PART II

Monetary policy rules in Switzerland: Do output and exchange rate matter?

Abstract

We estimate various forward-looking monetary policy rules in Switzerland for the period 1981-1997. In addition to an inflation gap, we find that rules with an output gap and an exchange rate gap nicely fit monetary aggregates as well as the call rate. We split the sample in 1990 when the Swiss National Bank replaced annual targets by medium-term targets for its official policy instrument, the monetary base. We find then that the same rule best describes $M0$ and $M1$ before 1990 and only the call rate after 1990. We also show that the exchange rate element in the rule does not necessarily imply exchange rate targeting per se. It mainly allows pursuing growth and price stability goals.

JEL Codes: E52, E58.

Keywords: Exchange rate, Monetary policy instrument, Output gap, Rule, Switzerland.

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1 Introduction and Overview

Much research in monetary economics is stimulated by the need to find the most appropriate way to conduct monetary policy. More precisely, this empirical research addresses among other issues the following questions: 'Can a feedback rule describe the behavior of an apparently discretionary central bank?', and if yes 'What is its form?'.

This introduction reviews the background and evolution of thinking on these questions. We then explain why it is of interest to answer these questions for Swiss monetary policy. We finally summarize our main results.

1.1 Rule or Discretion

The debate 'rule-versus-discretion', initiated at the end of the seventies by Kydland and Prescott (1977) and Barro and Gordon (1983a, 1983b), has launched a huge and fruitful research agenda mainly gravitating around two poles. On one hand, the attention on systematic monetary reactions to economic events has shown that rule-like behavior, and not only discretion, affects the outcomes and performance of the economy. On the other hand, the focus on the identification of monetary policy, dealing mainly with the exogenous part of monetary policy, the so-called monetary shocks, has been useful to assess the transmission mechanism of monetary policy into the nominal and real economy. This identification also helps to contrast these shock effects with the characteristics of a rule-like behavior. Generally, macroeconomists treat separately these two bodies of research for semantic and technical reasons[1]. Henceforth, we essentially concentrate our efforts on the systematic portion, the monetary policy rule, and not on the exogenous part of monetary policy.

The traditional focus on rules[2] is to avoid the inflationary bias of discretionary monetary policy (Barro and Gordon (1983a, 1983b)).

[1] Almost all papers about identification of monetary policy and about rule estimation virtually contain substance about these two complementary approaches. For example, vector autoregressions used as an identification scheme of monetary shocks express, in their reduced form for monetary policy variables, equations we may define as policy rules. Due to their complex functional form, researchers prefer to focus on simpler rules where they interpret their residuals as deviations, as other shocks, and not as exogenous monetary policy only. See Rudebusch (1998) for some justifications concerning this separation.

[2] We define a rule as nothing more than a systematic decision-making process that uses information in a consistent and predictable way. The concept of monetary policy rule is the application of this process to the implementation of monetary policy by a central bank (Poole, 1999). The rule specifies how the central bank varies its instrument as a function of the state of the economy. We do not distinguish between the concepts of rules and reaction functions. This is generally accepted in the literature that a rule comes from an optimal control exercise, whereas a reaction function is the product of econometricians.

A solution against this bias is the implementation of rules[3]. The monetary authority precommits to a policy rule that would ensure that its behavior is known in advance and would avoid any deviations. This rule is either a fixed rule like the one proposed by Friedman (1960), where the central bank sticks its policy instrument to a fixed target value given by the rule, or a nominal feedback rule (NFR) such as the one proposed by McCallum (1988) or Taylor (1993), where the policy instrument target feeds back in response to economic events[4].

However, in practice it has not been possible to identify rules which are so robust as to eliminate the need for some discretion in monetary policy. The empirical comparison between rules and discretion has been mainly a matter of degree rather than polar opposites (Stuart, 1996). Hence, we think it is worth discovering whether central banks act according to systematic NFR. There is growing sentiment that monetary policy behavior - even in appearance discretionary - can be represented by some fairly simple rules. The analysis of what a rule-like monetary policy would entail can be used as an informative device to describe past policy and to help market participants forecast future policy decisions in reducing uncertainty. This descriptive and informative function is thus more meaningful than the demand for a total commitment, because it is impossible for any central bank to mechanically follow the algebraic formulas that macroeconomists write down to describe their preferred policy rules (Taylor, 1993).

1.2 Rule in Switzerland

The search for a descriptive rule is interesting because the Swiss National Bank's (SNB) behavior oscillates between rule and discretion. On one hand, we observe the so-called 'courant normal' materialized as a fixed rule by its monetary base targeting. On the other hand, when necessary, the SNB carefully explains why it deviates from its rule-like behavior and how it uses its discretionary power (Laubach and Posen, 1997). While the SNB transparently acts, it does not

[3] Rules are not the single solution against this inflationary bias. They are often part of institutional reforms concerning the organization and management of the monetary authority, legislative changes, and increasing independence from politics.

[4] See Dueker and Fischer (1994, 1998) for an overview about NFR where they show their relative advantages over fixed rules.

publicly offer an explicit feedback form for its implicit rule.

A descriptive rule seems also appealing for Switzerland as a small open economy. Due to the high external shock sensitivity of the Swiss economy, the SNB is reluctant to completely leave its discretionary power for an internal rule. Generally, small open economies in a floating regime are still balancing internal and external considerations in implementing monetary policy. To reduce uncertainty, it is important for economic agents to know such a trade-off. It is thus possible to stress the informative role of rules - e.g. with an appropriate specification using an exchange rate term - in solving this apparent problem.

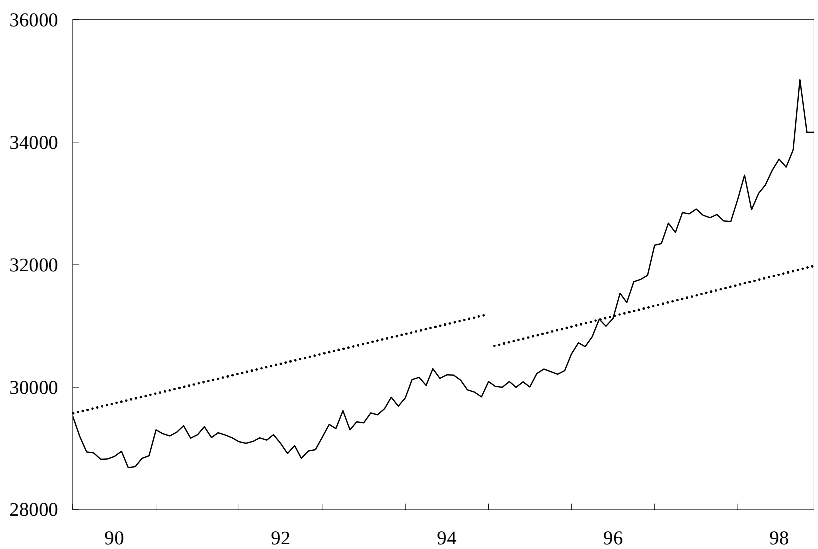
Henceforth, this paper is mostly empirical and descriptive. It is empirical because we try to picture SNB behavior within a NFR framework. It is then only descriptive because we think that a normative analysis is beyond the scope of this paper. Although the estimated rules come from a small open economy textbook model (Walsh, 1998), where behavioral relationships are directly specified rather than derived from underlying assumptions about the behavior of economic agents, it is of limited use for conducting a normative analysis. This ad hoc model is simply not able to make predictions about the welfare of economic agents and thus refrains prescriptive conclusions.

Albeit empirical and descriptive, this search for NFR still has exciting open questions we focus on: i) what is the role of output and exchange rate in rule estimations? what is their definition? ii) which instrument of Swiss monetary policy can be best described by NFR? iii) are NFR robust with respect to presumed changes in SNB policy?

A study from Taylor (1998) shows that the roles of output and exchange rate in rule estimation are issues without agreement. His results demonstrate that their inclusion is necessary for small open economies, but their form is still ajar. When the SNB has to react to variations in output or exchange rate, it is with respect to target values that we have to define. In estimating various rules for Switzerland, we thus test several output and exchange rate gaps depending on different assumed information sets of the SNB. We further use the mentioned textbook model to justify the presence of output and exchange rate beside inflation in the rule. In particular, we show that the make up of the rule is not necessarily an indicator about the ultimate goals of the central bank. The mandate of the SNB is to pursue a credit and monetary policy serving the interests of the country as a whole. This definition clearly sums up the traditional goals of fostering price stability and economic growth. The presence of an exchange rate element in the rule is to pursue these goals and not for explicit exchange rate targeting purposes.

The second question worth studying is the choice of policy instrument. Official operational instrument of monetary policy are the sight deposits of domestic banks (*giro* deposits) as a constituent of the monetary base. Moreover, the SNB has officially adopted a growth target for $M0$ in order to anchor its policy. However, in the mid-nineties, the SNB recognized that its monetary targets were of diminished use as a means of signaling the direction of its policy. Hence, we also test other aggregates and the call rate playing this function of monetary policy instrument.

Figure 1: Seasonally-Adjusted Monetary Base after 1990



Note: $M0$ and targets in mio CHF. Dashed lines represent medium-term target paths for the first and the second part of the nineties. They have the same slope and different intercepts. Both paths are motivated by the quantity theory and aim at keeping prices stable in the medium-term and allowing the economy to make full use of its production potential.

The last question concerns the estimation robustness, in particular with respect to suspected changes in applied monetary policy.

We replicate the whole sample (1981-1997) analysis for two subsamples, before and after 1990, in order to see whether there is a break in the systematic behavior of the SNB. Since 1990, the SNB has announced a five-year path for the seasonally-adjusted monetary base[5]. This statement replaced the annual announcements of the eighties. We use the change of policy announcement to split our sample. This new announcement has let place for more flexibility in the conduct of monetary policy as figure 1 suggests. Figure 1 shows the evolution of the monetary base compared to the two official target paths for the nineties.

