased over time.[33] Actual policy has been characterised by a somewhat more gradual adjustment of the interest rate than the RS rule prescribes, but there does not seem to have been any positive or negative bias; in most cases the policy rate has been changed in the direction suggested by the RS rule.

The deviations between the Riksbank's forecasts and the medians of other institutions' forecasts have been relatively small, which suggests that the Riksbank's judgmental adjustments of its forecasts have not been larger than those of other institutions. An alternative (or perhaps equivalent) interpretation of this result is that the Riksbank has (had) no large "informational (dis)advantage" compared to other professional forecasters. However, the difference between the Riksbank's forecasts and the forecasts of a VAR model are occasionally quite large. In the beginning of the sample period, immediately after the regime shift in monetary policy, the VAR model severely overestimated inflation. The Riksbank's judgmental forecasts presumably took more account of the effects of the regime shift, which led to smaller forecast errors. Towards the end of the sample period, however, the Riksbank's forecasts were "more conservative" than the VAR forecasts and were associated with somewhat larger errors.

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[31] A comparison based on the RS rule reinforces this result. In this case, "judgments" are quite considerably larger than "policy shocks". The results are available upon request.

[32] The sample correlations range between –0.31 and 0.15. A correlation larger than 0.46 or smaller than –0.46 is approximately significant at the 5% test level.

[33] "Policy shocks" have become smaller in terms of percentage points, but since the level of the interest rate has also decreased, they may have been quite stable in some relative sense. However, since it is the level of nominal interest rates and inflation in percentage points that plays an economic role (just as in the case of tax rates), it is the first feature that is important.

That there may sometimes be a rather sizeable judgmental element in the central bank forecasts suggests that it may not always be very easy to replicate (or even come close to) them using reasonable forecasting models and thus points to the need to supplement central bank forecasts with explanations concerning how the forecasts are derived. Inflation Reports or similar official policy documents appear to be natural forums for that purpose.

It would be interesting, at least in principle, to feed the estimated "policy shocks" and "judgments" into a macroeconomic model to investigate whether these interventions seem to have had positive (stabilising) effects or not. Of course, Lucas's critique of policy evaluations with econometric models forcefully spells out the problems associated with such an exercise. There are reasons to expect, however, that the estimated effects of "policy shocks" and "judgments" will be quite small. This is a common result in the literature on the effects of shocks to monetary policy more generally, partly because most models of the transmission mechanisms suggest that changes in nominal interest rates have rather little impact, but also because the typical interest rate "shocks" appear to be quite small.[34] It has been argued in connection with previous studies (see eg the discussion between Leeper (1997) and Romer and Romer (1997)) that many earlier estimates may have shown misleadingly large (or small) effects of monetary policy, because of difficulties in distinguishing between exogenous and endogenous interest rate movements. In this paper we have tried to handle such problems by making use of the Riksbank's own forecasts, ie by using information which the bank has claimed that policy really has been based upon (rather than eg ex post data on inflation and output). It should be worthwhile, therefore, to exploit this data on the central bank's information set further, eg by integrating our analysis with the approach suggested by Leeper and Zha (1999).

