Measurement Errors in GDP and Forward-Looking Monetary Policy: The Swiss Case

Peter Kugler, WWZ Universität Basel

Thomas Jordan, SNB Zürich

Carlos Lenz, WWZ Universität Basel

Marcel Savioz, SNB Zürich

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very preliminary, please do not quote

1. Introduction

After 25 years of monetary targeting, the Swiss National Bank (SNB) adopted a new monetary policy framework at the end of 1999. Severe shocks to the demand for central bank money, especially for large denominated bank notes and for reserves held by commercial banks at the SNB, rendered it impossible to use the medium-term target path for the seasonally adjusted monetary base as a guideline for monetary decisions. Since also the demand for the broader money aggregate suffered from an insufficient stability, the SNB decided to abandon monetary targeting.

The new framework consists of three elements. The first element is an explicit definition of price stability. The SNB regards price stability as achieved if CPI inflation is below 2 percent. The second element consists of the use of an inflation forecast as the main indicator to guide monetary policy decisions. The third element is a target range for the 3M-Libor as an operational target to implement monetary policy. Money aggregates continue to be important, but they are used as information variables rather than as intermediate targets. As in the old concept, maintaining price stability over the medium term remains the main objective of monetary policy also in the new framework.

The SNB strategy shares some elements with inflation targeting. However, it also differs from it in some important respects. The strategy has no inflation target. Rather, the SNB's concept knows a definition of price stability. The SNB has no obligation to keep inflation under all circumstances and all costs in the range of price stability. Also, the time horizon to bring inflation back in the range of price stability after an inflationary shock is not pre-specified. The SNB analyses each situation individually and decides depending on the current economic conditions. Contrary to countries pursuing an inflation targeting strategy, the SNB has great independence regarding the exact definition of price stability and the policy reaction if inflation is outside the objective.

In the new framework, the inflation forecast serves as the main indicator for guiding policy decisions. Although there is no mechanical reaction to the inflation forecast and the inflation forecast is not treated as an intermediate target, the discussion about monetary policy is focused on the inflation forecast. The forecast used in the decision making process is a consensus forecast, which is derived from a series of models and indicators. The SNB started recently to publish studies regarding these models. Jordan and Peytrignet (2001) delivered an introduction to the inflation forecast of the SNB and the models used to derive it. Stalder

(2001) presented the large traditional structural macro model of the SNB and Jordan, Kugler, Lenz and Savioz (2002) provided an overview over the different VAR approaches used at the SNB.

Since the inflation forecast is crucial for policy decisions, the process of forecasting inflation became very important in the new framework. The forecasts published by the SNB semi-annually always assume unchanged nominal interest rates at the current level over the whole forecasting horizon. For internal use and the decision making process, however, there is also a need for different types of forecasts or simulations. Forecasts are for instance also conducted by assuming that the interest rate is adjusted according to an estimated reaction function of the type of a traditional backward-looking Taylor rule.

Forecasts in which the interest rates are adjusted according to a forward-looking rule with an inflation and an output target are becoming increasingly important. A crucial question is which weight should be given to these different targets in order to improve the overall monetary objective of the SNB of maintaining price stability and at the same time to have low variability of inflation and output. Using rules with inflation and output targets for simulations and forecasting does not imply that the SNB actually pursues an inflation targeting strategy or an output targeting strategy. Rather, the results from these simulations and forecasts are taken into account in the context of the framework explained above and provide an important input to the monetary policy decision making process.

For the purpose of applying forward-looking rules, a small structural VAR consisting of four variables was developed by Kugler and Jordan (2000) and Kugler and Rich (2002). This paper is an extension of this research and addresses three important issues. First, given the setup of no measurement errors, the paper analyzes the inflation/output volatility trade off for a forward-looking policy aiming at a convex combination of an inflation and an output growth target implied by this SVAR model. Second, the paper considers the effect of measurement errors in GDP on this inflation/output volatility trade-off. Third, the paper analyzes to what extent a bias in the estimate of the potential growth rate affects the variability of output and inflation. The paper introduces an analytical method based on the parameters of the impulse response function to solve these questions for the SVAR models. This can be seen as a methodological innovation.