Contrary to the former disclosure framework in which hitting annual targets was a difficult task, the SNB has now more elasticity to achieve its target. This is obvious that movements apart the target path still have to be justified and motivated. This capacity to deviate from its target allows the SNB for a significant degree of flexibility in trying to stabilize the economy in the short-term, without sacrificing the benefits of low inflation and low inflation expectations in the long-term. Because Switzerland has an important external sector, the SNB often motivates such deviations by an excessive appreciation of the Swiss franc (CHF). Smoothing it is not a goal per se, but this appreciation could menace export-led recovery and growth.

1.3 Results

We describe the SNB's behavior by a forward-looking rule. This NFR, based on an inflation gap, an output gap, and an exchange rate gap, fits well Swiss data, in particular the call rate and different monetary aggregates for the period 1981-1997. For this period, it is of interest to mention that the evidence concerning the exchange rate is mixed. The presence of the exchange rate gap in the rule does not significantly contribute to explain the movements of the different policy instruments. Moreover, only the Deutschmark (DM) is concerned.

However, when we split the sample in 1990, following the new announcement policy of the SNB, we get another picture. There is a clear-cut separation between the use of aggregate instruments and the short-term interest rate instrument. Our rule best describes thus the monetary base and $M1$ as instruments before 1990 and only the

[5] See Rötheli (1999) for some justifications of this switch to medium-term monetary targeting.

call rate after the introduction of medium-term targeting. Moreover, we find that the inclusion of an exchange rate element is necessary to depict the SNB's behavior after 1990. On the other hand, for the period before 1990 only with aggregate instruments, models best perform without any exchange rate element. All these results confirm during the nineties the increasing flexibility in SNB policy, a progressive change in the used policy instruments towards interest rate management, and instabilities on the money and financial markets, partially inducing in turn this focus on short-term interest rates.

Besides, for the period after 1990, we estimate our rule taking into consideration the informational situation of the SNB. We thus only use known information when it implements its policy. Revealing the progressive change in the used instruments, not only the rule with the call rate but also the rule using the sight deposits appear. However, in terms of out-of-sample predictions for the year 1997, the rule using the call rate performs best. These results strengthen the descriptive estimation where we do not explicitly take into account the informational setup of the SNB.

The structure of this paper is as follows. The second section presents the methodology and the data. We briefly derive the targeting rule from the textbook model to reveal its foundations. Section 3 relates our results and the last section concludes.

2 Methodology and Data

We present the design of our forward-looking rule and two ways to estimate it. We also sketch the textbook model to background such rules. Finally, we describe the data.

2.1 Policy Design

Our model is based on the empirical research of Clarida, Gali, and Gertler (1998a, 1998b) for the US and different European countries. In these studies, they assume two equations building their model: a policy rule guiding the central bank's behavior and a market equation representing the monetary sector of aggregate demand. These two assumptions, both presented in the next sections, constitute the skeleton of our model. They form together the equations we estimate following two different approaches, depending on the use of expected series or not. These two estimations embody different assumptions about the informational setup of the SNB.

2.1.1 Targeting Rule Equation

The first equation concerns the targeting rule for setting the monetary policy instrument. It feeds back from target or trend deviations of inflation π, of output y, and of exchange rate q. All variables with a star represent target, potential, or desired values. The rule explaining the policy target instrument w_t^* is given by the following equation:

$$\begin{aligned} w_t^* &= \tilde{w} + \beta E_t \left(\pi_{t+l} - \pi_{t+l}^* \right) \\ &\quad + \gamma E_t \left(y_{t+m} - y_{t+m}^* \right) + \delta E_t \left(q_{t+n} - q_{t+n}^* \right). \end{aligned} \tag{1}$$

Equation (1) represents the targeting rule that the central bank implements and to which it is presumably committed. $E_t(.) = E(. \mid \Omega_t)$ is the mathematical expectation operator where Ω_t embodies the information set of the central bank available at time t. $\tilde{w}$ is a constant term representing the long-term value for the policy instrument, $\beta E_t \left(\pi_{t+l} - \pi_{t+l}^* \right)$ characterizes the inflation feedback element, $\gamma E_t \left(y_{t+m} - y_{t+m}^* \right)$ is the reaction to output gap, and the last term $\delta E_t \left(q_{t+n} - q_{t+n}^* \right)$ catches the effects of other variables influencing the policy target instrument, in our case an exchange rate element. The target w_t^* has to react to these elements in order to achieve central bank goals[6].

This rule has some appeal for both empirical and theoretical reasons. A number of authors (Ball (1999a, 1999b), Batini and Haldane (1998, 1999), Clarida, Gali and Gertler (1998a), and Taylor (1993)) have empirically emphasized that a NFR like equation (1) provides a reasonably good description of the way central banks behave.

Theoretically, we briefly show that this rule is optimal for a central bank that has a quadratic loss function of inflation and output

[6] Note two aspects of our targeting rule, that we ignore for the sake of simplicity. First, this specification does not allow for asymmetric responses to the explanatory gaps. We especially think to output gaps where we imagine the SNB responding in different manners following an overheating or a slowdown in the economy. Second, this structure does not take into account the different origins of shocks disturbing the economy where we expect contrasted reactions in terms of accommodation after supply or demand shocks.

deviations from their respective target[7]. We define the output gap x and the exchange rate gap s, respectively as $x = y - y^*$ and $s = q - q^*$. Subject to the open economy textbook model of Walsh (1998), we derive the optimal behavior of the bank assuming that it minimizes a discounted (θ) and weighted (a° and b°) sum of output and inflation variances, both around targets normalized to zero for convenience[8]. Equation (2) gives the loss function and represents a standard objective function in the policy design literature for a closed economy or for a small open economy in a floating system:

$$\frac{1}{2}E_t\left(\sum_{i=0}^{\infty}\theta^i\left(a^\circ x_{t+i}^2 + b^\circ \pi_{t+i}^2\right)\right). \tag{2}$$

We could assume other goals implying different loss functions for the SNB. It is specially tempting to introduce an exchange rate element as an explicit target into this loss function due to the important role of the exchange rate in the Swiss economy. However, we are not interested in testing different assumptions about the ultimate objectives of the SNB. We merely want to show that the presence of the exchange rate in the rule is already optimal and compatible with this conventional and generally accepted loss function[9].

The textbook model of the economy (Walsh, 1998) has four equations linking the inflation rate π, the output gap x, the exchange rate gap s, and two interest rates, real r and nominal i. e and u are iid disturbances with normalized joint distribution $N(\mathbf{0},\mathbf{I})$. Foreign variables are normalized to zero and constants omitted for convenience.

$$\begin{aligned}
x_t &= -b_1 s_t + b_2\left(\pi_t - E_{t-1}\left(\pi_t\right)\right) + e_t &(3)\\
x_t &= a_1 s_t - a_2 r_t + u_t &(4)\\
s_t &= E_t\left(s_{t+1}\right) - r_t &(5)\\
r_t &= i_t - E_t\left(\pi_{t+1}\right) &(6)
\end{aligned}$$

[7] For equivalent models and dynamic programming in closed economy, see, e.g., Bernanke and Woodford (1997), Clarida, Gali and Gertler (1999), and Svensson (1997).

[8] Appendix A shows how to calculate the targeting rule for a configuration using the price level instead of its changes over time. The implied form of the rule does not change.

[9] See Chadha and Schellekens (1999) and Fair and Howrey (1996) concerning loss functions and their implications for the conduct of monetary policy.

Equation (3) is a Phillips curve representing the inflation rate as a function of the current output x and exchange rate s. The dependence of output on price surprises in this equation arises from the presence of nominal wage and price rigidities. Equation (4) is an IS curve linking the output to the real interest rate r and to the exchange rate s. This curve stands for the aggregate demand side, while assuming that the nominal interest rate is the policy instrument. It implies that we do not need an explicit LM curve. Otherwise, when we assume a monetary aggregate as policy instrument, we add a standard money demand equation with an opportunity cost and a scale variable. Both scenarios lead then to a rule of the form of equation (1). The third equation (5) represents an uncovered interest rate parity meaning that the expected appreciation of the exchange rate is a function of the real interest rate (differential with abroad). Finally, this real interest rate is defined in the Fisher equation (6) as the difference between the nominal interest rate and the expected inflation rate.

Still assuming the short-term interest rate as policy instrument, the resulting optimal rule after some algebraic manipulation is equation (7). It corresponds to equation (1), with now specific variable leads implied by the optimal control exercise:

$$i_t = \alpha_1 E_t \left(\pi_{t+1}\right) + \alpha_2 x_t + \alpha_3 E_t \left(s_{t+1}\right). \tag{7}$$

This exercise intuitively shows that the suggested targeting rule (1), using an exchange rate element, does not necessarily imply exchange rate targeting in the loss function of the SNB. The exchange rate element is present first because the textbook model is open and second because it indirectly serves the minimization of cumulated output and inflation variances.

Rule (1) displays pleasant characteristics. First, it avoids the critique of Lucas (1977) because it is based on forward-looking variables and intertemporal optimization. Coefficient changes could not be brought by policy itself. However, underlying assumptions can change over time, confirming the need to split the sample in order to test the robustness of this rule[10,11]. Second, it nests the Taylor

[10] It is necessary to precise that the parameters of equations (3)-(6) are not 'deep parameters' because these equations are specified and not derived from underlying assumptions. It weakens the rule immunity. However, the closed-economy expression for these same equations displays 'deep parameters' and avoids thus the critique of Lucas (1977).

[11] We do not simulate our rule within the simple textbook model for three rea-

rule based on backward-looking variables, assuming that the expectations of explanatory variables are based only on lagged variables. Third, even if it is possible to apply different combinations of leads to the three variables in the rule, we follow the predictions of the textbook model. It gives the leads to set in our econometric estimation, namely the use of a one-year ahead inflation rate and exchange rate gap, and the current output gap as explanatory variables[12].