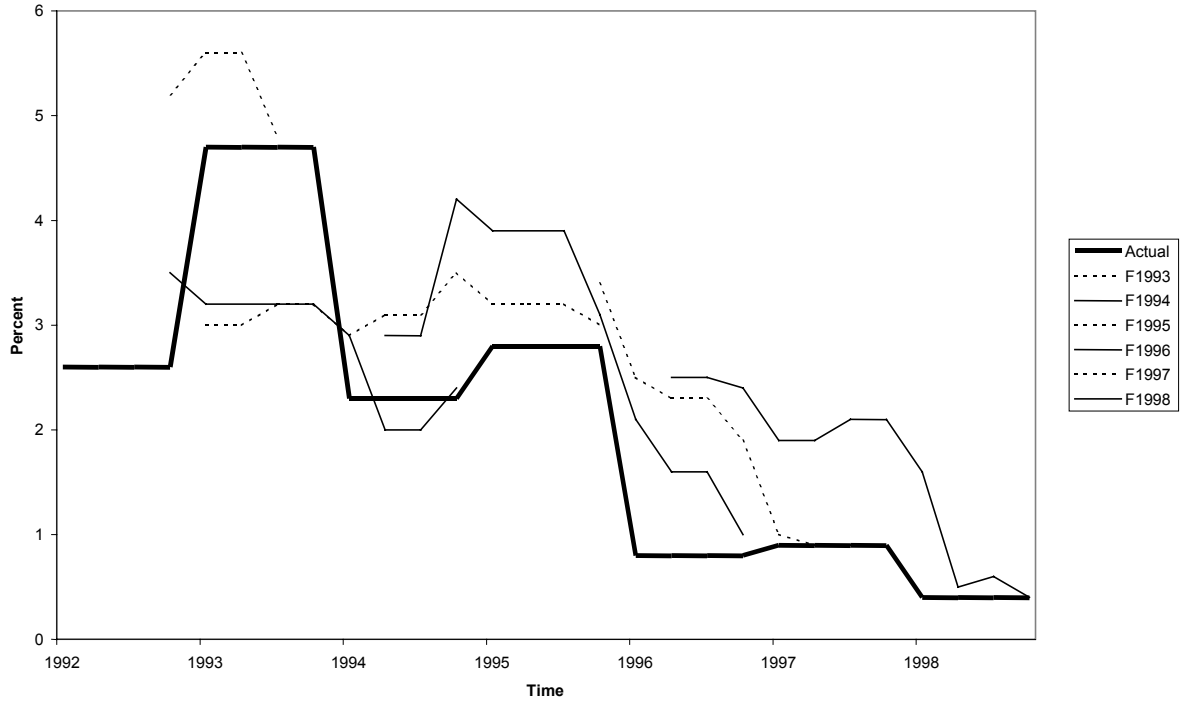
To our knowledge, our study constitutes the first comprehensive attempt to evaluate Swedish monetary policy during the inflation targeting regime. The use of the central bank's own forecasts distinguishes our study from eg studies of UK monetary policy by McCallum (2000) and Nelson (2000). Nevertheless, more work is obviously needed in this area. As suggested by Orphanides (1999), the use of real-time data on the output gap may affect the interpretation of monetary policy, so one interesting task for future research is to make an attempt to more carefully reproduce the Riksbank's estimates of actual and potential output (although we emphasise that this is difficult for reasons previously discussed; see Section 3).

A further extension is to compare our estimates of "policy shocks" and "judgments" with official explanations of monetary policy in the Inflation Reports and other policy documents. Is there a systematic pattern in the deviations from the simple policy rules and/or in the deviations between the Riksbank's forecasts and alternative forecasts? This would thus involve the same type of analyses as Romer and Romer (1989) and Leeper (1997) have applied to US data.

Ellingsen and Söderström (1998), inter alia, have pointed out that the market responses to changes in the central bank's instrument interest rate depend on whether the market interprets a change in the instrument as reflecting new information about eg future inflation, or as a sign of a change in policy. In principle, the data on the Riksbank's own forecasts used in this paper could also be used to separate "policy shocks" from "new information" (measured by eg changes in forecasts). One could then study how the yield curve responds to such innovations. As pointed out by Rudebusch (1998), among others, the yield curve and futures markets also contain information about the systematic and unexpected parts of monetary policy. There are thus several different ways to derive "policy shocks", and further work is needed to increase our understanding of the design and effects of monetary policy.

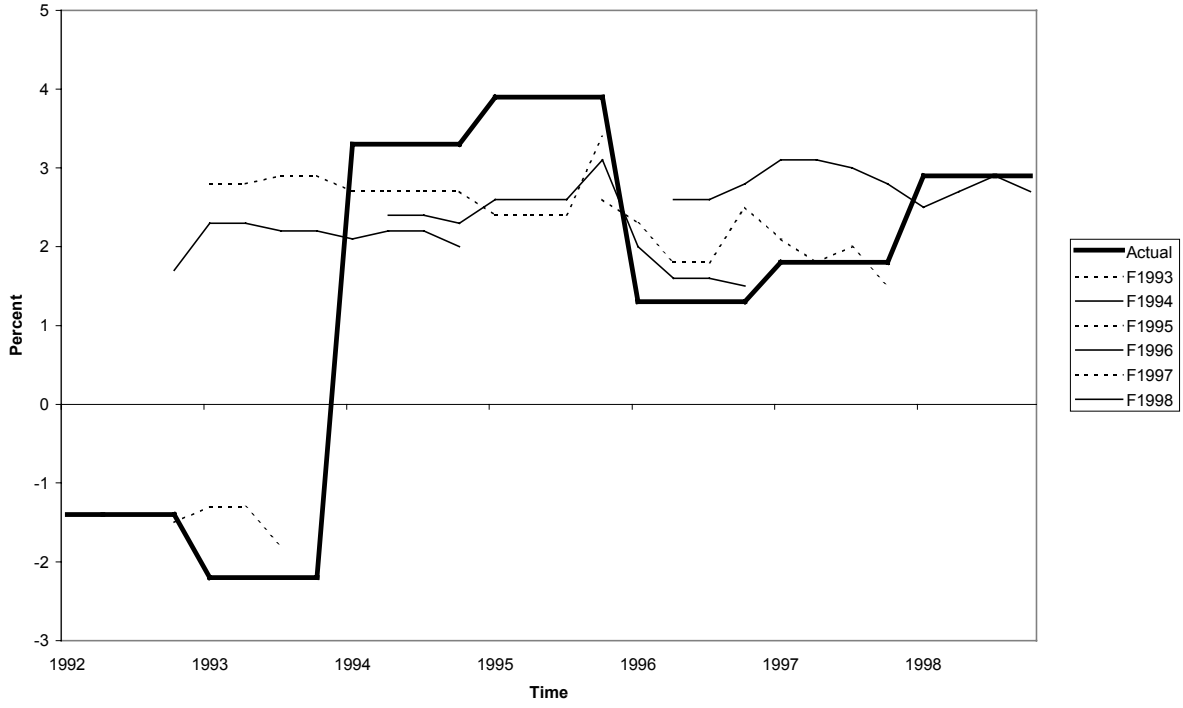
[34] We have added our "policy shocks" and "judgments" into a simple AS-AD model (used by the Riksbank for other purposes) and the results suggest that the effects on inflation and the output gap are indeed small.