There are three main results of the paper. First, without measurement errors, we obtain a standard convex efficiency frontier for the conditional (time T) variance of K period ahead average inflation and growth. Second, if measurement errors in GDP are taken into account, there is no longer a convex efficiency frontier: Decreasing the weight of the output target from 1 to approximately 0.65 decreases the conditional variance of inflation and growth. This result is due to the fact that with measurement errors monetary policy reacts too much to noisy data if the weight on output is big as the measurement error has a strong impact on the growth forecast but not on the inflation forecast. The third result shows that this effect of measurement errors is reinforced if there is a bias in the estimate of potential output growth: For a bias of 0.25 percent per annum we have an increase of both the conditional variance of both inflation and growth if the weight of the output target increases from 0 to approximately 0.5. Monetary policy reacts to a wrong signal - similarly as to the measurements errors - and thereby increases the variability of both inflation and output. In general, the paper indicates that under realistic assumptions by concentrating on output growth, the central bank induces higher output and inflation variability.

The remainder of the paper is organized as follows. Section 2 sets up the SVAR model for the analysis of Swiss monetary policy. In section 3, the inflation/growth trade off is determined in the absence of measurement errors. Measurement errors are taken into account in Section 4 and the impact of a bias in the estimation of potential output is analyzed in Section 5. Section 6 concludes.

2. A SVAR Analysis of Swiss Monetary Policy

In this section we give a brief account of the framework used for policy analysis. The VAR model includes a vector of changes in the following four variables:

$$x_t' = (\Delta \log p_t, \Delta \log y_t, \Delta \log m_t, \Delta r_t),$$

where p denotes the consumer price index, y is GDP in 1990 Swiss francs, m the money stock M1 and r the quarterly average of the three-month Swiss-franc Libor rate of interest. In order to keep the model as lean as possible, the exchange rate is excluded from the vector x. This may appear inappropriate as Switzerland is clearly a small open economy, with the exchange rate playing an important role. However, the transmission of monetary policy via the exchange rate is indirectly captured by the impulse responses of the VAR model. Explicit inclusion of the exchange rate would be necessary if this variable had influenced SNB behavior in a systematic way and, therefore, were required to identify a monetary policy shock. Although exchange rate considerations played an important role from time to time, notably in 1978/79, this was not true for the bulk of the sample period. Finally, we should mention that the standard unit-root and co-integration tests support the first-difference specification adopted in this paper.[1]

The VAR model contains structural short- and long-run restrictions in order to identify a monetary policy shock with a variance normalized to 1. First, there are four restrictions essential in the short run. They ensure that the monetary policy shock and the interest rate shock do not affect consumer prices and GDP contemporaneously. A sluggish response in prices and output seems to be a reasonable assumption for quarterly macroeconomic data. Second, the monetary policy shock as well as the price and the interest rate shocks are assumed to leave real GDP unchanged in the long run. Moreover, monetary policy and price shocks have no long-run effect on the interest rate. These restrictions imply that the dynamic effects on real GDP of consumer prices, money and the interest rate are offsetting in the long run, and that the same is true for the impact of prices and money on the interest rate (long-run neutrality of money).

All the variables included in the model are seasonally adjusted with the exception of the interest rate. The lag length k was set to five quarters, which is the optimal value according to the Akaike criterion. Before turning to the impulse response estimates, let us briefly mention that the LR test statistic for the null hypothesis of the overidentifying restrictions is 6.98. Under the null hypothesis, this statistic has a chi-square distribution with five degrees of freedom. Therefore, these restrictions cannot be rejected at any reasonable significance level.