2.1.2 Market Equation

The second assumption concerns the market equation. It helps to relax the strong assumption that the central bank can directly guide its policy instrument. We still assume that the central bank manages its instrument and sets it to achieve its goals, but inversely up to a certain degree represented by ρ. Other policy variables then adjust to clear the money market. Henceforth, the suggested dynamics of the policy instrument allows for a partial central bank control, or more precisely, for a total bank control with some persistence in the instrument. The market equation thus explains the observed instrument w with the central bank's target instrument w^*, a lagged element[13] w_{t-1}, and a shock v:

$$w_t = (1-\rho)w_t^* + \rho w_{t-1} + v_t. \tag{8}$$

We apply to the market equation (8) different policy instruments w. Two possibilities are at hand: a short-term interest rate, the call rate cr that is the equivalent of the federal fund rate in the US, or narrow aggregates as the sight deposits of commercial banks at the SNB and the monetary base. We also use a broader defined

sons. First, it is not clear whether the model accurately describes the Swiss economy with its particularities. Second, the textbook model is not able to provide normative features with profit and utility functions of economic agents, because these functions are only partially microfounded in this model. Third, simulations based on reduced-form models suffer from the critique of Lucas (1977), which states that the parameters used to simulate the data generating process for nominal variables are calibrated in a world devoid of a NFR and they would change if a NFR were in action (Dueker and Fischer (1994, 1998)).

[12] Ball (1999b) confirms the necessity to focus on medium-term inflation in the literature on rules for open economies.

[13] See Goodhart (1999) for the use of an autoregressive element in rule estimation. The main justification is gradualism in central bank interventions for the used instruments, call rate or growth rate of money stocks.

aggregate $M1$, even if the assumption of direct control is partially violated due to an unstable money multiplicator.

Market equation (8) describes the behavior of the observed instrument and its relationship to the instrument target w^* set by the SNB. This equation lays between two scenarios. The central bank either implements up to the shock v its target w_t^*, implying $\rho = 0$,[14] or it has to take into account rigidities on the money market, implying $\rho = 1$ in the most extreme case. Coefficient ρ gives information about the degree of instrument control the SNB exercises. We expect ρ to be small in case of narrow aggregates and quite high in case of broader defined aggregates as $M1$. Finally, v is a disturbance catching external influences on the instrument as financial crisis, velocity shocks, and deviations from target w^*.

2.1.3 Instrument Rule Regression

In order to estimate the coefficients of both equations (1) and (8), we plug equation (1) in the market equation (8) to get a new equation, an instrument rule. Depending on our assumptions concerning the expected explanatory variables, we then estimate the instrument rule according to two methods, namely either with instrumental variables called ‘description’ or with ordinary least squares (OLS) called ‘experimentation’. These assumptions depend themselves on the informational situation of the SNB.

A priori, the presented rule equation (1) allows us to use different leads for its explanatory variables. The textbook model described in the previous section nevertheless restricts our choice. We assume that the output gap is contemporaneous while inflation and exchange rate appear with a lead of a year. This reduced form is the following equation:

$$\begin{aligned} w_t &= (1-\rho)\tilde{w} + (1-\rho)\beta E_t\left(\pi_{t+12} - \pi^*_{t+12}\right) + (1-\rho)\gamma\left(y_t - y_t^*\right) \\ &\quad + (1-\rho)\delta E_t\left(q_{t+12} - q^*_{t+12}\right) + \rho w_{t-1} + v_t. \end{aligned} \tag{9}$$

2.1.3.1 Description The first way to estimate the coefficients is to follow Clarida, Gali, and Gertler (1998a, 1998b). We aim at describing what the SNB did, without especially taking into account whether the SNB, when it implemented its policy, had all the data

[14] This is the assumed setup for the central bank’s optimization explained in the previous section. We moreover assumed that there was no shock v.

we use in our estimation. We particularly think to the interpolated GDP and to the manner we avoid computing expected series.

We assume that the inflation target π^* is constant over the sample, implying first that we can move it in the intercept and second that π^* is determined by the estimation. We further assume that the expected forecast errors about explanatory variables are treated as residuals. Based on these two assumptions, we write this equation in detail using the definitions of the output gap x and the exchange rate gap s:

$$\begin{aligned} w_t &= (1-\rho)\overbrace{(\tilde{w}-\beta\pi^*)}^{\alpha}+(1-\rho)\beta\pi_{t+12} \\ &\quad +(1-\rho)\gamma x_t+(1-\rho)\delta s_{t+12}+\rho w_{t-1}+\varepsilon_t, \end{aligned} \tag{10}$$

where the composite residual ε_t is

$$\begin{aligned} \varepsilon_t &= v_t+\beta(\rho-1)\left(\pi_{t+12}-E_t\left(\pi_{t+12}\right)\right) \\ &\quad +\delta(\rho-1)\left(s_{t+12}-E_t\left(s_{t+12}\right)\right). \end{aligned} \tag{11}$$

Equation (11) represents the shock v and all forecast errors done by the bank in guessing the agents' expectations. It is not possible to discriminate between errors done by the agents and the possibly wrong perception of these expectations by the bank[15]. Residuals ε allow for different interpretations of shocks disturbing the money market. These shocks could be velocity shocks, significant deviations from the rule, or finally errors in expectations about the future variables used in equation (1). Focusing on equation (10) only, it is not possible to distinguish these three potential explanations.

We still follow Clarida, Gali, and Gertler (1998a, 1998b) to estimate the coefficients in using the residuals ε and their orthogonality relative to the information set Ω_t within a generalized method of moments (GMM) with instrumental variables. In the section 'Results', we thoroughly describe the elements of the bank information set Ω_t used as estimation instruments. We retrieve then by GMM the rule coefficients β, γ, δ, the market coefficient ρ, and the unique implied inflation target π^*. $\tilde{w}$ is given here by the data as mean of w.

2.1.3.2 Experimentation The second way consists in estimating equation (9) directly by OLS after having previously computed

[15] See Svensson (1997) about the different biases in estimating the agents' expectations.

the gaps, now based on expected series. We thus estimate the rule taking into account the informational situation the SNB faces when it implements its policy. This corrects the previous descriptive setup, where we use data known by the SNB only with some lags, or more precisely, only known after the policy implementation.

First, we assume explicit target values for inflation given by the SNB and not implicit ones as in the previous case. We further assume that expected inflation calculated by the SNB is orthogonal to the shock v[16]. It implies that $\tilde{w}$ takes now on a value calculated by the model due to its overidentification. Second, we use a so-called contemporaneous expected output gap x_e, because monthly gross domestic product (GDP) is only known with a lag of many months. The used series actually represents a monthly interpolated GDP before that quarterly values are known and thus does not sum to quarterly observations. The output gap is then the difference between a trend based on various scenarios concerning the development of Swiss potential output (e.g. Lüscher and Ruoss (1996)) and these contemporaneous expected monthly values for GDP. Third, we assume that the SNB has a fixed target for the exchange rate that we keep constant over the estimation sample. The assumed one-year ahead expected exchange rate is then its current value. Based on these assumptions, equation (9) becomes the following one:

$$\begin{aligned} w_t \quad = \quad & (1-\rho)\tilde{w} + (1-\rho)\beta E_t\left(\pi_{t+12} - \pi^*_{t+12}\right) + (1-\rho)\gamma x_t \\ & + (1-\rho)\delta\left(q_t - q^*\right) + \rho w_{t-1} + v_t. \end{aligned} \tag{12}$$

2.2 Data

Statistical characteristics of monthly data are given in table 1. There is data for three samples, whole sample 1981-1997, before, and after 1990. Table 1 displays information for the inflation rate π, six definitions of output gap x, three real exchange rate gaps using DM s^{dm}, using US$ s^{us}, and using a gap weighted by trade flows s^{all}. Concerning the monetary policy instruments, we report data for the call rate cr, the sight deposits of commercial banks at the SNB $giro$, the monetary base $M0$, and the monetary aggregate $M1$ (all expressed

[16] This assumption does not seem too restrictive for two reasons. First, with a forecasting horizon of a year, the correlation between v and $E_t\left(\pi_{t+12}\right)$ is assumed as low. Second, we think that the use of SNB data (taken from its publications) instead of externally forecasted inflation (Svensson, 1997) has marginal effects in this kind of regressions where we do not consider credibility arguments.

as real aggregates in growth rate)[17]. We assume all series stationary, although it is often at the 10-15% significance level.

We analyze six definitions of output gap using only monthly Swiss GDP interpolated according to Cuche and Hess (1999a, 1999b).

Table 1: Data Description

Whole Sample 81:01-97:12

	μ	σ	AR(1)	JB	ADF
π	3.13	1.68	0.97*	12.12*	-2.01
x_1	0.00	2.70	0.91*	15.72*	-1.69
x_2	0.00	1.72	0.76*	14.56*	-3.47*
x_3	-0.43	2.49	0.89*	10.79*	-1.33
x_4	0.00	1.08	0.41*	2.52	-3.53*
x_5	0.45	2.46	0.88*	12.25**	-1.98
x_e	-1.04	3.62	0.93*	14.71*	-1.32
s^{dm}	-1.13	3.76	0.95*	8.97**	-2.68
s^{us}	1.25	20.45	0.98*	33.08*	-1.77
s^{all}	0.24	4.20	0.94*	4.77	-3.90*
cr	3.87	2.40	0.92*	17.59*	-1.88
$giro$	2.89	10.54	0.97*	12.35**	-1.80
$M0$	-0.21	3.78	0.93*	11.78**	-1.76
$M1$	-0.41	6.28	0.95*	2.75	-2.20

Before 1990 81:01-89:12

	μ	σ	AR(1)	JB	ADF
π	3.26	1.60	0.96*	7.32**	-1.73
x_1	-0.45	2.19	0.88*	4.67	-0.53
x_2	-0.28	2.00	0.81*	15.61*	-2.99**
x_3	0.99	1.44	0.67*	1.90	-2.00
x_4	-0.09	1.16	0.46*	2.10	-2.78
x_5	-0.45	2.19	0.88*	4.67	-0.53
x_e	0.90	1.75	0.71*	3.18	-2.20
s^{dm}	-3.25	2.70	0.91*	16.58*	-2.49
s^{us}	14.48	19.27	0.98*	5.36	-1.52
s^{all}	0.82	3.76	0.94*	5.77	-2.74
cr	3.06	1.78	0.72*	9.55*	-1.31
$giro$	4.62	9.87	0.98*	37.85*	-0.49
$M0$	0.81	3.36	0.91*	9.81**	-1.26
$M1$	-1.07	5.88	0.94*	0.54	-1.91

[17] Estimations performed with nominal growth rates for the three aggregates produce similar results. In order to allow for comparisons with other studies, we report data and results for real growth rates.