Figure 1
Actual inflation and forecasts by Sveriges Riksbank



Note: Inflation is measured as average annual inflation. The series F199X show forecasts for the calendar year 199X available at the quarters indicated by the horizontal axis. Where no new forecast is available in a quarter, the most recent available forecast has been used.

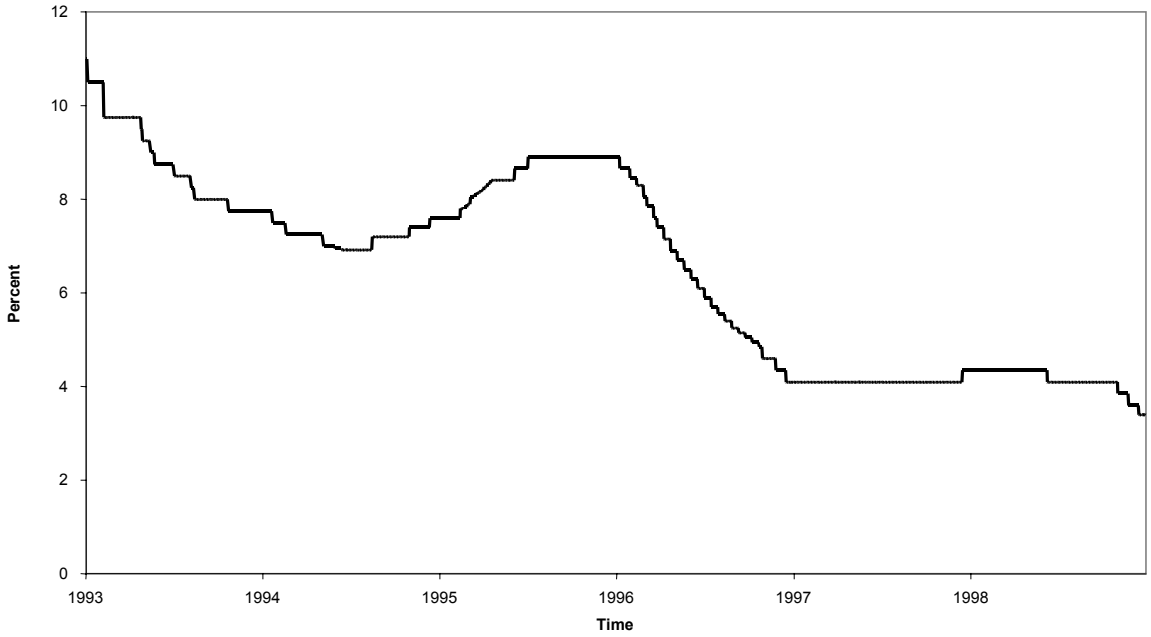
Figure 2
Actual real GDP growth and forecasts by Sveriges Riksbank



Note: GDP growth is measured at an annual rate. The series F199X show forecasts for the calendar year 199X available at the quarters indicated by the horizontal axis. Where no new forecast is available in a quarter, the most recent available forecast has been used.

