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Policy Reaction Function in a Crawling Peg Regime: Evidence from Costa Rica[¶]

by:

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Abstract

This paper discusses the policy reaction function for the Central Bank of Costa Rica that has successfully maintained a crawling peg for fifteen years. In addition to inflation and output, the role of movements in the exchange rate and reserves in determining interest rates is examined.. Abstracting from perfect capital mobility, the central bank has some room to set interest rates to achieve its objectives in the short-run. Not surprisingly, the evidence suggests that the central bank adjusts interest rates to defend the exchange rate peg. More surprising is the fact that recently interest rates have become more responsive to inflation.

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1. Introduction

Recently there has been renewed interest in monetary policy rules, including formulating optimal rules, comparing the properties of simple rules to optimal rules, robustness of rules to modification of key macroeconomic assumptions, and the estimation or calibration of rules. Following Taylor (1993), much of the literature has focused on interest rate rules describing the Federal Reserve's policy actions, and thus have been expressed as a rule determining interest rates in a close economy. The attractiveness of the Taylor rule is its simplicity and its ability to track interest movements using two arguments: (i) the deviation of inflation from its target and (ii) the output gap. Recently, monetary policy rules have been extended to central banks that target inflation (Rudebusch, and Svensson, 1999) and to open economies with flexible exchange rates (Ball, 1999).

This paper focuses on the ability of simple rules to characterize interest rate movements in a small open economy whose exchange rate follows a crawling peg regime. Clearly, the exchange rate regime combined with capital mobility will hinder the central bank's ability to conduct independent monetary policy, and thus conditions the authorities' policy responses. Indeed under perfect capital mobility, movements in domestic interest rates will fully reflect movements in world interest rates, i.e., the policy response function would be essentially a function of world interest rates.

Abstracting from perfect capital mobility, the exchange rate regime reduces the scope for independent monetary policy but does not entirely eliminate it in the short-run. For instance, facing weak domestic economy the central bank may decide to forego increasing domestic interest rates when world interest rates increase and defend the peg by selling reserves. This strategy cannot be followed indefinitely, and might not be the best response to a permanent increase in world interest rates, but it does suggest that the central bank has some scope to conduct independent monetary policy. Moreover, in these circumstances the central bank may decide to modify the crawling peg rate.

In particular, this paper estimates simple policy rules to characterize interest movements in Costa Rica, where a crawling peg regime has been in place ever since the debt crisis in the early 1980's. Costa Rica provides an interesting case study that allows empirical examination of interest rate movements to diverse shocks, including the Tequila crisis in 1995 and the Russia crisis in 199(7), as well as substantial capital inflows during 1999. Moreover, the absence of a major macroeconomic or exchange rate crisis during the 1990's that could hinder identifying "normal" policy responses, Costa Rica provides a relatively clean set of data to subject to econometric analysis. The main difficulty for econometric analysis, however, is to account for the frequent modifications to the policy objective/targets, i.e., shocks have been accommodated.

The rest of the paper is contains three additional sections. Section 2 describes inflation and monetary policy with emphasis on the two inflationary episodes during the 1990's. The main macroeconomic data is contrasted with the central bank's objectives as a simple way of characterizing the central bank's actions. Section 3 provides the bulk of the empirical evidence and provides a simple extension to the specification of policy reaction functions to account for changes in the targets. A series of functions are estimated including the standard Taylor rule. To complete the picture of monetary policy, adjustment of policy targets are modeled using a straightforward nonlinear time series model. Section 4 ends this paper by summarizing the main results.

2. Inflation and monetary policy in the 1990's.

Legal Framework. For the first half of the decade, roughly to the end of 1995, the Banco Central de Costa Rica (BCCR) was governed by the Law #1552, that established inflation as a secondary objective. Article 4 describes the host of objectives entrusted to the central bank as:

> "... promover el ordenado desarrollo de la economía costarricense dentro del propósito de lograr la ocupación plena de los recursos productivos de la nación, procurando evitar o moderar las tendencias inflacionistas o deflacionistas que pudieran surgir en el mercado monetario y crediticio. Procurará mantener la estabilidad interna y externa de la moneda y asegurar su convertibilidad, al mismo tiempo que cuidar del buen uso de las reservas monetarias de la nación para el logro de esas condiciones esenciales de estabilidad económica general."

that translates roughly as maintaining full employment while avoiding inflationary or deflationary pressures in the economy and to maintain domestic and external stability of the currency, ensure its convertibility with a judicious use of reserves to foster economic stability.

These objectives were simplified considerably by the Law #7558 issued in November 1995. Article 2 describes the BCCR's objective as:

> "...el Banco Central de Costa Rica tendrá como principales objetivos, mantener la estabilidad interna y externa de la moneda nacional y asegurar su conversión a otras monedas."

that translates roughly as maintaining the stability of the value of the currency both domestically and externally, i.e., price and exchange rate stability. Thus, inflation and the exchange rate become the main objectives for monetary policy in the second half of the decade. Table 1 summarizes the main objectives of monetary policy as described in the BCCR's annual report.

Monetary Policy in Practice. To understand how the legal framework have been interpreted in practice by the authorities, Figure 1 shows the historical evolution of the main macroeconomic variables and their respective targets or assumptions established in the annual monetary programs and their revisions during the 1990's. The deviations of these variables provide a way to characterize how the BCCR has responded when its monetary programs have been under stress. The discussion that follows centers on describing how the BCCR responded when the rate of inflation was persistently above its targeted level, as well as verifying whether the new law changed the BCCR's behavior.

Two inflationary episodes, defined as a period of time when inflation was persistently above its target, are clearly visible during the last decade (Panel a, Figure 1). Quite coincidentally, these episodes are closely aligned with the different laws: (i). the first episode occurs toward the beginning of the 1990's (1990-92); and (ii) the second episode occurs roughly in the mid 1990's (1994-96). Since these disinflations align almost perfectly with the two laws they can provide useful information regarding the policy response to inflation. Note that the macroeconomic conditions are similar in these episodes and are associated with a clear decline in economic activity and increased unemployment (panels b and c, Figure 1).

A plausible interpretation of the first episode is that an adverse supply shock hit the economy and this shock subsided in about two years. Although the primary interest of this study is not to identify the causes of the inflation, however, it is interesting to note that this episode coincides with the increases of oil prices associated with the Gulf War in 1991, and the subsequent decline in 1992. Moreover, the observed behavior of the economy coincides with the empirical responses to oil shocks in Hoffmaister et al. (2000). The data also suggests that exchange rate policy not monetary policy was used to support the disinflationary process. In particular, a real appreciation and not an increase in interest rates (or declines in the rate of growth of M0 or private sector credit) are observed during this period (panel f, Figure 1).

The second inflation episode suggests that it may have started as an adverse supply shock, as the increase in inflation was associated with a decline in economic activity. But in this case there does not seem to be an obvious candidate that could be singled out, aside from an increase in the sales tax of 300 basis points. In any event, the data supports the interpretation that the disinflationary episode was associated with a tightening in monetary policy, where interest rate increased substantially following a reduction in the rate of growth of monetary aggregates (M0) and credit to the private sector in 1994 (panels i, l, and j, Figure 1). Moreover, this tightening of monetary policy was noted in the Annual Memory of the BCCR (Memoria Annual, 1995). In contrast to the first episode, monetary policy not exchange rate policy appears to have played a supportive a role in reducing inflation (Panel f, Figure 1).

The stylized facts that emerge from the discussion above are suggestive of a change in the way monetary policy has been conducted at the BCCR following the modification to the law that establishes its policy objectives. The data suggest that more recently monetary policy has been directed to reduce inflation. Moreover, it is quite telling that inflation has remained around its target of ten percent since the second disinflation.

3. Deviations in the monetary program, estimating simple interest rate rules, and targets

This section provides a more systematic characterization of the monetary programs and how the BCCR has responded to deviations in its monetary program. First, basic statistic are compiled for the deviations, the difference between actual and target, implicit in Figure 1. Second, the deviations are used to estimate simple interest rate rules to obtain a reasonable characterization of the BCCR's policies, and to aid in uncovering the variables that drive its policies responses. Third, since in the presence of a large adverse shock the BCCR may choose not to adjust monetary policy and rather change its target accordingly (accommodate), this section ends by modeling adjustments in the targets.

3.1 Basic Statistics of the Deviations

Table 1 presents the basic statistics of the deviations (average, standard errors, and pairwise correlation) of the main variables of the monetary programs: (i) the interest rate (BEM); (ii) inflation; (iii) output; (iv) reserves; (v) the exchange rate; (vi) M1; and (vii) M0. The basic statistics are calculated for two definitions of the deviations. These correspond to deviations from the original monetary programs, as set out at the end of the previous year, and to deviations from revised monetary programs. Given the discussion above, the calculations are performed for two sub-samples, 1990-95 and 1996-99, to enable a simple way to examine whether there are any substantial changes that followed the new law.

In general the basic statistics suggest that the average deviations are smaller when the deviations are calculated relative to the revised program and when the second sub-sample is compared to the first sub-sample. The former suggests that the BCCR has tended to accommodate the observed deviations in the monetary program. The discussion of accommodating monetary policy is taken up below in Section 3.3.

The reduction of the deviation in the second sub-sample is particularly interesting regarding the inflation rate. The average deviation of inflation relative to original the programs declines from 8.1 (6.5 relative to the revised programs) in the first sub-sample, to 2.8 (2.2) percentage points en the second sub-sample. This reduction is accompanied by an increase in the concentration around the mean deviation, as the standard deviation falls from 0.07 (for the deviations relative to the original program) to 0.04 percentage points. The decline in the average deviation and the higher concentration around this average is consist with an increased commitment of the BCCR regarding its inflation objective that has followed the change in its main objectives as set out in law #7558.