Table 1 *Continued*

After 1990 90:01-97:12

	μ	σ	AR(1)	JB	ADF
π	2.98	1.76	0.98*	9.32*	-1.12
x_1	0.49	3.13	0.92*	7.19**	-0.95
x_2	0.32	1.28	0.59*	3.45	-1.79
x_3	-2.05	2.45	0.86*	22.37*	-2.22
x_4	0.10	0.98	0.33*	0.70	-2.10
x_5	1.49	2.34	0.86*	11.87**	-1.62
x_e	-3.24	3.92	0.93*	5.68	-1.73
s^{dm}	1.25	3.32	0.93*	0.95	-2.53
s^{us}	-13.61	7.24	0.93*	5.59	-2.73
s^{all}	-0.61	4.54	0.94*	4.66	-2.73
cr	4.79	2.66	0.98*	8.26**	-0.52
$giro$	0.95	10.98	0.98*	3.46	-0.63
$M0$	-1.37	3.92	0.96*	3.61	-0.62
$M1$	0.31	6.67	0.95*	5.07	-1.08

Note: All variables in annualized percentage. π = Inflation rate; x = Output gap definitions; s^{dm} = Real exchange rate gap (DM); s^{us} = Real exchange rate gap (US\$); s^{all} = Trade-weighted real exchange rate gap; cr = Call rate; $giro$ = Growth rate of sight deposits of commercial banks; $M0$ = $M0$ growth rate; $M1$ = $M1$ growth rate; μ = Mean; σ = Standard deviation; AR(1) = First-order autoregressive coefficient; JB = Jarque-Bera test; ADF = Augmented Dickey-Fuller test. Null hypotheses: i) first-order AR coefficient test, H_0: AR-coefficient = 0; ii) JB test, H_0: normal distribution; iii) ADF test, H_0: unit root. Rejection of the null hypothesis at the 1% significance level (*) and at the 5% significance level (**). Source: Datastream, International Financial Statistics, and SNB.

Figure 2: Monthly GDP and Trend

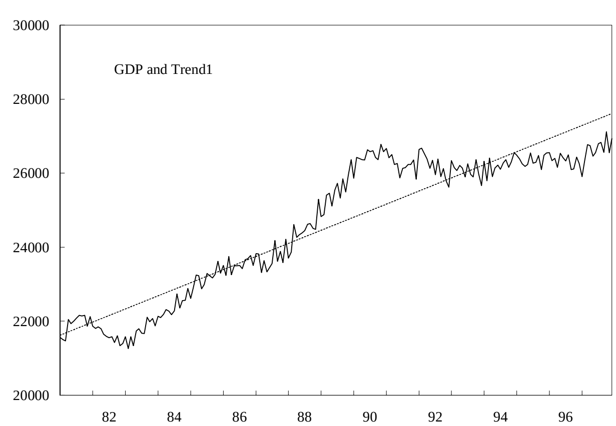


Figure 2 *Continued*

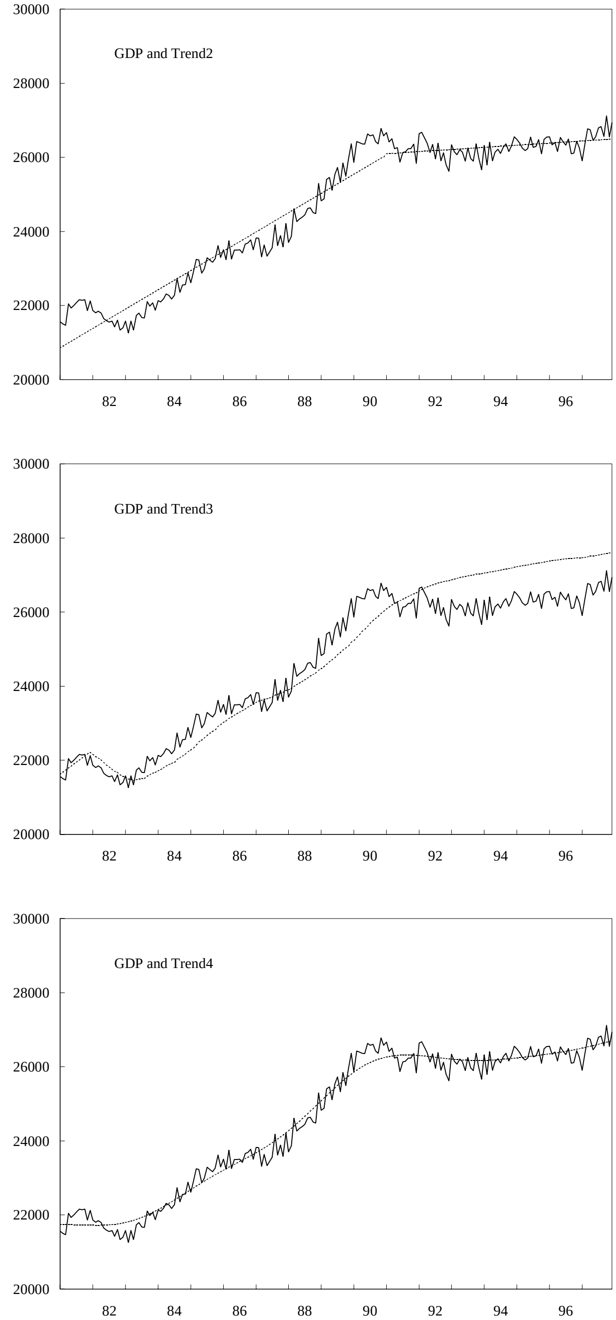
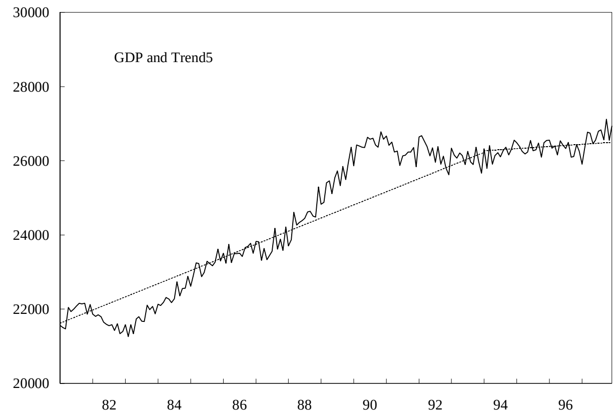
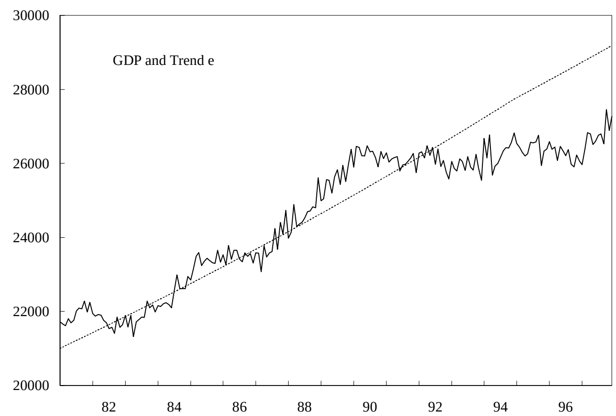


Figure 2 *Continued*





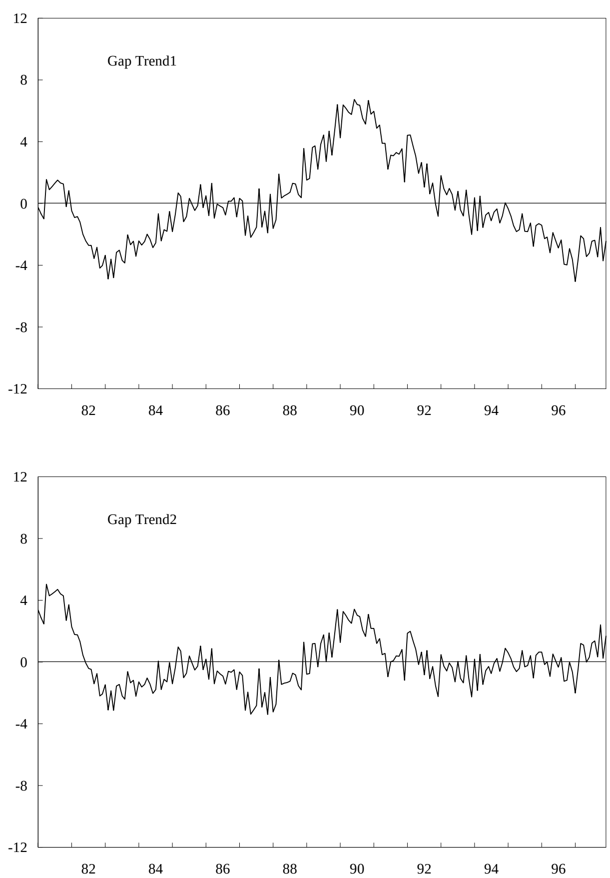
Note: Monthly GDP and trend in mio CHF. GDP = Gross domestic product (solid line); Trend (dashed line). Trend1 = Linear trend 1981-1997; Trend2 = Two-sector linear trend before and after 1990; Trend3 = Linear trend with adjustment in each period; Trend4 = HP trend; Trend5 = Trend1 before 1994 and Trend2 after 1994. Trend e = Trend used for experimentation. Source: Cuche and Hess (1999a, 1999b).

We do not use alternative proxies for GDP as Gali and Gertler (1999) did for example in computing a potential GDP based on labor income share in estimating a new Phillips curve[18]. The six output gaps are illustrated in figures 2 and 3. We define as an output gap

[18] See Dupasquier, Guay and St-Amant (1999) for a survey about alternative methodologies for estimating potential output and computing output gaps.

the difference between GDP and a chosen trend. Different trends produce different gaps[19]. We do not choose a priori the definition of y^*, the so-called potential output which the economy should reach with all its capacities busy. In our view, it is more convenient to understand y^* as a desired level that policymakers want the economy to reach[20].