Figure 3

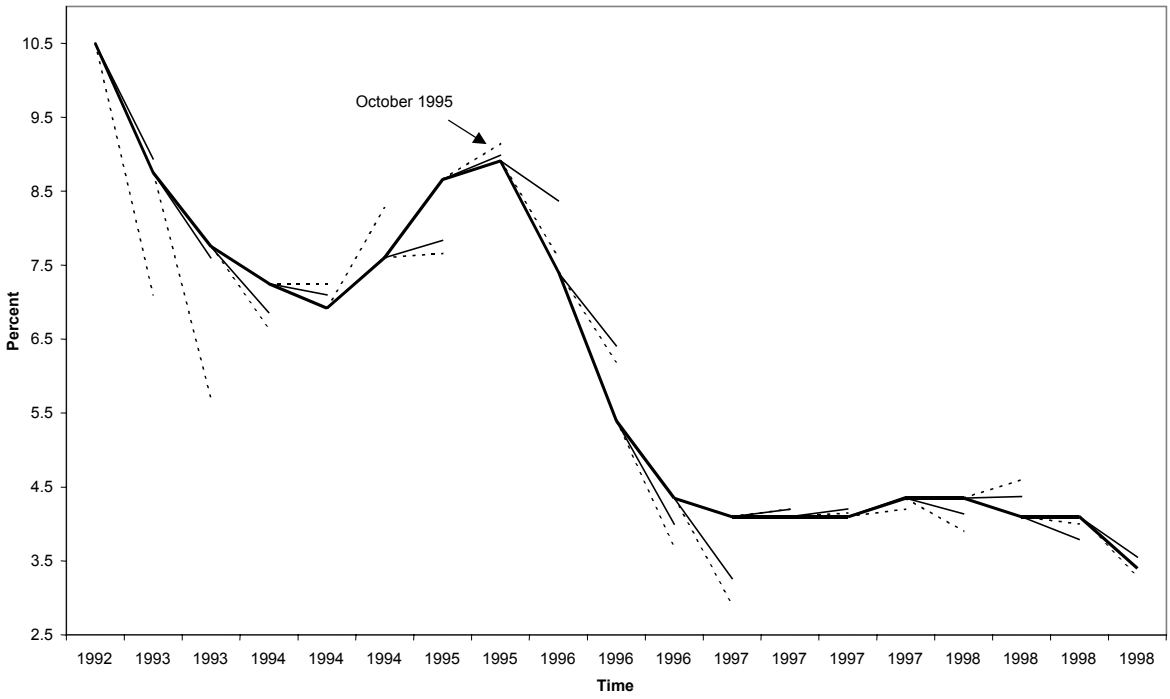
The Riksbank's policy (repo) rate



Note: The series shows the development of the repo rate on a daily basis.

Figure 4

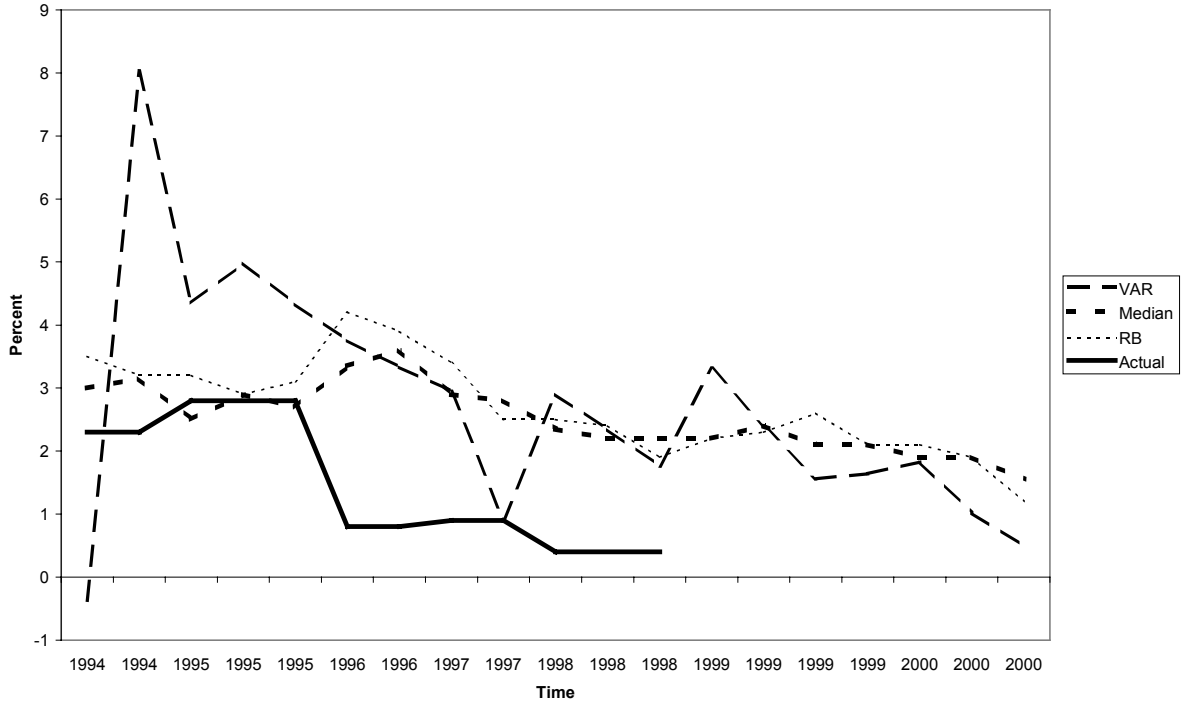
The actual policy rate and the Riksbank's "policy shocks"