Figure 1 shows the estimates for the cumulated impulse responses of the four (level) variables to the monetary policy shock. In order to get the required information, we run 1000 bootstrap replications of the OLS residuals corrected for their heteroscedasticity. The various panels in figure 1 show the median as well as the 5 and the 95 percent quantile of these replications. By and large, these response estimates correspond to the views held by most macroeconomists in Switzerland about the effects of monetary policy. First, there is evidence

1 It should be noted that we do not select a monetary aggregate with a stable long-run money demand function in levels such as M3. We are only interested in a money stock concept providing a lot of information for the identification of a monetary policy shock. The monetary base was not used as the introduction of the electronic Swiss Interbank Clearing System and the relaxation of banks' liquidity requirements in 1978 and 1988, respectively, strongly distorted even the rates of change in this aggregate.

of a short-run negative liquidity effect on the interest rate extending over four quarters. The positive reaction in real GDP[2] starts after a year, reaches its peak after two years and peters out after another year. With respect to prices, it takes six quarters until a major positive effect is felt and 14 quarters are needed for full adjustment of prices. After about the fourth quarter, rising prices and inflation expectations cause the interest rate to overshoot temporarily its long-run equilibrium level.

Swiss monetary policy can now be analyzed by deriving conditional forecasts from the SVAR model. Specifically, we determine a sequence of policy shocks required to satisfy such conditions as an average inflation target over a three-year period. Before we turn to this exercise in detail, we have to discuss briefly the appropriateness of our approach.

First, it might be argued that the change in the SNB's monetary regime, as outlined above, invalidates the use of a model fitted to data generated by a different monetary environment. However, we believe that this problem is unimportant in the present context. Price stability remained the ultimate objective of Swiss monetary policy throughout the sample period. Moreover, though the SNB adjusted its operating procedures at the end of 1999, this modification did not cause a break in the time series process of the variables considered in our SVAR model: Bank reserves, used as the main policy instrument before 1999, and the interest rate on repos, the principal new instrument, are not included in our VAR system.

Second, the monetary shocks generated in a simulation should not display a systematic pattern and should not be unusually “large”. Otherwise they are subject to the Lucas (1976) critique, as we may expect a shift in the behavior of private agents in the light of such unusual changes. In the words of Leeper and Zha (1999), the policy interventions considered should be “modest”. To this end, we use a statistic similar to that proposed by Leeper and Zha[3], i.e., the mean of all policy shocks over the K forecasting periods:

$$\eta(K,T) = \sum_{i=1}^{K} u_{3T+i} / K$$

[2] The negative impact of a monetary shock on real GDP in the subsequent quarter does not seem to be very plausible. However, this result may be caused by a temporary depreciation of the real exchange rate following a shift to an expansionary monetary policy.

[3] These authors use a specification based on the dynamic effects of the policy shocks to all variables of the system. While the Leeper-Zha specification is very similar to that employed here, it seems unnecessarily complicated. Furthermore, the chi-squared distribution of the sum of squared shocks under the null is used as an additional test.

If the mean is statistically different from zero, the policy shocks exhibit a systematic pattern with regard to the average sign of the shocks. Moreover, we may test that the size is too "large" by calculating the sum of the squared policy shocks:

$$Q(K,T) = \sum_{i=1}^{K} u_{3T+i}^2$$

If the policy interventions are not at odds with empirical evidence drawn from the sample, the first expression is distributed with expected value zero and variance $1/K$, whereas the second expression is chi-squared with K degrees of freedom (Recall that the shock has a unit variance). This hypothesis is easy to test given a sequence of policy shocks obtained by conditioning on a certain policy approach.