Figure 3: Output Gap



[19] All output gaps are expressed relatively to the chosen trend: $(y - y^*)\,100/y^*$. We also apply this method to exchange rate gaps. We can then interpret regression coefficients as elasticities.

[20] Note that there is an asymmetry in the treatment of y^* relative to π^*. This is explained by technical reasons and the more important role of inflation targets in the conduct of monetary policy.

Figure 3 *Continued*

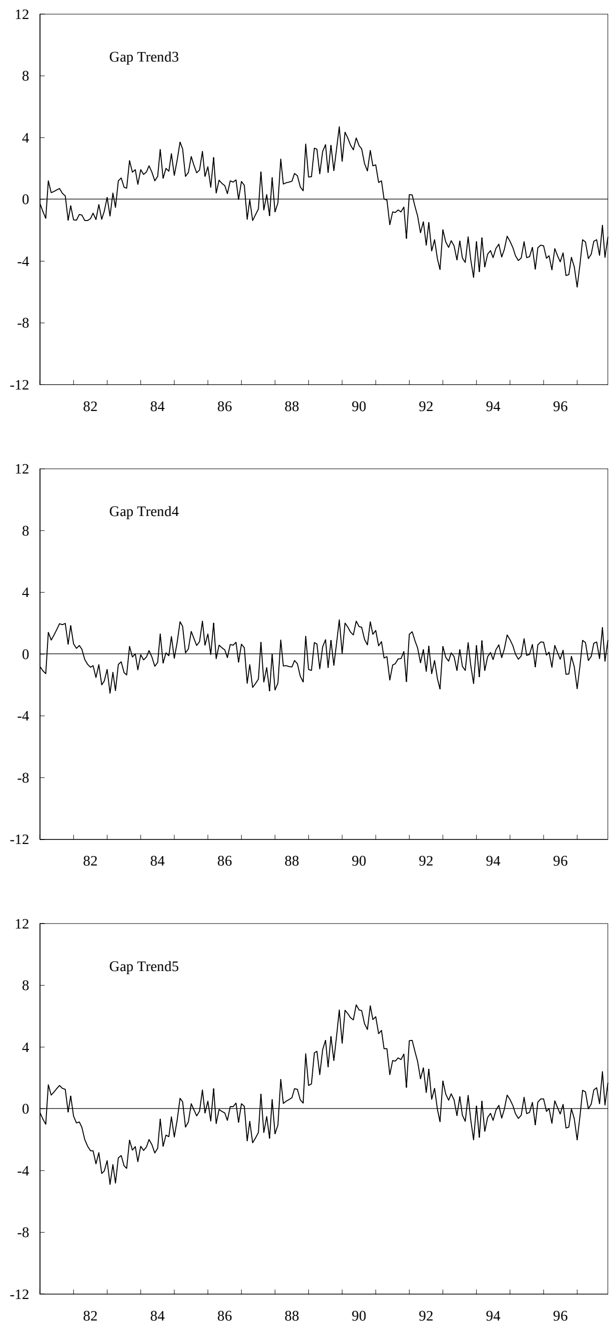
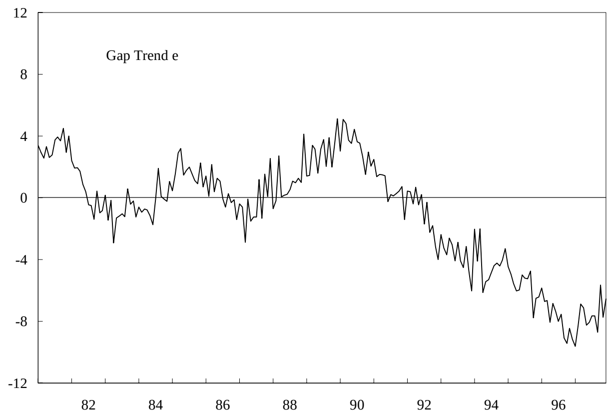


Figure 3 *Continued*



Note: Each gap (in percentage from trend) corresponds to the trend with the same number as in figure 2. Source: Cuche and Hess (1999a, 1999b).

The first gap definition x_1 is the difference between monthly GDP and a linear trend during these last fifteen years. The second definition x_2 is based on two linear trends separately calculated for two different subsamples. We assume that the linear trend is best caught with a break in the beginning of the nineties. We are not sure that the potential output decreases in the nineties. However, we can assume that the central bank realizes that the single linear trend, calculated for the eighties, becomes completely hypothetical and wants to re-adjust its trend definition in calculating a new gap in the beginning of the nineties. The two-sector trend implies that in the nineties the gap is smaller in its second definition than in the first one with a single trend. The gap for the eighties is less affected by this new calculation. The third definition x_3 is based on a single linear trend that the central bank recalculates after each period. It explains the smooth path in the graph. For each period, we get a new desired output. Cumulating these new desired values produces a smooth stochastic-looking trend. x_4 is an output gap after that the stochastic trend calculated by Hodrick-Prescott (HP) filtering has been removed. It has the feature to isolate the high frequencies of the business cycle producing a noisier series representing this cyclical part. The fifth definition x_5 is a mix between the two first gaps, where the trend is the first one up until 1994 ($x_{1,\leftarrow 1994}$) and Trend2 after 1994 ($x_{2,1994\rightarrow}$). Finally, x_e is the output gap between the non-corrected interpolated GDP and a trend based on various scenarios concerning the development of Swiss potential output (e.g. Lüscher and Ruoss (1996)). This gap takes into account the information set that the SNB analyzes when it implements monetary policy. Accordingly, interpolated months do not sum up to published quarterly GDP[21]. This monthly GDP is now strictly based on contemporaneous related series and not on future values as included in the previous five definitions that are interpolated using quarterly values known only with a lag of many months[22].

The exchange rate gap is also defined as deviation from a linear trend: s^{dm} for the DM, s^{us} for the US$, and s^{all} for the trade-weighted real exchange rate. On average, all three display a slow but distinct CHF appreciation with respect to other currencies.

3 Results

Our results depend on estimation processes, namely the descriptive and experimental regressions. We present our results in different sections emphasizing the open questions mentioned in the introduction. They concern the output gap selection and the coefficient interpretation for different samples. Implied targets for the inflation rate and policy instruments are also calculated. We further compare our results with the Taylor rule. Finally, we estimate our second model when we take into account the informational setup of the SNB.

3.1 Descriptive Estimation

In order to estimate equation (10), we use an overidentified GMM with instrumental variables coming from the SNB's information set Ω_t. We extract from this basket lagged inflation rates, lagged output gaps, lagged commodity price indices, lagged policy instruments, and lagged exchange rate gaps when we estimate the rules with an

[21] It is worth mentioning that we do not re-optimize, after each new quarterly observation, the coefficients of the Kalman filter that produces this non-corrected GDP. We assume that the SNB applies values that are calculated once for the whole estimation sample.

[22] Here is an example to illustrate this difference. In order to estimate x_e for January, February, and March, we use related series that presumably comove with monthly GDP. Accordingly, we produce each month a monthly estimate. At the end of May for example, when the quarterly value is known, these three non-corrected estimates are calibrated in order to match the quarterly observation. They now sum to it. We use them to calculate the gaps x_1 to x_5.

exchange rate term. The addition of lagged monetary aggregates (lagged call rates) as instrumental variables, while estimating rules with the call rate (a monetary aggregate) as policy instrument, does not significantly improve our results.

From an econometric point of view, this large set of instrumental variables may seem weak due to the high degree of overidentification to estimate a few coefficients[23]. This overdetermined system nevertheless offers the advantage to avoid the stock criticisms that rule-following central banks do not consider all available information when implementing their policy (Poole, 1999). On the other hand, we do not assume forward-looking variables in this information set. This motivates our approach in the next section 'Experimental Estimation', that corrects this shortcoming.

Concerning the selected leads in equation (10), we follow the textbook model: contemporaneous output gap and one-year ahead inflation rate and exchange rate gap. With monthly data, it corresponds to a lead of 12. We also estimate our rule with alternative leads having a plausible interpretation for the inflation rate. This approach is justified by the presence of long and variable lags of monetary policy effects in Switzerland, lasting sometimes three or four years for the full effect to take place (Rich, 1997). However, we think that the first signs may happen much earlier. Accordingly, we only find interesting and significant results for an inflation lead of 12 months. All estimations performed with 24, 36, and 48 months were not as significant as with 12 months. This lead indicates that the SNB reacts to one-year ahead deviations from the inflation target π^* and anticipates one-year ahead deviations of the exchange rate from its trend.

In table 2, we report all our results with a contemporaneous output gap, the twelve-month ahead inflation rate, and if any, a twelve-month ahead exchange rate gap. All reported regressions provide a good description of the chosen policy instrument for the considered sample (whole sample, before, and after 1990). We understand under a good description, significant results and a good fit of the observed policy instrument provided by our two-equation empirical setup[24].

[23] For all the reported regressions, based on Hansen (1982)-J-statistic we cannot reject the null hypothesis that overidentifying restrictions are satisfied at the 5% significance level.

[24] Goodness of fit is equivalent to the minimized sum of squared deviations ε that are equal to v and expectations errors.