Note: The thick solid line denotes the actual policy rate. The thin solid line denotes the changes of the policy rate that should have obtained had the rate been adjusted according to the RB rule using the Riksbank's forecasts. The dotted line denotes the changes of the policy rate that should have obtained had the rate been adjusted according to the RS rule using the Riksbank's forecasts. The horizontal axis has been "truncated" in order to correspond to symmetrically centred time points of the forecast dates (see the discussion in the text for further details).

Figure 5

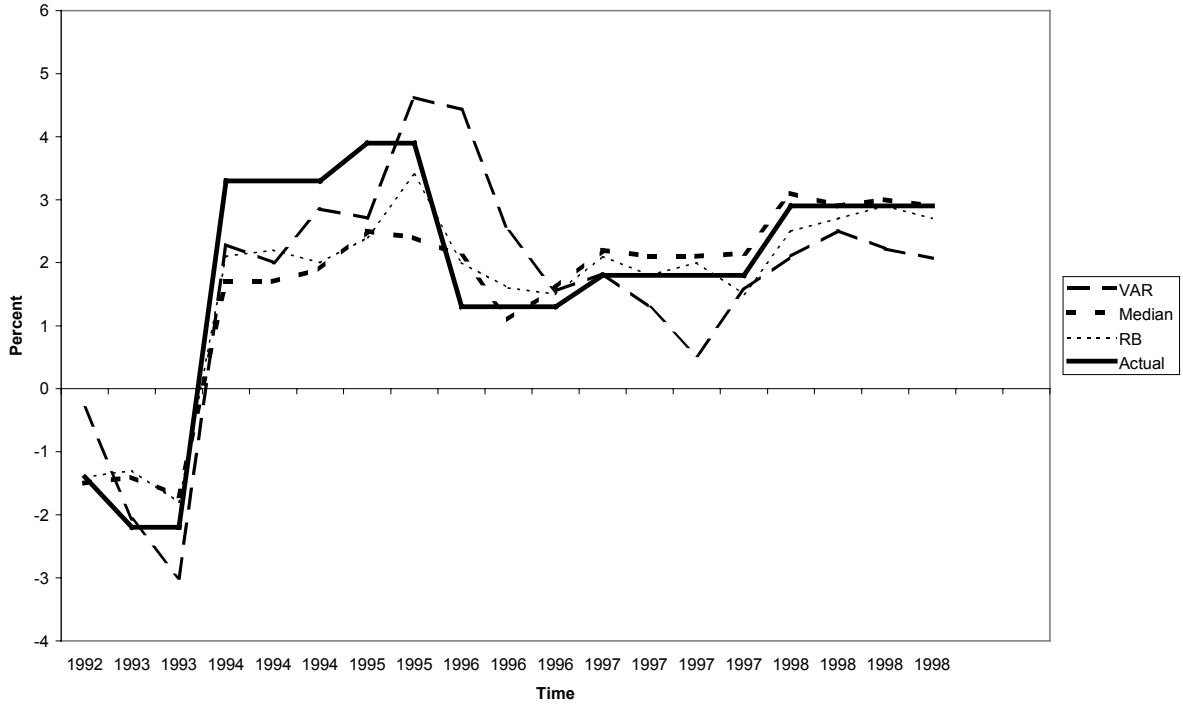
Actual inflation and two-years-ahead forecasts



Note: Inflation is measured as average annual inflation. VAR are the forecasts derived from a VAR model. Median are the median forecasts derived from a set of alternative analysts forecasts. For further details see the text. RB are the forecasts from Sveriges Riksbank. For each year on the horizontal axis the lines show the corresponding forecasts (made approximately two years previously) or actual value for that year.