It is not clear, however, whether a change in monetary policy was associated with the reduction in the deviations in the inflation versus its target. The basic statistics suggest that that there has been a greater degree of control of monetary aggregates established as the standard error of the deviations of intermediate targets have decline during the period they have been relevant. This is apparent from Table 1, keeping in mind that M1 and M0 were the intermediate targets respectively in the first and second sub-samples. Note that average deviation of M1 in the first sub-sample and M0 in the second sub-sample are similar, although the standard error of M0 is roughly half of that of M1 in these sub-samples. This is coupled with a similar decline in the standard error of the interest rate deviations. Both of these declines in the standard errors are indicative of a greater monetary control in the second sub-sample that coincides with the improved inflation performance. However, this interpretation contrasts some of the evidence stemming from the pair-wise correlation that suggest that monetary policy focused on defending the exchange rate peg as discussed below

The correlation of the deviations in inflation from its targeted level provides additional relevant information regarding the potential change in the BCCR's behavior following the change in its objectives. Perhaps the most indicative of change is the increase in the correlation with the deviations of interest rates (BEM). These correlation increased from about 0.20 to 0.70 for the deviations from the original program, and from about 0.10 to 0.50 for the deviations from the revised program. It is interesting that the (inverse) correlation of deviations of inflation with deviations of intermediate monetary targets also increased under the new law. These correlation support the idea that monetary policy has become more focused on the inflation target.

The correlation of deviation in interest rates from their target level are also indicate of the exchange rate regime. As could be expected in a crawling peg regime, interest rates are used to defend the peg. In particular, the correlation of the deviation in the interest rate with deviations in reserve is negative and with deviations in the exchange rate are positive. Thus, interest rates tend to increase above their targeted level when the peg is under stress either because reserves (exchange rates) are below (above) their targeted level. Note also that deviations in the monetary aggregates are negative which is suggestive of money demand determining the level of money in the economy, as could be expected when the exchange rate is predetermined.

3.2 Policy Reaction Function

Specification. Two versions of the reaction function are considered based on the deviations relative to the revised monetary programs. The *first version* corresponds to a Taylor rule:

$$(i_t - i_t^*) = a_0 + a_1(p - p^*) + a_2(\hat{y} - \hat{y}^*) + m_t$$

where i, p, y, and m correspond respectively to the interest rate, inflation, output growth and a well behaved error term; the superscript * denotes the revised target of the variable it is associated with. In this version the coefficients a_1, y a_2 measure respectively the change in the interest rate (basis point) that is associated with deviations in the inflation and in output growth.

This specification of the Taylor rule differs from the standard specification. First, the arguments in this function are measured as deviations from their programmed level. As elaborated below, this avoids biasing the estimates when targets are adjusted following their history , i.e., when targets are accommodated. This also means that some care is needed in interpreting the coefficient estimates. And second, the arguments included are inflation and output growth and not respectively expected inflation and output gap. Inflation is a good proxy of expected inflation as they are highly correlated given the high degree of persistence in inflation (see BCCR, 1997 and Hoffmaister et al, 2000). Moreover, inflation is more closely associated with the objectives of the BCCR. Output growth, not the output gap, is the variable that is specified in the monetary programs making it the appropriate variable to be included in the reaction function in Costa Rica.

To illustrate how the estimated coefficients can be biased when the reaction function is specified using the actual variables without subtracting the corresponding target, consider the standard specification:

$$i_t = a_0 + a_1 p + a_2 \hat{y}_t + \tilde{m}_t$$

where $a_0 = i^*$ and the error term would be expressed as:

$$\tilde{m}_t = m_t - (a_1 p_t^* + a_2 y_t^*)$$

so that it contains the targets multiplied by the corresponding coefficient. The standard specification assumes that the targets are time-invariant (or implicitly they are equal to zero) so that the term ($a_1\pi^* + a_2 y^*$) is subsumed in the constant with no effect on the slope estimates. However, as is clear from Figure 1 these targets cannot be viewed as time-invariant and since targets are likely to have been revised in light of the evolution of π_t and y_t the targets tend to be correlated with the regressors in the reaction function biasing the slope estimates. Only if the targets are uncorrelated with the regressors, as is the case when authorities do not accommodate shocks (time-invariant targets), are the estimates unbiased in the standard specification.

The *second version* of the reaction function corresponds more closely to monetary policy when the exchange rate follows a crawling peg, namely interest rates are set to defend the peg:

$$(i_t - i_t^*) = b_0 + b_1(\hat{e}_t - \hat{e}_t^{\ *}) + b_2(\log(RES_t / RES_t^{\ *})) + m_t$$

where ê and *RES* correspond respectively to the rate of depreciation and international reserves. This specification captures the idea that interest rates increase when the exchange rate tends to depreciate beyond its target (b_1>0), and when reserve fall below their targeted level (b_2>0).

It is plausible that interest rates react more when the peg is under pressure than otherwise. That is the monetary authorities may decide to increase interest rates more when reserves (exchange rate) are below (above) their targeted levels than when the opposite is true.[1] To

[1]Dummy variables were also added to version 1 of the reaction function, however, those results are not presented in the paper. In large part, those results reflect the dissapointing results obtained with version 1 without dummy variables (see below).

explore this asymmetric behavior the reaction function is extended to include dummy variables interacted with the regressors:

$$(i_t - i_t^*) = b_0 + \quad b_1(\hat{e}_t - \hat{e}_t^{\,*}) + \quad b_2(\log(RES_t / RES_t^{\,*})) \quad + \\ D1_t \times b_3(\hat{e}_t - \hat{e}_t^{\,*}) + D2_t \times b_4(\log(RES_t / RES_t^{\,*})) \quad + m_t$$

where *D1* and *D2* are dummy variables that are zero under favorable circumstances and are one under adverse circumstances. Thus, the dummy variables are defined as follows:

$$D1_t = \begin{cases} 0, \ if \ \ \hat{e}_t < \hat{e}^*{}_t \\ 1, \ otherwise \end{cases} \qquad D2_t = \begin{cases} 0, \ if \ \ \log(RES_t / RES_t^*) > 1 \\ 1, \ otherwise \end{cases}$$

In this extended function the response of interest rates to deviations in reserves (exchange rate) is b_1 (b_2) under favorable circumstances, and the response is augmented in b_3 (b_4) under adverse circumstances. Note that *D1* y *D2* are likely to be correlated as it is possible that when the exchange rate market is under pressure it is likely to be manifested in deviations in reserves and the exchange rate simultaneously. This could introduce multicollinearity that could make it difficult to obtain precise estimates of b_3 and b_4.

Estimation results. Table 3.1 summarizes the estimation results for the reaction functions for two sample periods corresponding to the two laws governing the goals of the central bank. The estimates for *version 1* are mixed. The response of the interest rate to the deviation in inflation is positive as expected but small. This estimate increases slightly in the second sub-sample but the increase is well within one standard error. The response of the interest rate to the deviation in output is negative and imprecisely measured. The perverse result suggests that interest rates were set pro-cyclically, especially in the first sub-sample! Note that this specification of the reaction function explains only a small fraction of the movements in interest rates, roughly 20 percent.

The estimates for version 2 are more interesting and clearly reflect the exchange rate regime. The response of the interest rate to the deviation in the exchange rate and to the deviation in reserves have the expected sign, and these coefficients are more precisely estimated than those in version 1. Specifically, a deviation of one percent in the rate of devaluation leads to an increase of the deviation in the interest rate of 160 and 116 basis points respectively in the first and second sub-samples. The same deviation in the reserves leads to decline of the deviation in the interest rate of roughly 10 points in both sub-samples. Note that this reaction function explains roughly twice as much of the movements in interest rate, than version 1.

Estimates are also presented for a combined of the reaction function, version 3, to explore whether version 2 should be expanded to include more traditional arguments. Interestingly, the coefficients for deviations in exchange rates and reserves are essentially unchanged. The biggest difference is a decline in the coefficient for the exchange rate whose second sub-sample estimate decline to 0.78 from 1.16, although this decline barely exceeds one standard error. Regarding the coefficient for deviation in inflation and in output are both perversely signed in the first sub-sample but are correctly signed in the second sub-sample, although the coefficient for deviations in output is less than half its standard error. For this reason deviations of output are dropped from the final version, version 4, of the reaction function. Once again the coefficients for deviations in exchange rates and reserves are qualitatively similar to those in version 2. The biggest difference is the coefficient of deviations of the exchange rate in the first sub-sample that increases to over 2.0 from 1.6. The coefficient on deviations of inflation are roughly the same as in version 3, where it is perversely signed in the first sub-sample. Note that the these reaction function now explain about 50 percent of the movements in the deviations in the interest rate.[2]

Table 3.2 explores the robustness of the results for version 4 by adding additional arguments to that specification; the first two columns reproduce the estimates of version 4 in Table 3.1. Version 4.1 and 4.2 add respectively M1 and M0 to verify whether the central bank adjusts interest rates when its intermediate targets deviation from their targeted values. The coefficient estimates do not support the idea that interest rise above their target level when either monetary aggregates exceed their target levels. Quite to the contrary, these estimates suggests that interest rates are lower when monetary aggregates exceed their target levels. These results are more suggestive of a money demand relation (inverse money demand) which is consistent with the fact that money demand determines the level of money in the economy with a predetermined exchange rate.