Now consider a monetary policy strategy based on an average inflation forecast for the next K quarters. Take the example of a monetary policy reacting symmetrically to positive and negative deviations from the inflation target π^* measured at a quarterly rate. For such a monetary policy, we get conditional forecasts in the following way: First let us define the expected deviation of the price level from target:

$$d_p(K,T) = (\log p_T + K\pi^*) - E_T \log p_{T+K} \, ,$$

Next we have to determine the sequence of monetary shocks from $T+1$ to $T+K$ that leads to an expected price level which is equal to the target price level in period $T+K$. Of course there are infinitely many ways to calculate these shocks. A natural approach is to minimize the sum of the squared shocks subject to the restriction that the impulse response of the price level to these shocks in $T+K$ is $d_p(K,T)$:

$$\sum_{i=1}^{K} u_{3T+i}^2 \rightarrow \min$$
$$\sum_{i=1}^{K} AA_{13}(K-i)u_{3T+i} - d_p(K,T) = 0$$

where *AA (j)* is the matrix of the impulse response, cumulated over *j* periods. Thus, the element 1,3 of this matrix gives the *j* period response of the price level to a monetary shock.

The solution of this minimization problem is easily obtained as

$$u_{3T+i} = \frac{AA_{13}(K-i)}{\sum_{j=0}^{K-1} AA_{13}^2(j)} d_p(K,T) = g_{pi} d_p(K,T)$$

Finally we calculate conditional forecasts given these future values of the monetary shock using our SVAR model. In the remainder of the paper, we call a rule within our SVAR approach based exclusively on an inflation target a strategy of strict inflation targeting.

Of course, we can apply the same approach as outlined before using the average output growth as a target of monetary policy. Assume that the growth rate aimed at is denoted by $\gamma *$. Again we define first the deviation of the unconditional (all future shocks are assumed to be zero) forecast of the output level from target *K* periods ahead:

$$d_y(K,T) = (\log y_T + K\gamma *) - E_T \log y_{T+K}$$

The application of the same approach as applied for the price level provides us with the following optimal (in the least squares sense) policy shocks for *T+1* to *T+K*:

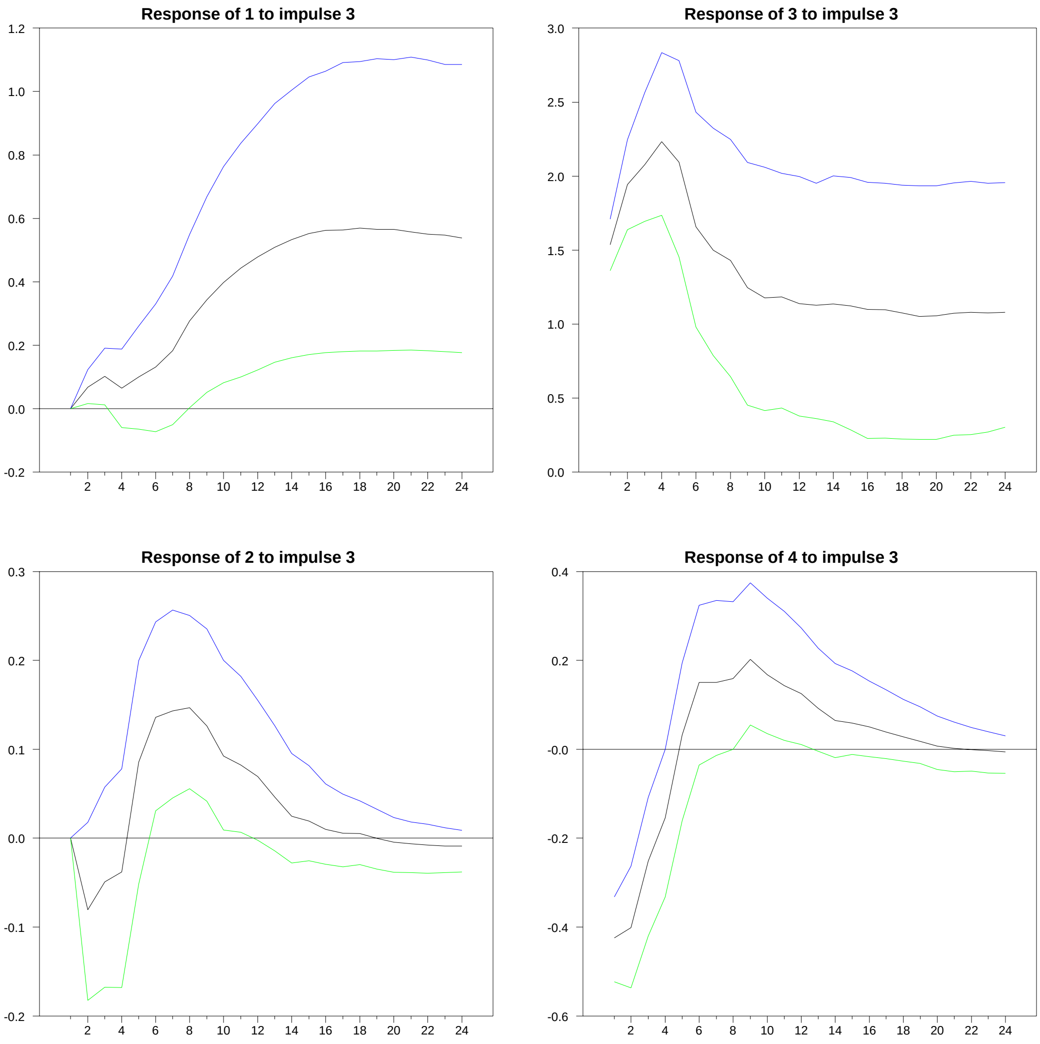
$$u_{3T+i} = \frac{AA_{23}(K-i)}{\sum_{j=0}^{K-1} AA_{23}^2(j)} d_y(K,T) = g_{yi} d_y(K,T)$$