Figure 6

Actual GDP growth and current-year forecasts

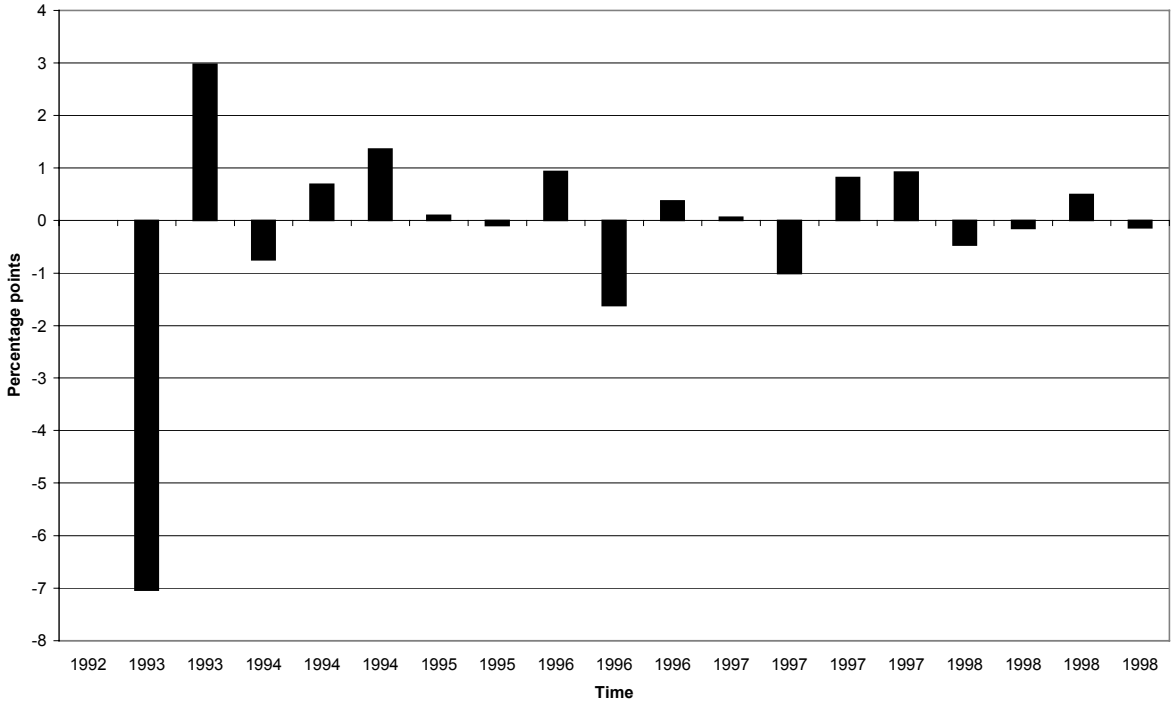


Note: GDP growth is measured at an annual rate. VAR are the forecasts derived from a VAR model. Median are the median forecasts derived from a set of alternative analysts forecasts. For further details see the text. RB are the forecasts from Sveriges Riksbank. For each year on the horizontal axis the lines show the corresponding forecasts (made within the current year) or actual value for that year.