Table 2: Descriptive Rule Estimation

Whole Sample 81:01-97:12

Model	α	β	γ	δ	ρ	π^*
1 $cr\ x_1$	2.56*	0.47**	0.46*	-	0.84*	2.6
2 $cr\ x_1\ s^{dm}$	2.26*	0.71*	0.57*	0.36*	0.71*	2.1
3 $cr\ x_5$	1.56*	0.75*	0.33**	-	0.88*	2.9
4 $cr\ x_5\ s^{dm}$	1.90*	0.75*	0.49*	0.37*	0.83*	2.5
5 $giro\ x_1\ s^{dm}$	9.24*	-1.82**	-2.10*	-0.99*	0.87*	3.4
6 $giro\ x_5\ s^{dm}$	14.61*	-3.80*	-1.05	-1.18*	0.88*	3.1
7 $M0\ x_1$	3.95**	-1.42*	-1.13*	-	0.84*	2.9
8 $M0\ x_1\ s^{dm}$	2.07*	-1.07*	-0.52*	-0.62*	0.35*	2.1
9 $M0\ x_5$	5.65*	-2.07*	-1.05*	-	0.80*	2.8
10 $M0\ x_5\ s^{dm}$	3.18*	-1.45*	-0.57*	-0.56*	0.41*	2.3
11 $M1\ x_1$	6.12*	-1.99*	-0.92*	-	0.75*	3.2
12 $M1\ x_5$	7.32*	-2.35*	-0.74*	-	0.77*	3.2

Before 1990 81:01-89:12

Model	α	β	γ	δ	ρ	π^*
7 $M0\ x_1$	7.04*	-2.11*	-0.68*	-	0.62*	2.9
9 $M0\ x_5$	7.04*	-2.11*	-0.68*	-	0.62*	2.9
11 $M1\ x_1$	9.36*	-1.98**	-1.56*	-	0.90*	5.2
12 $M1\ x_5$	9.36*	-1.98**	-1.56*	-	0.90*	5.2

After 1990 90:01-97:12

Model	α	β	γ	δ	ρ	π^*
2 $cr\ x_1\ s^{dm}$	2.70*	0.75*	0.43*	0.08*	0.53*	2.8
13 $cr\ x_1\ s^{us}$	2.89*	0.91*	0.48*	0.02*	0.44*	2.1
14 $cr\ x_1\ s^{all}$	3.08*	0.67*	0.53*	0.03*	0.44*	2.5

Note: Model = Model number, explained policy instrument, chosen output gap x, and chosen exchange rate gap s; s^{dm} = Real exchange rate gap (DM); s^{us} = Real exchange rate gap (US$); s^{all} = Trade-weighted real exchange rate gap; cr = Call rate; $giro$ = Growth rate of sight deposits of commercial banks; $M0$ = $M0$ growth rate; $M1$ = $M1$ growth rate. Rejection of the null hypothesis of a zero coefficient at the 1% significance level (*) and at the 5% significance level (**).

Table 2 contains only regression results using output gaps defined with Trend1 and Trend5, and alternative monetary policy instruments, call rate, sight deposits, $M0$, and $M1$[25]. Certain regressions also include different exchange rate gaps as explanatory variables.

[25] Swank and Velden (1997) found that the revealed policy instrument is the one-month Euromarket rate. Results with this rate are quite similar to the ones with the call rate. In the year 2000, it is worth mentioning that the SNB is going to officially take a flexible approach in steering the London Interbank Offered Rate (LIBOR). This rate follows the call rate without its short-term swings.

Table 3: Overview Descriptive Estimation

Best Combinations

Whole Sample		Before 1990		After 1990	
1 $cr\ x_1$	0.91	7 $M0\ x_1$	0.84	2 $cr\ x_1\ s^{dm}$	0.95
2 $cr\ x_1\ s^{dm}$	0.89	9 $M0\ x_5$	0.84	13 $cr\ x_1\ s^{us}$	0.94
3 $cr\ x_5$	0.91	11 $M1\ x_1$	0.85	14 $cr\ x_1\ s^{all}$	0.95
4 $cr\ x_5\ s^{dm}$	0.90	12 $M1\ x_5$	0.85		
5 $giro\ x_1\ s^{dm}$	0.95				
6 $giro\ x_5\ s^{dm}$	0.83				
7 $M0\ x_1$	0.88				
8 $M0\ x_1\ s^{dm}$	0.81				
9 $M0\ x_5$	0.88				
10 $M0\ x_5\ s^{dm}$	0.83				
11 $M1\ x_1$	0.75				
12 $M1\ x_5$	0.89				

Note: For each regression, we report the model number, the chosen policy instrument, and the chosen output gap. When the exchange rate gap appears, we mention it. Inflation rate is used in each regression. Second column is a measure of goodness of fit (R^2) for the estimated equation. x = Output gap definitions; s^{dm} = Real exchange rate gap (DM); s^{us} = Real exchange rate gap (US\$); s^{all} = Trade-weighted real exchange rate gap; cr = Call rate; $giro$ = Growth rate of sight deposits of commercial banks; $M0$ = $M0$ growth rate; $M1$ = $M1$ growth rate.

All regressions need the one-year ahead inflation rate. #1-4 represent regressions with the call rate as policy instrument. #5-6, #7-10, and #11-12 use different aggregates, *giro*, $M0$, and $M1$, respectively. Finally, #13-14 are models that only show up for the subsample after 1990 using the call rate with Trend1 and the three different exchange rates. We have also estimated all these models without output gap, combining inflation and exchange rate only. All equations performed poorly and are not reported[26].

[26] Results using OLS estimators in this setup, with and without output gap, are not reported as well. These results are misleadingly good. A simple regression between the call rate or $M1$ and the one-year ahead inflation rate easily gives significant coefficients. However, they do not correspond any more to our specified model. It says, and it is quite implausible, that the one-year ahead observed inflation rate equals the current expected inflation rate. Moreover, these naive regressions do not solve the identification problem when estimating reaction functions. The use of instrumental variables - or our assumptions in the experimental estimation - avoids this circularity problem, where the explanatory variables could significantly respond to changes in SNB policy. The simultaneity between the instruments of monetary policy and the targets at which they are directed has to be considered while estimating policy rules. See Black (1983) for more details and Poole (1999) for a short explanation.

Table 3 summarizes the combinations between instruments, output gaps, and exchange rate gaps, that provide the best descriptions of the considered instruments for the three samples. It also indicates the coefficient of determination R^2 for our estimations.

Our first conclusion is that the data carries well the forward-looking descriptive rule both with the call rate and monetary aggregates as policy instrument. When we split the sample, we still show that the data supports our rule but with significant improvements. The monetary base and $M1$ as instruments display the best fit before 1990. However, they do not appear after 1990, only the call rate does and moreover with the three proposed exchange rate gaps.

3.1.1 Output Gap Selection

Tables 2 and 3 only report results with output gaps based on Trend1 and Trend5. We exclude from these tables results using output gaps defined with Trend2, Trend3, and Trend4 due to poor results in performing the regressions.

We notice that the second two-sector trend performs badly. We think that the inclusion of a broken trend is appealing, but that the breaking point is not in the beginning but rather in the middle of the nineties. Moreover, it has to be a correction of the trend for the nineties and not a recalculation for the whole sample. This is confirmed by the results obtained with gap x_5.

Trend3 allows smoothing a linear trend. The central bank calculates each month a new trend and adjusts its gap definition to the newly calculated trend. However, the results are not satisfying at all for this mechanism. We are not able to state whether it comes from the gap definition or from the data. An explanation is that this constantly newly calculated trend is sensitive to the initial period (here a year) when the trend is linear. This initialization influences the trend path in the next years after implementation of this mechanism. A second more intuitive explanation is that this procedure reveals a positive gap in the beginning of the eighties and then sticks to a negative gap. Both humps do not fit to the stylized facts for the chosen sample.

We finally remove the fourth gap produced by the stochastic trend after HP filtering, that allows isolating and considering the cyclical part of the business cycle as a gap. This gap displays too much noise that disturbs the coefficient estimation[27].

We discover that good descriptions of the different instruments are only possible because the selected output gaps display a positive hump in the beginning of the nineties in order to catch the increase in the call rate or the slowdown in the monetary growth over this period. Discarded gaps are the ones that do not display this feature. Definition and uncertainty concerning output gaps are important issues when estimating rules. With five different gaps, we show that our rule is not robust with respect to the different definitions used in the regressions[28]. However, we are not able to precisely decide whether Swiss data or the five tested configurations are the criterion for sorting out the output gaps. We would incline to the data.

3.1.2 Lean-Against-the-Wind Policy and Exchange Rate

All reported coefficients in table 2 are in the sign range according to the theory and all coefficients are significant. We expect positive coefficients with the call rate and negative coefficients with monetary aggregates as policy instrument. With both policy instruments, these signs correspond to a lean-against-the-wind policy for the three explanatory variables. All other things being equal, the SNB raises the call rate or lowers the growth of its aggregates, when the inflation rate is above the implied inflation target rate, when output gap is positive, or when the exchange rate appreciates above its trend. A few other models (not reported) also display significant coefficients with signs that do not correspond to this lean-against-the-wind policy. Moreover, we eliminate them because they all show a weaker explanatory power of policy instruments than the reported results.

For the whole sample 1981-1997, we see that models with the call rate and monetary aggregate $M1$, but without exchange rate, appear as the best ones (#1, 3, and 12). Comparing call rate models with $M1$ models reveals that setups using the call rate perform slightly better. Based on these results, we see for example that the SNB raises the call rate when the inflation rate or the output deviate from their trend. All other things being equal, after an increase in the inflation rate by 100 basis points above the target rate, the SNB raises the call rate by 50-80 basis points. Concerning the output gap,

[27] Similarities in spectra between explained and explanatory variables are required to potentially explain the different policy instruments.

[28] See Smets (1998) for more details about a similar analysis.

after an increase by 1%, the SNB raises the call rate by 30-50 basis points.

When we add the different exchange rates for the same sample, we see that the performance of the call rate models does not significantly change and that it becomes even worse with monetary aggregates. Exceptions are models #5-6 using the sight deposits, that only appear with an exchange rate element. Considering the whole sample, the addition of an exchange rate element does not improve the regressions.

When we split the sample, we see that models using the call rate do not show up for the period before the break. However, they are the best regressions for the period after 1990. Before the break, significant regressions are the ones using aggregates, $M0$ and $M1$, with the latter showing a slightly more powerful explanation. It seems that the SNB, especially during the period when it was crucial to target each year the adjusted monetary base, was systematically focusing on these aggregates. It is worth mentioning that, neither with the base nor with $M1$, the exchange rate appears before 1990 as a significant explanatory variable. However, in the nineties after the new announcement policy, the SNB seems to lead the call rate in a systematic fashion, while models using aggregates do not show up. Moreover, only call rate models with an exchange rate element - and it is true for the three tested exchange rates - are able to picture the call rate during this period.