Version 4.3 and 4.4 adds world inflation and monetary aggregates in an effort to examine whether the results so far are not due to the absence of external developments in the specification. These developments can exert an important effect on domestic interest rates under a crawling peg regime and some degree of capital mobility. In general, the estimates in version 4.3. do not change much when the world inflation is added to version 4, aside from a one standard deviation increase in the coefficient of the deviation of the exchange rate in the second sub-sample. Note, however, the coefficient on the world inflation is perversely signed in the second sub-sample.[3] Version 4.4 adds to each sub-sample the relevant intermediate target, M1 and M0 respectively in the first and second sub-samples, with very small changes relative to the estimates already discussed in versions 4.1 and 4.2.

And turning briefly to Table 4 that contains the estimates of the asymmetric reaction function of the deviation of the interest rate; the first two columns reproduce the estimates of version 4 in Table 3.1 (now version 1). Version 2-4 add a single dummy interaction to the version 1,

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[2] Version 4 results are fully in line with the increased (pairwise) correlation apparent in Table 2.

[3] Adding i^* or π^* does, however, significantly reduces the impact of interest rates shocks on the economy (see Flores, et al, 2000).

respectively inflation, the exchange rate, and reserves. Perhaps the most suggestive results are those contained in version 2 that explores asymmetric response to deviations of inflation. The estimate suggest that when inflation exceeds its target the response of the deviation of interest rates increases to about 1.6 (=0.15+ 1.46).from 0.15 when inflation is below its target. The other coefficient estimates are essentially unchanged. The evidence for asymmetric responses is less clear for other variables as their coefficients are imprecisely measured.

In brief, the estimation of the reaction function suggest that interest rates have responded to movements exchange rates, reserves, and inflation. This is consistent with the crawling peg regime that have conditioned interest rate movements. Nonetheless, it is interesting to note that the inflation objective has played a role in interest rate movements, especially after the change in the central bank objective since 1996. This coupled with the evidence a stronger response of interest rates when inflation exceeds its target since 1996, tend to favor that there is evidence that the BCCR’s interest behavior has changed with the introduction of the new law in late 1995.

This interpretation, however, is at odds with the small sensitivity of interest rates to inflation, that is less than one. Typically, a coefficient greater than one is needed so that the response of nominal interest rate exceed the increase in inflation, so that real interest rates increase when inflation increases. In the context of the reaction function specified using deviation of the variables with respect to their targets this is not the case. To illustrate this point consider the following Taylor rule when targets are time-variant:

$$i_t = (i_t^* - p_t^*) + p_t^* + a_1(p_t - p_t^*) + a_2(\hat{y}_t - \hat{y}_t^*) + m_t$$

that renders the response of interest rates to changes in inflation as:

$$d_t / dp_t = d(i_t^* - p_t^*) / dp_t + (1 - a_1)\, dp_t^* / dp_t + a_1$$

where the partial derivative of output and its target with respect to inflation are set to zero to be consistent with the standard interpretation. Note that this response boils down to the standard case where $a_1 > 1$ is required for real interest increase following an increase in inflation, when targets are time-invariant. When targets are time-variant the condition for real interest rates to increase is less clear. For instance, when the inflation target fully accommodates changes in inflation, $\partial\pi*/\partial\pi=1$, then:

$$d_t / dp_t = d(i_t^* - p_t^*) / dp_t + 1$$

that does not depend on the size of a_1. In other words, when targets time-variant and are adjusted in light of economic developments, understanding whether real interest rates increase following an increase in inflation requires knowledge of how targets have been adjusted. This issue is discussed below.

3.3 Modeling Monetary Targets

Authorities have two options when their monetary program is off track: they can choose to tighten monetary policy to get the program back on track, and/or they can choose to modify their targets to reflect the new economic reality, i.e. accommodate monetary policy targets. It is likely that for small deviations from the program, the authorities will choose to adjust monetary policy to put it back on track. This is less likely when deviations exceed a "threshold" value that would imply unacceptable economic costs to put the program back on track. In these cases authorities are likely to accommodate policy targets. Accommodating policy targets is also more likely when the uncertainties in formulating monetary programs are important. Figure 1 illustrates clearly that targets have been revised considerably in Costa Rica during the 1990's.

Specification. To formalize these ideas and capture the step function characteristic of the time series that describe policy targets consider the following model:

$$x^* = \begin{cases} x_{t-1}^* + h \times (z_{t-1} - z_{t-1}^*) + m, & if \quad \left| z_{t-1} - z_{t-1}^* \right| \geq a \\ x_{t-1}^* + m, & otherwise \end{cases}$$

where x^*, $(z_{t-1} - z^*_{t-1})$, y $|z_{t-1} - z^*_{t-1}|$ denote respectively the policy target, the deviation of the central policy objective, and the absolute value of that deviation; α and η parameterize respectively the threshold deviation that triggers the revision in monetary targets, and the sensitivity of the target to the deviation in the central goal. This is essentially a "self-exciting threshold AR" (SETAR) model when x*=z* (see Tong, 1990).

Consider the case of the inflation target when inflation is the central goal of monetary policy:

$$p^* = \begin{cases} p_{t-1}^* + h \times (p_{t-1} - p_{t-1}^*) + m, & if \quad \left| p_{t-1} - p_{t-1}^* \right| \geq a \\ p_{t-1}^* + m, & otherwise \end{cases}$$

which describes a SETAR model for the inflation target. Note that to the extent that the inflation has become a central goal since 1996, one would expect that α to have increased reflecting the fact that authorities have become more willing to adjust monetary policy and stick to the target and less likely to accommodate deviations. It is also possible that η has decreased implying that when the authorities decide to revise the monetary target, they accommodate a smaller amount of the deviation.

In light of the results above, this basic model is extended to include two objectives:[4]

$$x^* = \begin{cases} x_{t-1}^* + h_1 \times (z_{1,t-1} - z_{1,t-1}^*) + m, & if \quad \left| z_{1,t-1} - z_{1,t-1}^* \right| \geq a_1 \\ x_{t-1}^* + h_2 \times (z_{2,t-1} - z_{2,t-1}^*) + m, & if \quad \left| z_{2,t-1} - z_{2,t-1}^* \right| \geq a_2 \\ x_{t-1}^* + h_1 \times (z_{1,t-1} - z_{1,t-1}^*) + h_2 \times (z_{2,t-1} - z_{2,t-1}^*) + m, & if \quad \left| z_{1,t-1} - z_{1,t-1}^* \right| \geq a_1 \\ & and \quad \left| z_{2,t-1} - z_{2,t-1}^* \right| \geq a_2 \\ x_{t-1}^* + m, & otherwise \end{cases}$$

where the target can be modified when the deviation in one or both objectives exceed their corresponding threshold values. Note that the threshold and sensitivity parameters when both objectives are off track have been constrained to be equal to those when only one objective is off track for practical reasons: without this restriction the estimation procedure failed to converge.

Estimation. The estimation of these nonlinear models is not standard since the residual sum of squared (RSS) is not a continuous function of the parameters in the model. As noted above, these models belong to the general class of "threshold autoregressive" models and the estimation is achieved by minimizing the "conditional" RSS (see Tong, 1990, pp. 292-322). Specifically, the estimation problem is to:

$$\min_{h,\, a \geq 0}(mm') = \begin{cases} \sum [x_t^* - \{x_{t-1}^* + h \times (z_{t-1} - z_{t-1}^*)\}]^2, & if \quad \left| z_{t-1} - z_{t-1}^* \right| \geq a \\ \sum [x_t^* - x_{t-1}^*]^2, & otherwise \end{cases}$$

Since the first and second derivative of the RSS are ill defined due to the discontinuity introduced by α, the minimization can not be solve using standard nonlinear optimization procedures that rely one way or another on a linear approximated of the problem, and thus a

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[4] In principle, the results in Section 3.2 would suggest that three objectives, namely the exchange, reserves and inflation, to be relevant in determining targets. However, a three objective model were not pursued here as the complexity of these model increases exponentially with the number of objectives. A model with three objectives has nine possible outcomes and given the difficulties in achieving convergence with two objectives are left for future research.

grid search procedure is required. This also complicates obtaining distributions for the standard errors of the estimates. Nonetheless, Tong (1990, theorems 5.7 and 5.8, pp. 305-8) shows that conditional on α the distribution of the estimate η is asymptotically normal, so that standard test results can be applied asymptotically. Regarding the distribution of α, Tong (1990, p. 387) suggests using bootstrap methods to provide an interval of the required probability to approximate simple tests.

Estimation results. Table 5.1 presents the estimation results for six targets (dependent variable) arranged in columns. Each column contains the estimates for the three individual goals (regressor) considered, namely the exchange rate, reserves and inflation. Although a total of 18 (6*3) models estimates are shown, the discussion centers on the six models for interest rate and inflation targets.

The estimates for the interest rate and inflation targets are supportive of the idea that inflation has become a more important goal for the central bank since 1996. In particular when inflation is the main objective, (Z-Z*)= (π-π*), the threshold estimate for the inflation target quadruples to about four percentage points in the second sub-sample and although the sensitivity of the inflation target increases, this change is within a standard error. These results suggest that indeed the central bank has become more reluctant to revise its inflation target when inflation is off track. (The results for the other two objectives are less clear cut and generally supportive of this interpretation.)

It is also interesting to note that the estimates for the interest rate target have not changed much when inflation is the main goal and suggest that the threshold estimate has decline and the sensitivity estimate has either increased of remains unchanged when the main goal is the exchange rate or reserves. Regardless of the model, these threshold AR models track the data fairly closely (see Figure 2).