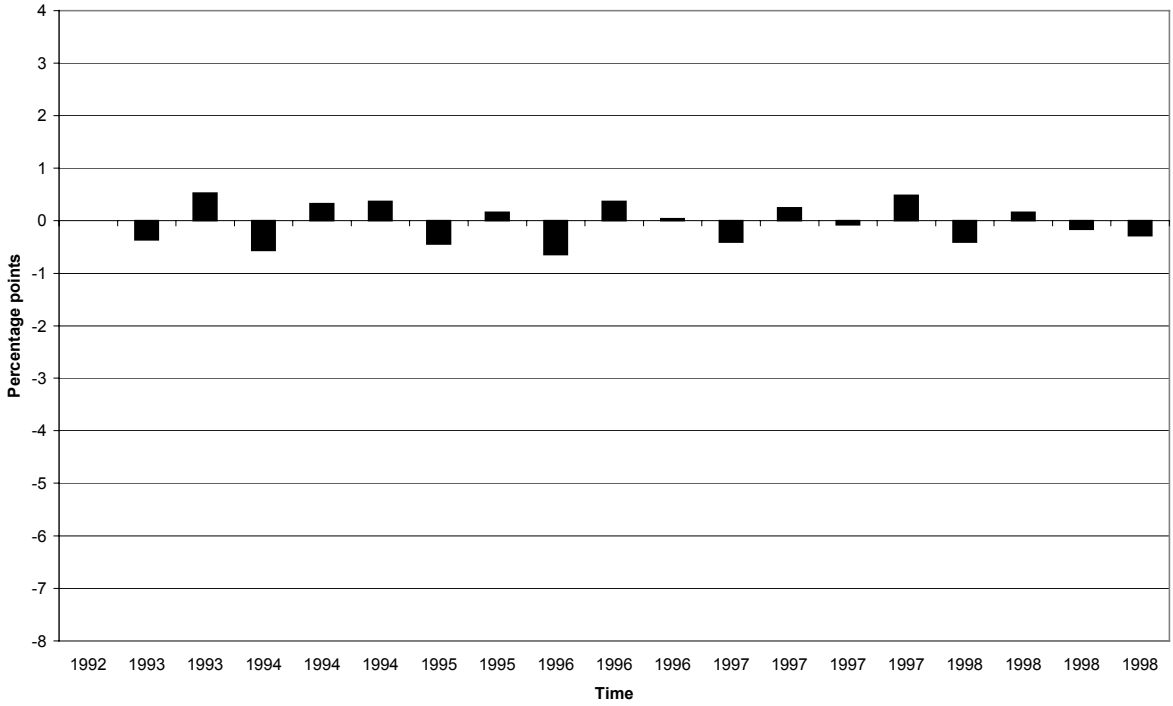
Figure 7

The Riksbank's "judgments"

Comparison with VAR forecasts



Comparison with forecasts from other analysts (medians)



Note: The bars represent the differences between the changes in the policy rate that should have obtained had the rate been adjusted according to the RB rule using the Riksbank's forecasts and the alternative forecasts (VAR, median of other analysts' forecasts) respectively.

Table 1

Actual inflation and forecasts by Sveriges Riksbank

	Forecast for year									
Forecast derived at time	**1992**	**1993**	**1994**	**1995**	**1996**	**1997**	**1998**	**1999**	**2000**	**2001**
1992: Dec		5.2	***3.5***							
1993: Mar		5.6	***3.2***	3.0						
1993: Aug		4.8	3.2	***3.2***						
1994: Jan			2.9	***2.9***						
1994: Apr			2.0	***3.1***	2.9					
1994: Oct			2.4	3.5	***4.2***					
1995: Feb				3.2	***3.9***					
1995: Oct				3.0	3.1	***3.4***				
1996: Jan					2.1	***2.5***				
1996: Jun					1.6	2.3	***2.5***			
1996: Oct					1.0	1.9	***2.4***			
1997: Feb						1.0	***1.9***			
1997: Jun						0.9	1.9	***2.2***		
1997: Aug						0.9	2.1	***2.3***		
1997: Nov						0.9	2.1	***2.6***		
1998: Feb							1.6	***2.1***	2.0	
1998: May							0.5	0.9	***2.1***	
1998: Sep							0.6	0.8	***1.9***	
1998: Nov							0.4	0.6	***1.2***	
1999: Mar								0.3	***1.0***	
1999: May								0.2	1.0	***1.6***
Actual		4.7	2.3	2.8	0.8	0.9	0.4			
RMSE		0.6	0.77	0.38	2.18	1.21	1.42			
Variance		0.16	0.32	0.04	1.39	0.83	0.64			

Note: The forecasts used in the RS and RB rules are bold and italic. RMSE is the root mean-squared error. Variance is the centred sample variance of the forecasts.

Table 2

Actual real GDP growth and forecasts by Sveriges Riksbank

	Forecast for year									
Forecast derived at time	**1992**	**1993**	**1994**	**1995**	**1996**	**1997**	**1998**	**1999**	**2000**	**2001**
1992: Dec	***–1.4***	1.5	1.7							
1993: Mar		***–1.3***	2.3	2.8						
1993: Aug		***–1.8***	2.2	2.9						
1994: Jan			***2.1***	2.7						
1994: Apr			***2.2***	2.7	2.4					
1994: Oct			***2.0***	2.7	2.3					
1995: Feb				***2.4***	2.6					
1995: Oct				***3.4***	3.1	2.6				
1996: Jan					***2.0***	2.3				
1996: Jun					***1.6***	1.8	2.6			
1996: Oct					***1.5***	2.5	2.8			
1997: Feb						***2.1***	3.1			
1997: Jun						***1.8***	3.1	3.6		
1997: Aug						***2.0***	3.0	3.4		
1997: Nov						***1.5***	2.8	3.2		
1998: Feb							***2.5***	2.9	3.0	
1998: May							***2.7***	3.0	2.9	
1998: Sep							***2.9***	2.8	2.6	
1998: Nov							***2.7***	2.1	2.3	
1999: Mar								***2.1***	2.5	
1999: May								***2.5***	3.0	3.0
Actual	–1.4	–2.2	3.3	3.9	1.3	1.8	2.9			
RMSE	0.0	0.70	1.23	1.14	1.05	0.45	0.21			
Variance		0.06	0.05	0.09	0.32	0.29	0.04			

Note: The forecasts used in the RS rule are bold and italic. RMSE is the root mean-squared error. Variance is the centred sample variance of the forecasts.