A potential explanation for the presence of the exchange rate in the rule after 1990 is a historical perspective. In the nineties, due to more integrated economies and external exchange rate market turbulences, the SNB had to focus on the external value of the CHF in order to stabilize its two traditional goal variables, inflation and growth. These financial turbulences moreover call for a change in the followed instrument (Poole, 1970). Accordingly, our regressions reveal a switch to short-term interest rates management. These regressions also confirm the increasing flexibility in the policy management after the new announcement policy in the beginning of the nineties.

The impossibility to make out the two output gaps x_1 and x_5 for the whole sample is here clearer for the period after 1990, because only the output gap x_1 appears, while results are quite similar between x_1 and x_5 before 1990.

The quantitative reactions of $M0$ or $M1$ growth rates are almost the same over the period before 1990. The SNB decreases these rates by approximately 200 basis points, in case of an increase in inflation by 100 points above the target rate. It decreases the growth rate by 70-150 points after an increase in the output gap by 1%. For the period after 1990, the call rate feeds back from the three exchange rate gaps. The models with s^{dm} or s^{all} perform better than the US$ model. For the DM model, all other things being equal, alternatively after increases by 100 points above target in inflation, output gap, or exchange rate gap, the SNB raises the call rate by 75, 50, and 10 points, respectively. These values are for the US$ model 90, 40, and 2, and for the trade-weighted real exchange rate model 70, 50, and 3. We expect that the call rate reacts more to single currencies than to pooled currencies. There is a kind of risk diversification using the pooled currencies. This is verified for the DM, but not for the US$.

The size of reaction to inflation expectations calls for a last comment. Because we do not focus on their ability to rule out bad outcomes as self-fulfilling burst of inflation, we cannot ensure that the estimated rules are not themselves a source of endogenous instability for the Swiss economy. This is not clear whether the monetary authority, especially with the call rate, has to overreact to inflation expectations, in order to induce for example a decrease in the real interest rate. The recent literature about such an issue (Christiano and Gust (1999), Clarida, Gali and Gertler (1998a), and Taylor (1999)) unfortunately offers no solution for small open economies.

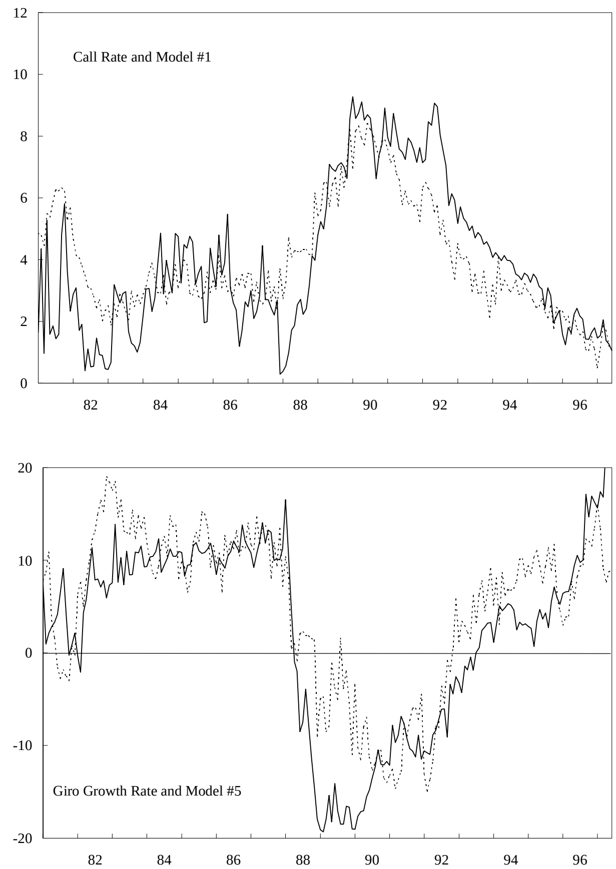
3.1.3 Implied Inflation and Instrument Target

Based only on regression results, it is difficult to further discriminate the models. To do this, we especially focus on the implied inflation targets and instrument targets[29]. Using the constant term from the regression, we can extract an implied inflation target π^* that is the target rate that the bank has presumably targeted. We see that the implied inflation targets based on models #1 and 8 are more appropriate than the other ones due to too high rates. π^* equals on average 2.1% for the whole sample. For the period before 1990, we see that the target inflation rates are implausible for models using $M1$ and more realistic for $M0$ with 2.9%. After 1990, values are plausible with the model #13 implying a rate of 2.1% as for the

[29] In this descriptive setup, implied inflation target π^* is a single value for the considered sample. Implied policy instrument target w_t^* is a monthly series.

whole sample[30].

Figure 4: Observed Instrument and Implied Target Whole Sample



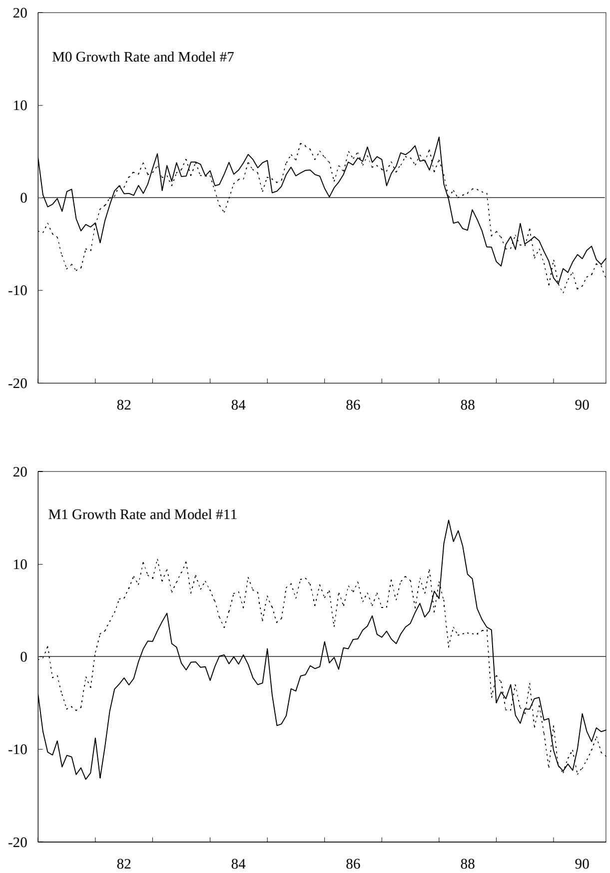
Note: All variables in percentage. Observed instrument (solid line); implied target (dashed line).

Another useful indicator to analyze our models are the implied instrument targets. Figure 4, 5, and 6 show different instrument targets w_t^* for some models described in table 2. These figures illustrate the goodness of fit mentioned in the previous sections. The gap

[30] We assume a nominal interest rate of 3.8% being the mean of the one-month Euromarket interest rate. Before 1990 we use 3% and after 1990 4.8%. To retrieve inflation rate targets with aggregate instruments, we use average growth rates. For the whole sample, before, and after 1990, these values are for the deposits 2.90, 4.60, 1.00, for $M0$ -0.20, 0.80, -1.40, and for $M1$ -0.40, -1.10, 0.30%.

between two curves is given by $w_t - w_t^* = v_t + \rho\,(w_{t-1} - w_t^*)$. This gap consists of the shock v_t and a fraction ρ of the gap $w_{t-1} - w_t^*$ between the observed instrument from last period and the current target. $\rho\,(w_{t-1} - w_t^*)$ represents the gap $\hat{w}_t - w_t^*$ between the fitted value given by equation (8) and the instrument target.

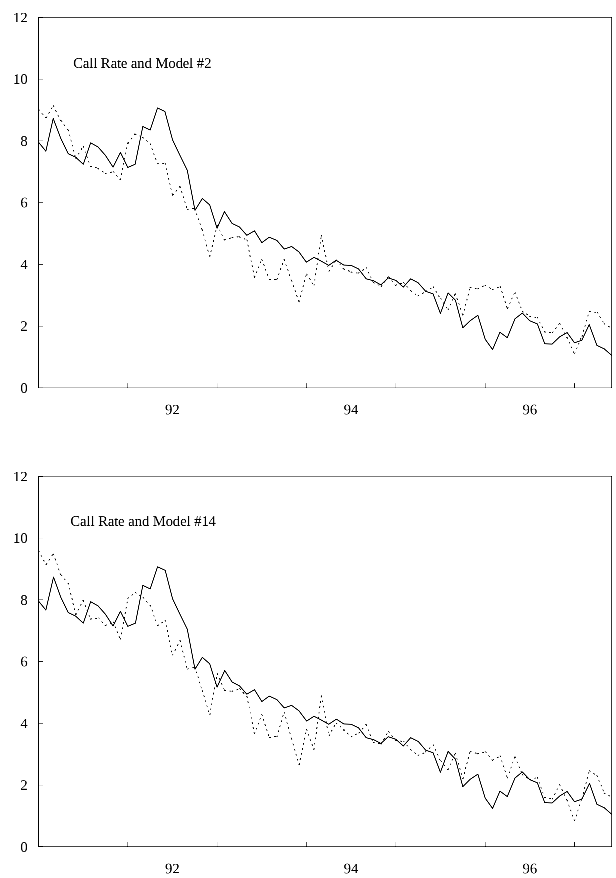
Figure 5: Observed Instrument and Implied Target Before 1990



Note: All variables in percentage. Observed instrument (solid line); implied target (dashed line).

ρ indicates how the central bank controls its instrument. We see mixed evidence that narrow defined aggregates provide lower ρ corresponding to a better control than broader defined aggregates. We think now that the assumption to use ρ as a control indicator is too strong. It is more plausible to assume that ρ catches, in addition to this control indicator, other influences which are not observed. The more persistence we have ($\rho \to 1$), the further w^* has to be from the fitted value $\hat{w}$ which closely follows the observed policy instrument.

Figure 6: Observed Instrument and Implied Target After 1990



Note: All variables in percentage. Observed instrument (solid line); implied target (dashed line).