Table 5.2 presents the estimation results for four targets (dependent variable) using two sets of two goals. The first set corresponds to a Taylor rule view of goals (inflation and output) and the second set corresponds to a crawling peg view of goals (exchange rate and reserves). The estimation results are disappointing because the estimated threshold is essentially zero in all cases. And although these models continue to track well the data (see Figure 3) these threshold values make it difficult to interpret as these models imply that targets are revised continuously. This clashes with the conception of the model and with the nature of the monetary targets discussed in this paper. These results suggest that the data set is probably not rich enough to discriminate between two distinct goals simultaneously. Understanding these puzzling results is left for future research.

Table 6 summarizes changes in the interest rate when targets are adjustable. Recall that the response of the interest rate to changes in inflation can be expressed as:

$$d_t / d\pi_t = d(i_t^* - p_t^*) / d\pi_t + (1 - a_1)\, d\pi_t^* / d\pi_t + a_1$$

where:

$$d_t^* / dp_t = h_i (1 - dp_t^* / dp_t)$$
$$dp_t^* / dp_t = \begin{cases} h_p (1 - dp_t^* / dp) = h_p / (1 - h_p) & if \quad |p - p^*| > a_p \\ 0 \end{cases}$$

taking α_i=0 (the interest rate target is adjusted to all movements in inflation) consistent with the estimates in Table 5.1. It is clear that given the size of the estimates, the modifications to the standard interpretation are small, i.e., a_1 provides most of the information needed to verify whether real interest rates increase in response to increases in inflation.

Simulation. A dynamic simulation of the variables considered above can be used to discern which target describes best the observed movements in the interest rate.[5] Specifically, the results Table 5.1 combined with the results in Table 4 provides a framework to simulate interest rate movements using the estimates for the second half of the 1990's.

Specifically, the simulation model consists of the following equations:

$$(i_t - i_t^*) = b_0 + b_1 \log(e_t / e_t^*) + b_2(\log(RES_t / RES_t^*)) + b_3(p - p^*) + D1_t \times b_4(p - p^*)$$

$$i^* = \begin{cases} i_{t-1}^* + h_i \times (Z_{t-1} - Z_{t-1}^*), & if \quad \left| Z_{t-1} - Z_{t-1}^* \right| \geq a_i \\ i_{t-1}^* & otherwise \end{cases}$$

$$\log(e_t^*) = \begin{cases} \log(e^*_{t-1}) + h_e \times (Z_{t-1} - Z_{t-1}^*), & if \quad \left| Z_{t-1} - Z_{t-1}^* \right| \geq a_e \\ \log(e_{t-1}^*), & otherwise \end{cases}$$

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[5] In rigor, dynamic simulations refer to the simulations were all variables are forecasted. However, the results discussed in here do not forecast the values of log(*e*), log(RES), and π since these are not of primary interest in this paper. Alternative simulations where these variables were forecasted have been obtained by augmenting the model in the text with a reduced-form (VAR) model $A(L)X_1+B(L)X_2+C=M$, where A(L), and B(L) are respectively a (3×3) matrix and a (3×1) column vector of polynomial lags; $X_1=[\Delta\log(e), \Delta\log(RES), \pi]'$ contains the endogenous variables, and $X_2=[i]$ contains the exogenous variable of the reduced-form model; C and M denote respectively the deterministic components and the shocks of the model. The main differences in the simulations are noted were appropriate.

$$\log(RES^*) = \begin{cases} \log(RES_{t-1}^{\;*}) + h_{RES} \times (Z_{t-1} - Z_{t-1}^{\;*}), & if \quad \left| Z_{t-1} - Z_{t-1}^{\;*} \right| \geq a_{RES} \\ RES_{t-1}^{\;*}, & otherwise \end{cases}$$

$$p^* = \begin{cases} p_{t-1}^{\;*} + h_p \times (Z_{t-1} - Z_{t-1}^{\;*}), & if \quad \left| Z_{t-1} - Z_{t-1}^{\;*} \right| \geq a_p \\ p_{t-1}^{\;*}, & otherwise \end{cases}$$

where in successive simulations Z and Z* are defined respectively as π and π*, log(RES) and log(RES*), and log(*e*) and log(*e**).[6] By comparing the results of the successive simulations provides evidence as to which target best fits the observed movements in the interest rate.

This model was used to dynamically simulate the interest rate beginning in January 1998 through December 1999. Figure 3 depicts the successive simulations in three columns, respectively when inflation, reserves, and exchange rate are the main targets; rows correspond to the simulations of the interest rate, the deviation of the interest rate from its target, the main target (Z) and the deviation of the main target (Z-Z*). The simulations are discussed in turn.

The first simulation assuming that the inflation target was the main goal of monetary policy does not appear to be a useful description of policy (Figure 3, column 1). For most of the simulation period π-π* was small and negative, i.e.,. inflation was running a bit below its targeted level! For the most part, this translates into an unchanging inflation target at roughly 12.5 percent (row 3). This is because the target exceeded the observed target for most of the simulation, so that by this metric inflation was under control. The simulated trajectories of *i*-*i**, and *i* are off for most of the simulation period, except for the first three months.[7] Thus, the inflation target does not appear to be the most appropriate way to characterize the observed interest rate movements.

The second simulation assuming that international reserves target were the main goal of monetary policy provides a more accurate picture of policy (Figure 3, column 2). During the simulation period the simulations for log(RES/RES*) and log(RES*) track the data remarkably well, forecasting most of the observed turning points. Also, the simulation for

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[6] In addition, the simulation model contains a series of identities that link the levels of variables to their deviations from target, linking Δlog(RES/RES*) and Δlog(*e*/*e**) respectively to log(RES/RES*) and log(*e*/*e**), and an equation that determines the value of D1.

[7] The results are qualitatively similar when all variables are forecasted. The main difference is that the simulated trajectories of *i*-*i**, and *i* are go off track in the first month.

i-*i**, and *i* are much better than those in the first simulation. However, the interest rate simulation goes off track roughly at the same time as in the first simulation.[8] The international reserves target provides some improvement over an inflation target to characterize the observed interest rate movements but is still wanting.

The final simulation assumes that the exchange rate was the main goal of monetary policy appears to be the most useful description of policy (Figure 3, column 3). Throughout the simulation period the simulation for log(*e*/*e**) and log(e*) track the data closely. Although, the simulation misses the upward revision of the exchange rate peg of roughly one percentage point in January 2000. The simulation also seems to picks up the major turning points in *i*-*i** , although the simulated increases fall short of those observed in final quarter of 1998. The simulation of *i* is quite good, and does not go off track as in the first two simulations.[9] To the extent that this model is an accurate depiction of interest rate behavior, the simulations suggest that the increases in interest rates in latter part of 1998 were a bit latter than expected, and so were the subsequent declines.

Concluding remarks

This paper focuses on the ability of simple rules to characterize interest rate movements in Costa Rica, a small open economy whose exchange rate follows a crawling peg regime. Although some degree of independent monetary policy is possible in the short-run, as long as capital mobility is less than perfect, domestic interest rate movements are conditioned by external conditions.

This papers examines monetary policy in Costa Rica in the 1990's. In this period the objectives of monetary policy were modified by Law #7558 issued in November 1995, increasing the importance of price (and exchange rate) stability. Whether this law effectively modified the central bank's goals is subject to debate. Corbo (1999) interprets the main objective stated in this law "mantener la estabilidad interna y externa de la moneda nacional" as "monetary stability" with multiple subsidiary objectives, rather than the interpretation here as internal and external stability of domestic currency, or more specifically as stability of the internal and external value of domestic currency (domestic prices and exchange rate).

Regardless of the interpretation of the central bank's goals, the evidence tends to favor the interpretation that inflation if not the main goal of monetary policy, its importance has

[8] The results are qualitatively similar when all variables are forecasted. The main differences are that the simulated trajectories of *i*-*i**, and *i* go off track earlier, roughly in December 1998, and model tracks less well the turning points of log(RES/RES*).

[9] The results are qualitatively similar when all variables are forecasted. The main difference is that the simulated increase in interest rates is smaller and occurs earlier, roughly in February 1997. Thus, the simulated path of interest rates does not show a decline in 1999.

increased since the law was issued. First, stylized facts suggest that the average deviation of inflation from its targeted level have fallen in size and have tended to become more concentrated around this smaller average. This is coupled with evidence that the positive correlation of the deviations of inflation and those of interest rates has increased, suggesting that interest rates have been increased in light of deviations of the inflation target. Second, estimates of an interest rate reaction functions confirm the evidence from pair wise correlation, and suggest that the response of interest rates to deviations in inflation from its target has increased in the second half of the 1990's. Moreover, the responsiveness of interest rates is much higher when inflation exceeds it target than otherwise. Third, the evidence suggest that authorities have been less prone to accommodate deviations of the observed inflation from its target in the second half of the 1990's.

Regarding the reaction function, the estimation of the reaction function suggests that interest rates have responded to movements in exchange rates, reserves, and inflation. This is consistent with the crawling peg regime that have conditioned interest rate movements. This coupled with the evidence a stronger response of interest rates when inflation exceeds its target since 1996, tend to favor that there is evidence that the BCCR's interest rate setting behavior has changed since the introduction of the new law in late 1995. Also, note that given this reaction function, that the best way to characterize interest movements in recent years, is to assume that the exchange rate target is the main objective of monetary policy.

Finally, the role of exchange rate movements in determining interest rates movements is consistent with the "price puzzle" that emerges from interest rates shocks (Flores, et al, 2000). To the extent that interest rate increases reflect increased rates of depreciation, increases in interest rates will be associated with increased inflation through the pass through exchange rates movements.