Table 3

Accuracy of forecasts

	RMSE		
Type of forecast	**Inflation**	**GDP growth**	**No of forecasts**
RB 0-steps ahead	0.17	0.59	6
RB 1-step ahead	0.13 (min)	0.26 (min)	3
RB 2-steps ahead	0.43	0.58	4
RB 3-steps ahead	0.86	0.93	6
RB 4-steps ahead	1.41	1.06	5
RB 5-steps ahead	1.36	0.78	2
RB 6-steps ahead	1.20	0.70	3
RB 7-steps ahead	1.75	0.94	5
RB 8-steps ahead	2.41 (max)	1.03	4
RB 9-steps ahead	0.40	1.00	1
RB 10-steps ahead	2.10	0.81	2
RB 11-steps ahead	0.20	1.10 (max)	1
RB	1.90	0.68	12 (π); 19 (Δy)
VAR	2.59	1.07	12 (π); 19 (Δy)
Median	1.67	0.84	12 (π); 19 (Δy)

Note: The X-step(s)-ahead forecasts are annual forecasts undertaken X quarter(s) in advance. 0-steps ahead means a forecast undertaken in the last three months of a year. VAR are the forecasts derived from a VAR model. Median are the median forecasts derived from a set of alternative analysts' forecasts. For further details see the text. RB are the forecasts from Sveriges Riksbank. Inflation forecasts RB, VAR, Median are two years ahead and GDP growth forecasts RB, VAR, Median are current year. π denotes inflation and Δy GDP growth.

Table 4

Recursive analysis of equation (3)

	Coefficient estimate [standard error] on			
Recursive sample	**Constant**	**Inflation**	**Output**	**Interest rate**
2-19 (full sample)	−0.09	0.81	0.05	0.62
	[0.35]	[0.29]	[0.14]	[0.21]
3-19	−0.05	0.80	0.03	0.62
4-19	−0.69	0.89	0.31	0.53
5-19	−0.65	0.91	0.29	0.58
6-19	−0.68	0.94	0.31	0.57
7-19	−0.70	1.03	0.33	0.57
8-19	−1.09	1.06	0.45	0.40
9-19	−1.16	1.07	0.49	0.41
2-18	−0.09	0.78	0.05	0.62
2-17	−0.07	0.79	0.04	0.63
2-16	−0.07	0.80	0.05	0.63
2-15	−0.09	0.83	0.05	0.62
2-14	−0.09	0.82	0.05	0.62
2-13	−0.07	0.83	0.05	0.63
2-12	−0.05	0.85	0.04	0.63

Note: None of the recursive-sample estimates in rows two to 15 are significantly different (at the 5% test level) from the full-sample estimates (top row).

Table 5

Setup for alternative forecasters' forecasts

	Inflation forecasts		Forecasts of GDP growth	
Forecast derived at time	**Information set up to and including**	**Forecast for year (two years ahead)**	**Information set up to and including**	**Forecast for year (current year)**
1992: Dec	1992:4 *♦	1994	1992:2 *	1992
1993: Mar	1993:1	1994	1992:3	1993
1993: Aug	1993:3	1995	1993:1 ♦	1993
1994: Jan	1993:4	1995	1993:3	1994
1994: Apr	1994:1	1995	1993:4	1994
1994: Oct	1994:2 *	1996	1994:2	1994
1995: Feb	1995:1	1996	1994:3 *	1995
1995: Oct	1995:3	1997	1995:2	1995
1996: Jan	1995:4	1997	1995:3	1996
1996: Jun	1996:2	1998	1995:4	1996
1996: Oct	1996:3 *	1998	1996:2	1996
1997: Feb	1997:1	1998	1996:3	1997
1997: Jun	1997:2	1999	1996:4 *	1997
1997: Aug	1997:3	1999	1997:1	1997
1997: Nov	1997:4	1999	1997:2	1997
1998: Feb	1998:1 *	1999	1997:3	1998
1998: May	1998:2	2000	1997:4	1998
1998: Sep	1998:3	2000	1998:1	1998
1998: Nov	1998:4	2000	1998:2 *	1998

Note: * indicates the points in time at which the cointegration-space parameters of the VAR model are re-estimated; ♦ indicates the time from which the regime-shift dummy in Sweden (the floating exchange rate, inflation targeting, regime) is included in the VAR.

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