3.1.4 Taylor Rule

It is interesting to compare the goodness of fit of our regression (9) with the so-called Taylor rule. We consider the original Taylor (1993) rule with inflation and output gaps as explanatory variables[31]. This rule does not deliver a fit with Swiss data as good as our descriptive rule. The calibrated version, without exchange rate and with elasticities of 0.5 for inflation and output deviations, cannot satisfactorily describe the call rate in Switzerland. However, when we do not constrain these coefficients to 0.5 and estimate them, we obviously improve the fit of the regression, but not as much as our first regressions do. It is no better, still in terms of goodness of fit, with the more aggressive coefficients recently suggested by Taylor (1999)[32].

3.2 Experimental Estimation

For our second estimation we use OLS. Moreover, we assume that the explanatory variables are defined such as to avoid the circularity problem between policy targets and instruments. We perform this analysis only for the period 1990-1996 due to data availability. All regressions use the output gap defined as x_e, the expected inflation gap based on expectations and goals of the SNB[33], and finally the exchange rate gap based on the assumption that the SNB focuses on an appropriate value for its goals[34].

The results are reported in table 4. We see that models #15-16 perform well and display significant coefficients. Model #15 using the call rate performs best. Moreover, the size of its coefficients corresponds more or less to the descriptive model #2. Surprisingly, the sight deposits appear as a significant instrument in this experimental estimation. Taking into account the informational setup of the SNB, it seems that the sight deposits are still a revealed policy instrument. We interpret the presence of both deposits and call rate as a sign for a progressive change in the used instruments, stating their use as short-term operational instrument. For comparison, when we

[31] We do not consider alternative Taylor rules estimated either with instrumental variables or with additional variables in order to find the inflation and output elasticities. See McCallum (1999) for a survey.

[32] See the survey paper of Kozicki (1999) about the usefulness of traditional Taylor rules. It strengthens both our forward-looking assumption and our recommendation to use NFR as an informative and descriptive device only.

[33] Figures taken from the SNB's Quarterly Bulletin. This series is given annually, because the SNB does not publish inflation targets and expectations each month.

[34] Assuming q^* constant over time corresponds to an intercept change in the estimation. This value does not significantly influence the reported results.

described the situation ex-post, only the call rate appeared as a significant instrument for this subsample. Moreover, we see that models using $M0$ and $M1$, as in the descriptive setup, do not perform well.

Table 4: Experimental Rule Estimation

After 1990 90:01-96:12

Model	$\tilde{w}$	β	γ	δ	ρ
15 cr x_e s^{dm}	5.11*	0.74*	0.47*	0.23*	0.71*
16 $giro$ x_e s^{dm}	-1.02	-2.64*	-1.76*	-0.39**	0.69*
17 $M0$ x_e s^{dm}	-2.63**	-0.74	-0.71*	-0.14	0.61*
18 $M1$ x_e s^{dm}	-0.35	-2.03*	-1.17*	-0.22	0.56*

Note: Model = Model number, explained policy instrument, chosen output gap x, and chosen exchange rate gap s; s^{dm} = Real exchange rate gap (DM); cr = Call rate; $giro$ = Growth rate of sight deposits of commercial banks; $M0$ = $M0$ growth rate; $M1$ = $M1$ growth rate. Rejection of the null hypothesis of a zero coefficient at the 1% significance level (*) and at the 5% significance level (**).

The significance of x_e calls for a last comment. We note that the difference between corrected (used for x_1-x_5) and non-corrected GDP (used only for x_e) is marginal in terms of influence on the coefficients. Both series are similar focusing on their moments in growth rate. This impression confirms the sentiment that the difference between descriptive and experimental estimations essentially comes from the treatment of expected variables - for the inflation and exchange rate - so indirectly from estimation processes.

To further discriminate between models #15-16, we analyze how they perform in terms of forecasting for the year 1997. The model with the call rate performs better than the model using the sight deposits. The mean-absolute-percentage error are 30 and 34%, respectively for dynamic forecasting[35]. This gives more weight to the descriptive revelation of the call rate.

4 Conclusion

In order to describe the SNB's behavior by a rule, we have estimated and analyzed several rules for the samples 1981-1997, before, and after 1990. A thorough explanation of the movements of various policy instruments requires a forward-looking rule. It consists of a

[35] Mean absolute percentage error: $\frac{100}{h-1}\sum_{i=s+h}^{h}\left(\frac{\hat{w}_t - w_t}{w_t}\right)$.

one-year ahead inflation gap and a contemporaneous output gap, both defined as deviation from trend. In order to catch the policy instrument dynamics, an exchange rate element is not necessary for the whole sample and for the period before 1990. However, in the subsample after 1990, mainly due to disturbed financial markets, the rule has to include a one-year ahead exchange rate gap. We have chosen the real DM exchange rate gap, the real US$ gap, and a trade-weighted exchange rate gap, all defined as deviation from trend.

We see that this rule accurately explains the behavior of the call rate as a policy instrument for the whole sample and after 1990. Monetary aggregates are also significantly described by the rule in the whole sample study. Moreover, before 1990 only monetary aggregates $M0$ and $M1$ show up.

This rule is not robust with respect to the different output gap definitions we applied. More precisely, we notice that the rule predicts movements in the policy instruments only with the use of output gaps displaying a large positive gap in the beginning of the nineties. This hump justifies the sustained restrictive policy stance during this period. It is thus tempting to conclude that the observed high degree of restrictiveness fed into the broken trend of GDP growth. We do not make this step. First, the causality between these two variables is still an open and complex question. Second, our model is certainly built on and clearly supports the assumed causality from output gap to policy instrument. Third, there are alternative definitions for the output gap we do not include in our analysis, that may deeply influence this conclusion. Yet it clearly shows that the output gap definition is relevant to estimate rules, and particularly in Switzerland.

Our estimations reveal a distinct break in the conduct of the SNB's policy in the beginning of the nineties. After 1990, the Swiss monetary authority seems to use the call rate in a systematic way instead of the monetary base as suggested by the medium-term target paths. We think it is partially due to the new announcement policy that allows for more freedom in the conduct of monetary policy. The former announcement policy used to place tight limits on the ability of the SNB to respond to unforeseen circumstances. It was practically impossible to monitor a more appropriate instrument than the one described by the annual targets.

Despite the difficulty of the task, we have finally recreated the informational situation the SNB faces when it implements monetary policy, to see if the ex-post descriptive rule is robust. The results are good in terms of fitting and forecasting with the call rate as an instrument after 1990. It indicates that the descriptive estimated rules are a good indicator of past SNB policy.

However, if this rule is ever to fulfill all the hopes - the demonstration of its superiority against alternative policies - we pin on it, further normative research is needed in the evaluation of this rule and in its implications for the Swiss economy. This requires new tools as general equilibrium models for small open economies with frictions, as sticky prices or limited participation, that generate monetary short-term nonneutrality.

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Appendix

Appendix A Central Bank Optimization

We derive the rule (1) based upon the Walsh (1998) textbook model[36]. Variables are price level p, output gap x, exchange rate gap s, and two interest rates, real r and nominal i. e and u are iid disturbances with joint distribution $N(\mathbf{0}, \mathbf{I})$. We assume that $E_{t-1}(p_t)$ and foreign variables are constant and normalized to zero for convenience. We also assume $w = i$[37]. Equations (3') and (6') are now expressed with the price level instead of its changes over time.

$$\begin{aligned} x_t &= -b_1 s_t + b_2 (p_t - E_{t-1}(p_t)) + e_t && (3') \\ x_t &= a_1 s_t - a_2 r_t + u_t && (4) \\ s_t &= E_t(s_{t+1}) - r_t && (5) \\ r_t &= i_t + p_t - E_t(p_{t+1}) && (6') \end{aligned}$$

The SNB commits to a stage contingent sequence for x_{t+i} and p_{t+i}. It maximizes the negative of its loss function $-\frac{1}{2}E_t\left(\sum_{i=0}^{\infty}\theta^i\left(a^\circ x_{t+i}^2 + b^\circ p_{t+i}^2\right)\right)$ subject to equations (3')-(6'). We form the Lagrangian $\mathcal{L}$ with multiplier ϕ and derive its first-order conditions (FOC).

$$\begin{aligned} \mathcal{L} &= -\frac{1}{2}E_t\left(\sum_{i=0}^{\infty}\theta^i\left(a^\circ x_{t+i}^2 + b^\circ p_{t+i}^2\right)\right) \\ &\quad -\frac{1}{2}E_t\left(\phi_{t+i}\theta^i\left(p_{t+i} - \frac{1}{b_2}x_{t+i} - \frac{b_1}{b_2}s_{t+i} + \frac{1}{b_2}e_{t+i}\right)\right) \end{aligned}$$

FOC1

$$\begin{aligned} x_{t+i} &: -\frac{1}{2}E_t\left(\theta^i 2a^\circ x_{t+i}\right) - \frac{1}{2}E_t\left(\phi_{t+i}\theta^i\left(-\frac{1}{b_2}\right)\right) = 0 \\ &: \phi_{t+i} = 2a^\circ b_2 x_{t+i} \end{aligned}$$

FOC2

$$\begin{aligned} p_{t+i} &: -\frac{1}{2}E_t\left(\theta^i 2b^\circ p_{t+i}\right) - \frac{1}{2}E_t\left(\phi_{t+i}\theta^i\right) = 0 \\ &: \phi_{t+i} = -2b^\circ p_{t+i} \end{aligned}$$

FOC3, from FOC1 and FOC2

$$p_{t+i} = -\frac{a^\circ b_2}{b^\circ}x_{t+i}$$

Finally, we plug FOC3 in aggregate demand (5), setting $u_t = 0$:

$$\begin{aligned} i_t &= E_t(p_{t+1}) + \frac{(a_1 + a_2)\,a^\circ b_2 - b^\circ}{b^\circ (a_1 + a_2)}x_t + \frac{a_1}{(a_1 + a_2)}E_t(s_{t+1}), \\ i_t &= \alpha_1 E_t(p_{t+1}) + \alpha_2 x_t + \alpha_3 E_t(s_{t+1}), \end{aligned}$$

where $\alpha_1 = 1$ is implied by the textbook model (constants omitted).

[36] Chapter 6, page 269.

[37] We get a similar rule with a monetary aggregate as policy instrument and a money demand function in the model.