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Table 1

Objetivos Anuales de la Política Monetaria
Periodo 1990-1998

1990	Contribuir al logro de una mayor estabilidad de la economía, procurando reducir la tasa de crecimiento de los precios internos y contener la pérdida de reservas monetarias internacionales. Asimismo se orientó a crear condiciones propicias para la firma de un nuevo "convenio de contingencia" con el FMI y a lograr acuerdos con otros organismos financieros internacionales.
1991	Contribuir a la consecución de los objetivos de aminorar el ritmo de crecimiento de los precios internos y mejorar la posición externa del país. Para coadyuvar al logro de esos objetivos el BCCR trató de regular la liquidez de la economía, procurando evitar un exceso de oferta monetaria, en relación con la demanda de dinero, que pudiera originar un aumento importante de la demanda de importaciones o presiones adicionales sobre los precios internos. En línea con esa política, el Banco Central procuró neutralizar la expansión monetaria que a lo largo del año fue generando, básicamente, la acumulación de reservas monetarias internacionales.
1992	Mantener la estabilidad de la moneda, por lo que se ejerció un permanente control de la liquidez con el fin de reducir la tasa de inflación y fortalecer la posición externa del país. Asimismo, se ejecutaron importantes reformas tendientes a modernizar y mejorar el funcionamiento del sistema financiero.
1993	Consolidar la estabilidad económica interna y fortalecer la posición externa del país.
1994	Mantener la inflación interna en niveles similares a los de 1993 y fortalecer la posición externa del país. Sin embargo, ese objetivo se vio debilitado por el deterioro que registraron las finanzas públicas y el cierre del Banco Anglo.
1995	Contrarrestar las presiones inflacionarias presentes en la economía, producto de la elevada expansión monetaria que se dio en 1994 a raíz del cierre y liquidación del Banco Anglo, así como neutralizar los efectos negativos que generó la persistencia del déficit fiscal y fortalecer la posición externa de la moneda nacional.
1996	Política monetaria "cautelosa" dirigida a lograr la estabilidad interna y externa de la moneda nacional.
1997	Política monetaria "cautelosa" dirigida a la reducción de las presiones inflacionarias y coadyuvar al logro de la estabilidad y solidez del sector externo.
1998	Mantener la estabilidad interna y externa de la moneda nacional. Para ello, la Institución aplicó una serie de medidas tendientes a lograr un adecuado control de los medios de pago que permitiera, entre otros aspectos, un crecimiento razonable del crédito bancario, sin añadir presiones excesivas sobre la demanda interna y que, a su vez, contribuyera a sostener el ritmo de crecimiento de la actividad productiva.

Fuente: Tomado de la Sección II, "Política y situación monetaria", de las Memorias Anuales del Banco Central de Costa Rica.

Table 2. Average, Standard Error and Correlations of the Main Macroeconomic Variables.
(variables measured as deviations from their respective targets)

	BEM		Inflation		Output		Reserves		Exchange rate		M1		M0	
	1992:1-1995:12	1996:1-1999:12	1990:1-1995:12	1996:1-1999:12	1990:1-1995:12	1996:1-1999:12	1990:1-1995:12	1996:1-1999:12	1990:1-1995:12	1996:1-1999:12	1990:1-1995:12	1996:1-1999:12	1990:1-1995:12	1996:1-1999:12
Average														
Original program	1.682	1.184	8.191	2.781	1.725	0.321	-6.682	-1.219	2.198	1.252	4.705	6.976	9.5958	5.7634
Revised program	1.682	1.340	6.535	2.240	1.501	0.393	-4.220	-2.615	1.236	0.874	5.291	6.847	7.2194	4.2093
Standard error														
Original program	0.071	0.035	0.067	0.037	0.015	0.027	0.217	0.175	0.038	0.015	0.135	0.145	0.0813	0.075
Revised program	0.071	0.028	0.068	0.037	0.013	0.024	0.164	0.101	0.029	0.010	0.133	0.130	0.0663	0.0737
Correlations:														
Inflation														
Original program	0.219	0.691												
Revised program	0.121	0.459												
Output														
Original program	-0.403	-0.450	-0.787	-0.697										
Revised program	-0.391	-0.349	-0.485	-0.669										
Reserves														
Original program	-0.416	-0.756	0.093	-0.472	-0.088	0.598								
Revised program	-0.123	-0.496	0.190	-0.104	-0.244	0.296								
Exchange rate														
Original program	0.598	0.654	0.747	0.522	-0.736	-0.284	-0.172	-0.475						
Revised program	0.694	0.415	0.773	0.400	-0.546	-0.146	0.182	-0.044						
M1														
Original program	-0.777	-0.659	-0.024	-0.635	0.215	0.229	0.462	0.168	-0.377	-0.556				
Revised program	-0.747	-0.610	-0.046	-0.423	0.071	0.086	0.438	-0.030	-0.257	-0.425				
M0														
Original program	-0.811	-0.161	0.010	-0.284	0.258	-0.119	0.213	-0.296	-0.281	-0.119	0.896	0.523		
Revised program	-0.730	-0.343	0.067	-0.148	0.264	-0.282	0.242	0.011	-0.198	-0.131	0.838	0.595		

Note: The variables used have been expressed as the difference between the actual percent change (eop) and their target or their revised target, except for reserves and the exchange rate that have been expressed as the log difference between the actual and their target or their revised target. Thus, the deviation is positive (negative) when the actual is greater (lesser) than its target.

Table 3.1. Reaction Function, versions 1-4.
(variables are measured as deviations from their respective targets)

	Version 1		Version 2		Version 3		Version 4	
	1990:1-1995:12	1996:1-1999:12	1990:1-1995:12	1996:1-1999:12	1990:1-1995:12	1996:1-1999:12	1990:1-1995:12	1996:1-1999:12
Inflation	0.26	0.31			-0.27	0.26	-0.26	0.23
(+)	(0.12)	(0.14)			(0.12)	(0.13)	(0.12)	(0.09)
Output	-1.35	-0.09			-0.65	0.07		
(+)	(0.60)	(0.22)			(0.49)	(0.19)		
Exchange rate			1.60	1.16	1.94	0.78	2.06	0.81
(+)			0.19	0.34	(0.30)	(0.36)	(0.29)	(0.35)
Reserves			-0.10	-0.13	-0.10	-0.13	-0.09	-0.13
(-)			0.03	0.03	(0.03)	(0.03)	(0.03)	(0.03)
Constant	0.04	0.01	0.01	0.00	0.03	0.00	0.02	0.00
	(0.02)	(0.01)	0.01	0.00	(0.01)	(0.00)	(0.01)	(0.00)
R2	0.22	0.21	0.52	0.40	0.56	0.48	0.55	0.48
Adjusted R2	0.20	0.18	0.50	0.37	0.53	0.43	0.53	0.44
Standard error of the estimate	0.06	0.03	0.05	0.02	0.04	0.02	0.04	0.02

Note: The dependent variable is the deviation of the interest rate expressed as the difference between the BEM on six month paper and its target established in the monetary program. See Table 2 for the definition of the regressors. Below each regressor in parenthesis is its expected sign. Standard errors of the estimated coefficients are shown in parenthesis.

Table 3.2. Reaction Function, exploring version 4.
(variables are measured as deviations from their respective targets)

	Version 4		Version 4.1		Version 4.2		Version 4.3		Version 4.4	
	1990:1-1995:12	1996:1-1999:12	1990:1-1995:12	1996:1-1999:12	1990:1-1995:12	1996:1-1999:12	1990:1-1995:12	1996:1-1999:12	1990:1-1995:12	1996:1-1999:12
Inflation	-0.26	0.23	-0.09	0.11	-0.05	0.21	-0.26	0.32	-0.09	0.29
(+)	(0.12)	(0.09)	(0.10)	(0.08)	(0.11)	(0.09)	(0.12)	(0.09)	(0.10)	(0.09)
Exchange rate	2.06	0.81	1.36	0.35	1.46	0.74	2.02	1.26	1.35	1.17
(+)	(0.29)	(0.35)	(0.25)	(0.30)	(0.27)	(0.33)	(0.29)	(0.37)	(0.25)	(0.35)
Reserves	-0.09	-0.13	0.01	-0.14	-0.05	-0.13	-0.07	-0.09	0.00	-0.09
(-)	(0.03)	(0.03)	(0.03)	(0.02)	(0.03)	(0.03)	(0.04)	(0.03)	(0.03)	(0.03)
M1			-0.26	-0.11					-0.26	
(+)			(0.04)	(0.02)					(0.04)	
M0					-0.40	-0.10				-0.10
(+)					(0.08)	(0.04)				(0.04)
International inflation							0.42	-0.48	-0.08	-0.46
(+)							(0.31)	(0.18)	(0.26)	(0.17)
Constant	0.021	-0.002	0.037	0.012	0.046	0.003	0.015	-0.006	0.038	-0.001
	(0.01)	(0.00)	(0.01)	(0.00)	(0.01)	(0.00)	(0.01)	(0.00)	(0.01)	(0.00)
R2	0.55	0.48	0.73	0.67	0.68	0.54	0.56	0.55	0.73	0.61
Adjusted R2	0.53	0.44	0.71	0.64	0.66	0.50	0.53	0.51	0.71	0.57
Standard error of the estimate	0.04	0.02	0.03	0.02	0.04	0.02	0.04	0.02	0.04	0.02

Note: See Tables 2 and 3.1 for the description of the variables and related remarks.

Table 4. Reaction function and asymmetry
(variables measured as deviations from their respective targets)

	Version 1		Version 2		Version 3		Version 4		Version 5	
	1990:1-1995:12	1996:1-1999:12	1990:1-1995:12	1996:1-1999:12	1990:1-1995:12	1996:1-1999:12	1990:1-1995:12	1996:1-1999:12	1990:1-1995:12	1996:1-1999:12
Inflation	-0.26	0.23	-0.11	0.15	-0.18	0.23	-0.25	0.27	0.12	0.19
(+)	(0.12)	(0.09)	(0.13)	(0.10)	(0.13)	(0.09)	(0.13)	(0.09)	(0.15)	(0.10)
Exchange rate	2.06	0.81	2.04	0.88	1.54	0.69	2.07	0.77	1.06	0.89
(+)	(0.29)	(0.35)	(0.28)	(0.34)	(0.41)	(0.41)	(0.30)	(0.34)	(0.44)	(0.40)
Reserves	-0.09	-0.13	-0.08	-0.13	-0.09	-0.13	-0.10	-0.03	-0.08	-0.06
(-)	(0.03)	(0.03)	(0.03)	(0.03)	(0.03)	(0.03)	(0.07)	(0.05)	(0.07)	(0.06)
D1 * Inflation			-1.55	1.46					-2.58	1.17
			(0.68)	(0.67)					(0.73)	(0.73)
D2 * exchange rate					1.22	1.39			2.28	-0.56
					(0.69)	(2.58)			(0.74)	(2.57)
D3 * Reserves							0.02	-0.17	0.02	-0.13
							(0.11)	(0.08)	(0.11)	(0.09)
Constant	0.02	0.00	0.01	0.00	0.03	0.00	0.02	-0.01	0.01	0.00
	(0.01)	(0.00)	(0.01)	(0.00)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)
R^2	0.55	0.48	0.58	0.53	0.57	0.48	0.55	0.52	0.64	0.55
Adjusted R2	0.53	0.44	0.55	0.49	0.54	0.43	0.52	0.48	0.60	0.49
Standard error	0.04	0.02	0.04	0.02	0.04	0.02	0.05	0.02	0.04	0.02

Note: D1, D2 and D3 denote dummy variables that take the value of zero under favorable circumstances, and one under unfavorable circumstances. Refer to the text for the conditions that determine favorable or unfavorable circumstances in each case. See Table 2 and Table 3.1 for the description of the variables and related remarks.

Table 5.1. Modeling the Targets with a Single Criteria.
(variables measured as deviations from their respective targets)

$$Model:\ X^* = X^*_{-1} + \begin{cases} h*(Z_{-1} - Z^*_{-1}) & , \ if\ \left|Z_{-1} - Z^*_{-1}\right| \geq a \\ 0 & , \ otherwise \end{cases}$$

X^* :	Interest rate		Inflation		Output		Rate exchange		Reserves		M0	
	1990:1-1995:12	1996:1-1999:12	1990:1-1995:12	1996:1-1999:12	1990:1-1995:12	1996:1-1999:12	1990:1-1995:12	1996:1-1999:12	1990:1-1995:12	1996:1-1999:12	1990:1-1995:12	1996:1-1999:12
$(Z-Z^*) \equiv (p-p^*)$												
η	0.019	0.017	0.034	0.045	-0.006	-0.025	0.130	0.102	0.084	-0.081	0.016	-0.037
	(0.017)	(0.017)	(0.019)	(0.022)	(0.025)	(0.022)	(0.040)	(0.040)	(0.051)	(0.063)	(0.021)	(0.028)
α	0.003	0.000	0.007	0.042	0.010	0.083	0.002	0.001	0.029	0.070	0.010	0.064
Confidence interval	[0.002,0.007]	[0.000,0.000]	[0.004,0.011]	[0.031,0.068]	[0.004,0.040]	[0.064,0.106]	[0.000,0.005]	[0.001,0.002]	[-0.010,0.099]	[0.000,0.123]	[0.002,0.028]	[-0.252,0.111]
Standard error	0.012	0.009	0.015	0.007	0.005	0.005	0.012	0.009	0.092	0.059	0.018	0.022
R^2	0.868	0.956	0.801	0.975	0.896	0.931	0.999	1.000	0.952	0.987	0.836	0.846
Adjusted R2	0.867	0.955	0.798	0.975	0.894	0.929	0.999	1.000	0.951	0.987	0.834	0.843
$(Z-Z^*) \equiv (RES-RES^*)$												
η	0.035	-0.027	0.004	-0.007	0.004	0.011	-0.020	-0.033	0.262	0.398	0.012	0.018
	(0.001)	(0.020)	(0.018)	(0.024)	(0.022)	(0.031)	(0.085)	(0.093)	(0.044)	(0.086)	(0.029)	(0.027)
α	0.408	0.035	0.000	0.036	0.000	0.036	0.029	0.037	0.016	0.133	0.073	0.052
Confidence interval	[0.373,0.550]	[0.004,0.077]	[0.000,0.003]	[0.000,0.090]	[0.000,0.003]	[0.010,0.095]	[0.011,0.061]	[0.023,0.067]	[0.007,0.039]	[0.000,0.217]	[0.000,0.343]	[0.000,0.246]
Standard error	0.012	0.008	0.016	0.007	0.005	0.005	0.017	0.010	0.081	0.047	0.018	0.022
R^2	0.873	0.961	0.792	0.974	0.896	0.932	0.999	1.000	0.963	0.992	0.837	0.846
Adjusted R2	0.871	0.960	0.789	0.973	0.894	0.930	0.999	1.000	0.963	0.992	0.834	0.843
$(Z-Z^*) \equiv (e-e^*)$												
η	0.084	0.159	0.063	0.081	-0.047	0.653	0.353	0.548	0.037	-0.842	-0.090	0.075
	(0.019)	(0.017)	(0.018)	(0.018)	(0.026)	(0.031)	(0.040)	(0.040)	(0.044)	(0.047)	(0.022)	(0.020)
α	0.012	0.006	0.000	0.002	0.041	0.030	0.039	0.006	0.009	0.011	0.003	0.006
Confidence interval	[0.002,0.016]	[0.000,0.008]	[0.000,0.001]	[0.000,0.006]	[0.000,0.065]	[0.030,0.033]	[0.009,0.045]	[0.003,0.007]	[0.000,0.055]	[0.000,0.014]	[0.000,0.079]	[0.000,0.031]
Standard error	0.012	0.008	0.016	0.007	0.005	0.004	0.013	0.007	0.092	0.058	0.018	0.022
R^2	0.872	0.959	0.795	0.974	0.902	0.950	0.999	1.000	0.952	0.988	0.838	0.846
Adjusted R2	0.870	0.958	0.792	0.973	0.900	0.949	0.999	1.000	0.951	0.987	0.836	0.842

Note: The dependent variable, X*, for the regression is indicated in each column. Regressors, (Z-Z*) are indicated in the first column. Following Tong (1990) the approximate standard errors of η were obtained from a standard regression conditional on the estimate of α, and the 95 percent interval for α was obtained form 1000 bootstrap replications. (Intervals will be added in the revised version.) Refer to Tables 2 and 3.1 for definitions of the variables and related remarks.

Table 5.2. Modeling the Targets with Two Criterion.
(variables measured as deviations from their respective targets)

$$Model:\ X^{*} = X^{*}_{-1} + \begin{cases} h_1 * [(Z_1)_{-1} - (Z_1)^{*}_{-1}] & ,\ if\ \left|(Z_1)_{-1} - (Z_1)^{*}_{-1}\right| \geq a_1 \\ h_2 * [(Z_2)_{-1} - (Z_2)^{*}_{-1}] & ,\ if\ \left|(Z_2)_{-1} - (Z_2)^{*}_{-1}\right| \geq a_2 \\ h_1 * [(Z_1)_{-1} - (Z_1)^{*}_{-1}] + h_2 * [(Z_2)_{-1} - (Z_2)^{*}_{-1}] & ,\ if\ \left|(Z_1)_{-1} - (Z_1)^{*}_{-1}\right| \geq a_1\ y\ si\ \left|(Z_2)_{-1} - (Z_2)^{*}_{-1}\right| \geq a_2 \\ 0 & ,\ Otherwise \end{cases}$$

X^{*} :	Interest rate		Inflation		Rate exchange		Reserves	
	1990:1-1995:12	1996:1-1999:12	1990:1-1995:12	1996:1-1999:12	1990:1-1995:12	1996:1-1999:12	1990:1-1995:12	1996:1-1999:12
Taylor rule								
η_1	0.027	0.022	0.038	0.032	0.121	0.137	0.079	0.068
Standard error of h1	(0.003)	(0.003)	(0.004)	(0.002)	(0.010)	(0.010)	(0.008)	(0.064)
η_2	-0.134	0.018	-0.058	-0.032	0.142	0.135	0.017	0.398
Standard error of h2	(0.014)	(0.002)	(0.006)	(0.004)	(0.020)	(0.001)	(0.000)	(0.020)
α_1	0.000	0.000	0.000	0.001	0.000	0.002	0.000	0.001
α_2	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Standard error	0.012	0.009	0.015	0.007	0.012	0.009	0.092	0.058
R^2	0.874	0.957	0.802	0.975	0.999	1.000	0.952	0.988
Adjusted R2	0.873	0.956	0.799	0.975	0.999	1.000	0.951	0.987
Exchange rate rule								
η_1	0.082	0.112	0.062	0.072	0.360	0.537	-0.043	0.612
Standard error of h1	(0.009)	(0.022)	(0.007)	(0.018)	(0.031)	(0.035)	(0.005)	(0.035)
η_2	0.002	-0.023	0.003	-0.004	-0.024	-0.014	0.263	0.301
Standard error of h2	(0.000)	(0.003)	(0.000)	(0.003)	(0.003)	(0.000)	(0.027)	(0.026)
α_1	0.000	0.001	0.000	0.002	0.001	0.005	0.000	0.174
α_2	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Standard error	0.012	0.008	0.016	0.007	0.013	0.007	0.081	0.050
R^2	0.872	0.962	0.795	0.974	0.999	1.000	0.963	0.991
Adjusted R2	0.870	0.961	0.792	0.973	0.999	1.000	0.963	0.991

Note: Refer to Tables 2, 3.1 and 5.1 for relevant details.

Table 6. Response of the Interest Rate with Time-varying Targets

$$\frac{\partial i_t}{\partial p_t} = \frac{\partial (i_t^* - p_t^*)}{\partial p_t} + (1-a_1)\frac{\partial p_t^*}{\partial p_t} + a_1$$

			$\lvert p - p^* \rvert < h_p$	$\lvert p - p^* \rvert > h_p$
$\frac{\partial (i_t^* - p_t^*)}{\partial p_t}$	:	Expression	h_i	$h_i - \frac{h_p}{1-h_p}(h_i + 1)$
		Value	0.017	$0.017 - 0.048$
$(1-a_1)\frac{\partial p_t^*}{\partial p_t}$	:	Expression	0	$(1-a_1)\frac{h_p}{1-h_p}$
		Value	0	$(1-a_1)\ 0.047$
a_1	:	Expression	a_1	a_1
$\frac{\partial i_t}{\partial p_t}$	:	Expression	$a_1 + h_i$	$a_1(1-h_i\frac{h_p}{1-h_p}) + h_i$
		Value	$a_1 + 0.017$	$a_1 0.999 + 0.017$

Note: The values η_i and η_π correspond to the estimates in Table 5.1 for the second half of the 90´s. Consistent with these estimates $\alpha_i = 0$ so that i^* is continoustly adjusted to changes in π.

Figure 1. Actual versus Original and Revised Targets

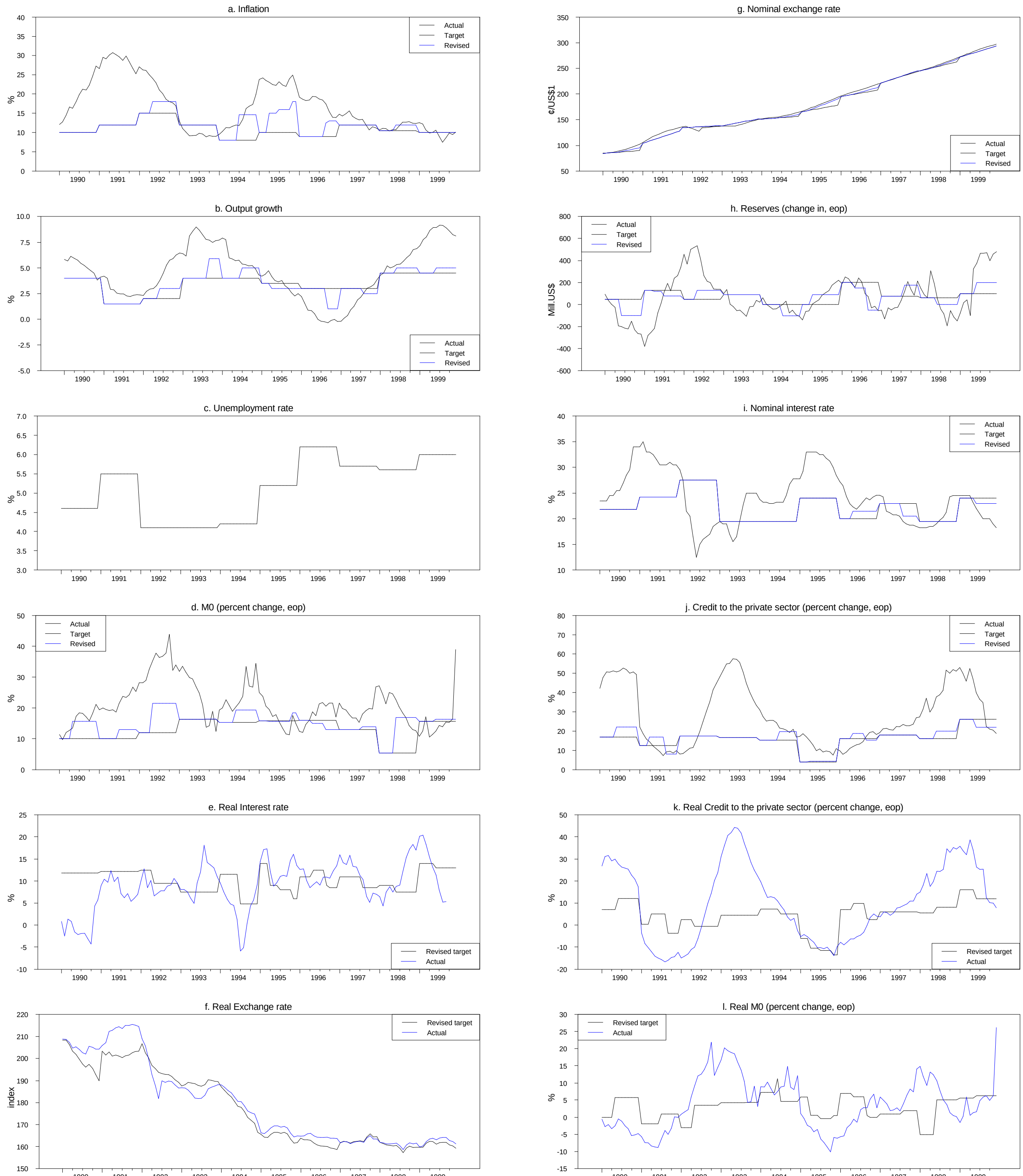


Figure 2. Actual versus fitted values of target with a single criteria

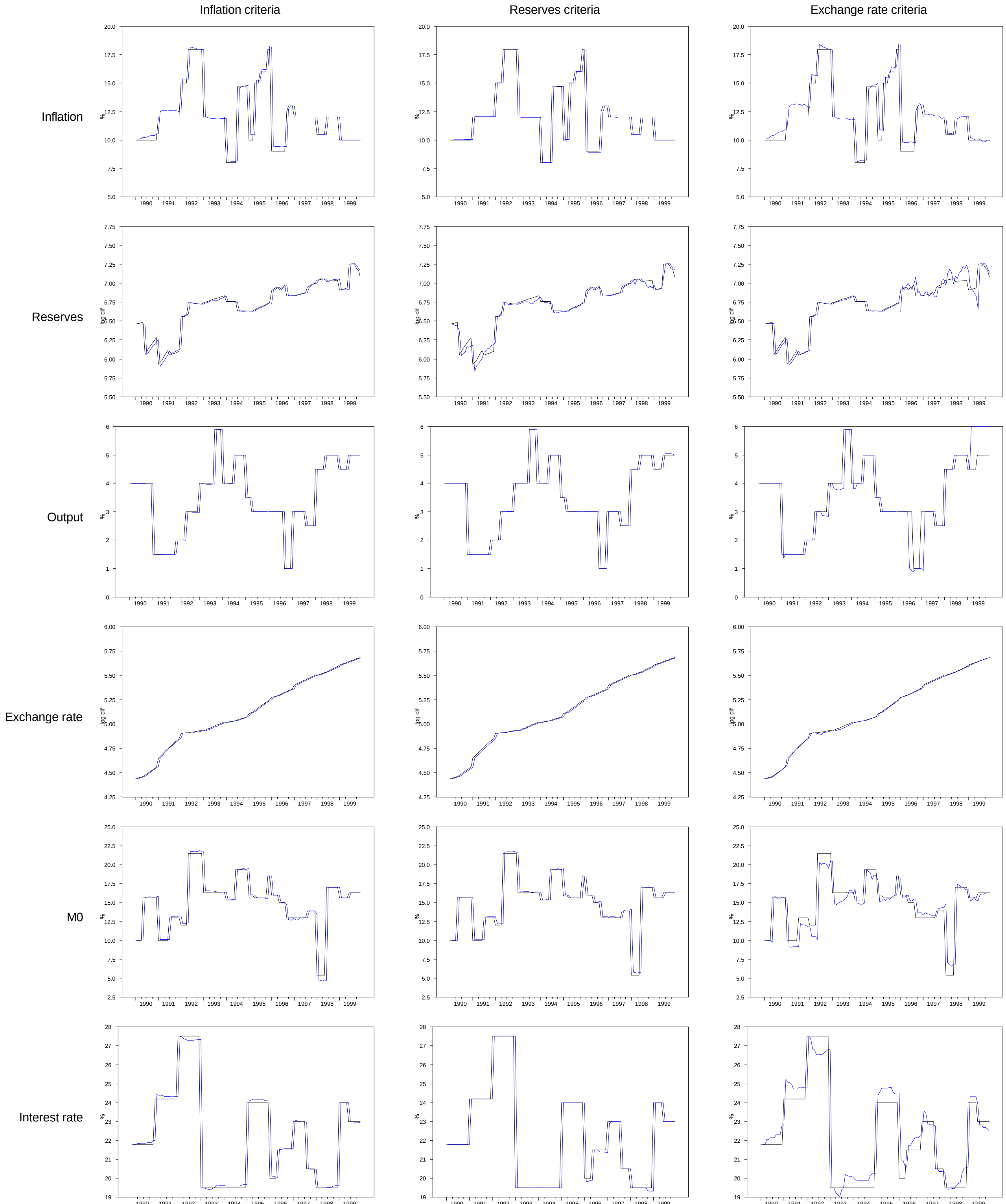


Figure 3. Actual versus fitted values of targets, with two criterion

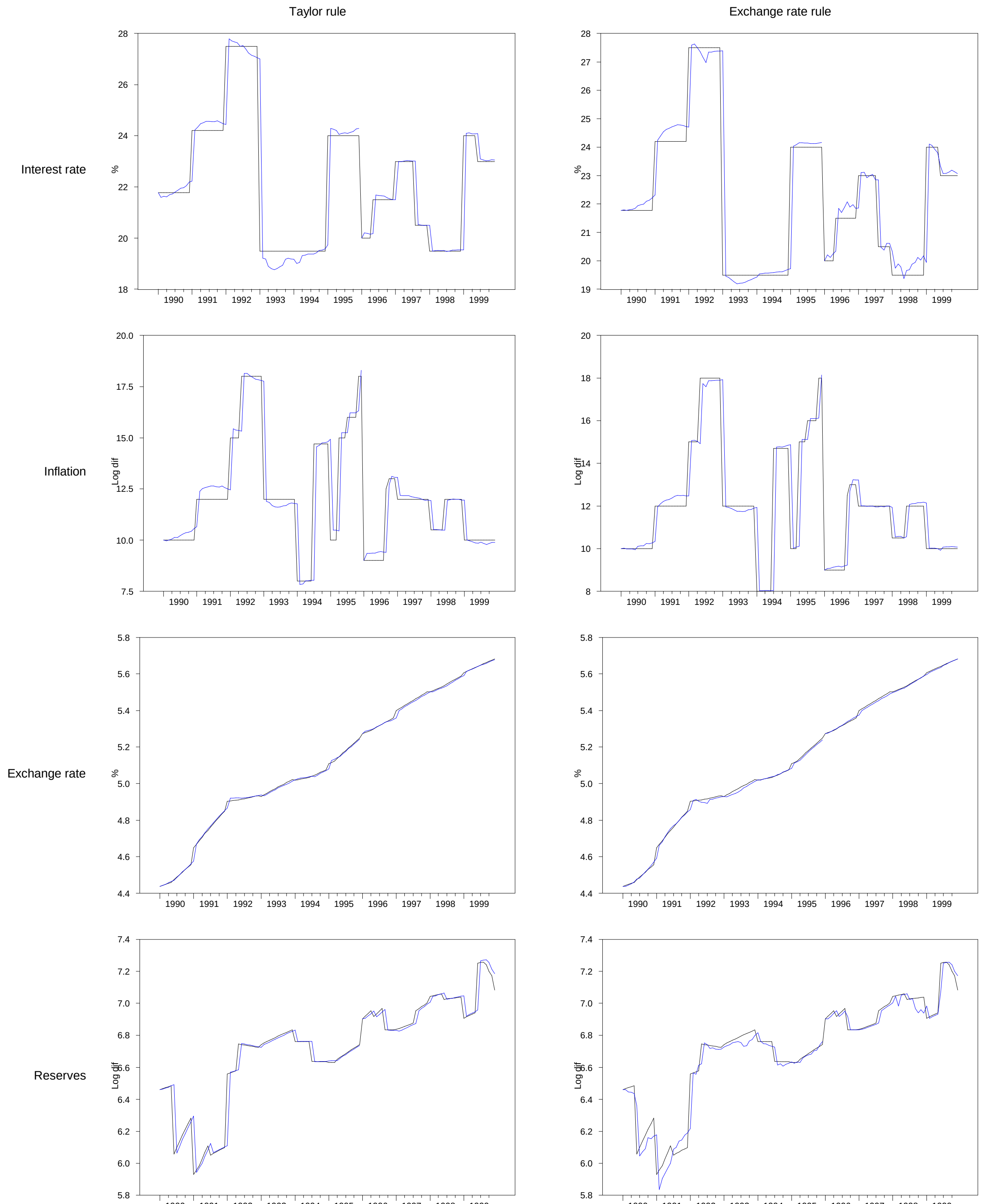
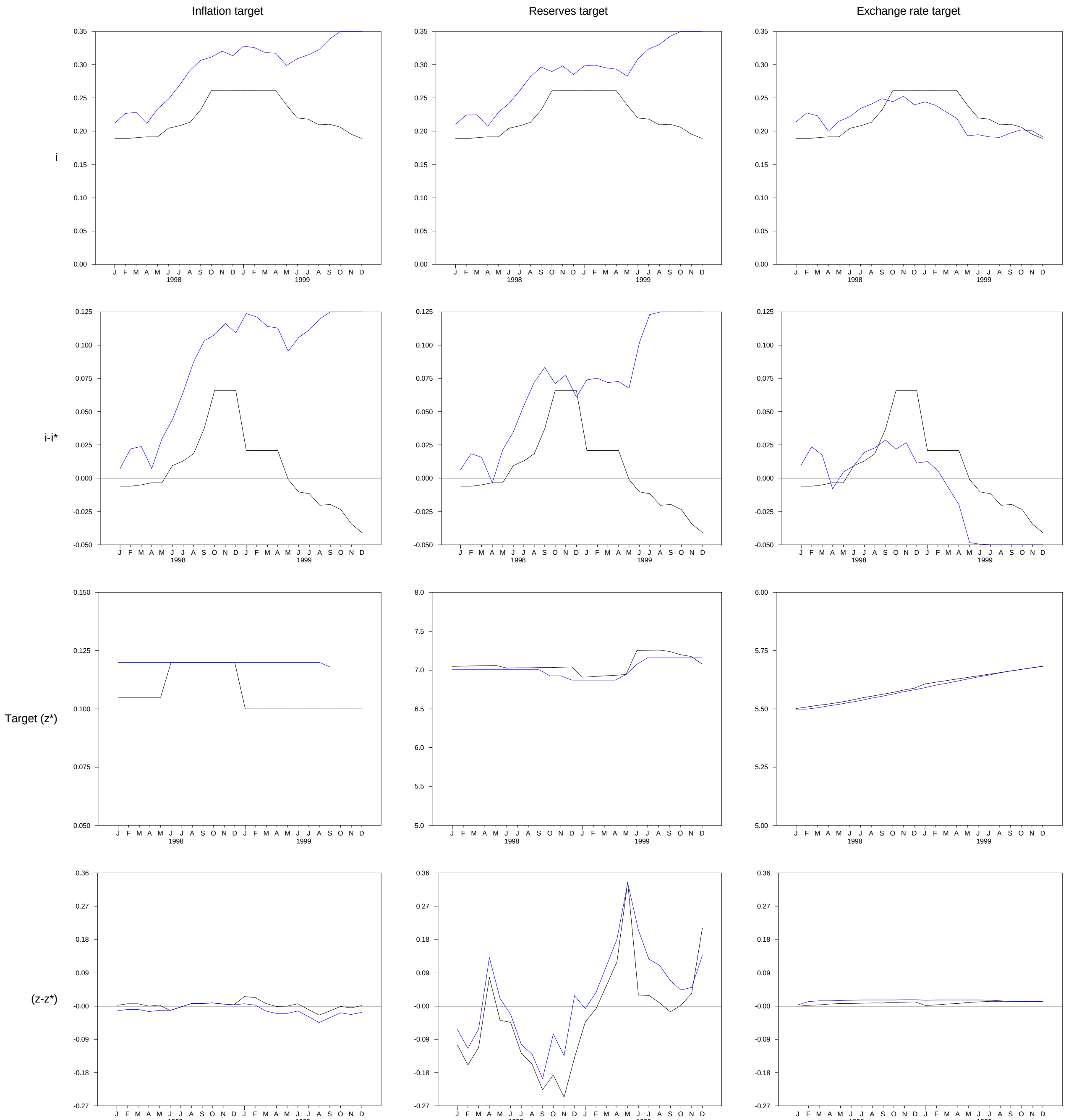


Figure 4. Dynamic Simulations of the Interest Rate and its Target
January 1998 through December 1999



Appendix

Table A1
Description of Variables

Variable	Description
Interest rate	Interest rate of BEM, 6 months.
Inflation	Inter-annual growth rate T(1,12) of Consumer Prices Index (IPC), 1995=100
IPC	Consumer Prices Index (IPC), 1995=100
IMAE	Monthly Index of Economic Activity (IMAE), 1991=100.
Producto	Inter-annual growth rate T(1,12) of Monthly Index of Economic Activity (IMAE), 1991=100
RIN	International Reserves, millions of USD, end of period.
Exchange rate	Nominal exchange rate (¢ / US$1)
M1	Money supply (currency plus demand deposits), millions of colones, end of period
M0	Millions of colones, end of period
International inflation	Inter.-annual growth rate T(1,12) of United States Producer Prices Index (IPP), 1995=100
Real interest rate (actual)	$r_{obs} = \left[\left(\frac{i_{BEM}}{2} \right) - \left(\frac{IPC_{t+6}}{IPC} \right) - 1 \right] * 2$
Revised target of real interest rate	Revised target of nominal interest rate less Inter-annual growth rate T(1,12) of Consumer Prices Index (IPC), 1995=100
Real exchange rate (actual)	Nominal exchange rate level deflated by IPC
Revised target of real exchange rate	Revised target of nominal exchange rate deflated by IPC
Real credit to the private sector (actual)	Inter-annual growth rate of credit to private sector for national banking sector deflated by IPC
Revised target of real credit to the private sector	Revised target of Inter-annual growth rate of credit to private sector for national banking sector deflated by IPC
Real M0 (actual)	Inter-annual growth rate T(1,12) of M0 deflated by IPC
Revised target of real M0	Revised target of Inter-annual growth rate T(1,12) of M0 deflated by IPC