In what follows, we call a rule within our SVAR approach based exclusively on an output target a strategy of strict output targeting.

Figure 1: Impulse response of key macroeconomic variables to a monetary policy shock: SVAR(5), quarterly data 1974/I-2001/IV,

Median and 5% and 95% quantile of 1000 bootstrap runs

Consumer prices (1) **Money M1 (3)**



GDP (2) **Interest rate (4)**

3. The Effect of Structural Shocks on Inflation and Growth Rate Volatility

In this section we consider the trade off faced by monetary policy in the framework of our SVAR model. To this end we consider the variability of inflation and output growth implied by different degrees of inflation and output growth targeting over the K period horizon. To start with we define a convex combination of the monetary policy shocks for strict inflation or output growth targeting derived in the last section:

$$u_{3T+i} = \alpha g_{pi} d_p(K,T) + (1-\alpha) g_{yi} d_y(K,T), \qquad i = 1,...K$$

These are the optimal policy shocks if the rule weights the inflation with α and output with $1-\alpha$. Of course for $\alpha = 1$ we have the case of strict inflation targeting and for $\alpha = 0$ we follow a strict output growth targeting. Now let us see how the log price and log output levels react to this sequence of shocks. The net effect of the policy shocks is the response to the policy shocks minus the forecasted deviation from target induced by the three non-policy shocks at *T*. These effects can be easily calculated using the corresponding cumulated impulse responses and the formulae for the two strict targeting shocks given in the last section:

$$\begin{aligned}
rp_{T+K} &= \sum_{i=1}^{K} AA_{13}(K-i) u_{3T+i} - d_p(K,T) \\
&= \sum_{i=1}^{K} \left[\alpha \frac{AA_{13}(K-i) AA_{13}(K-i)}{\sum_{j=0}^{K-1} AA_{13}^2(j)} d_p(K,T) + (1-\alpha) \frac{AA_{13}(K-i) AA_{23}(K-i)}{\sum_{j=0}^{K-1} AA_{23}^2(j)} d_y(K,T) \right] - d_p(K,T) \\
&= \alpha d_p(K,T) + (1-\alpha) G_y d_y(K,T) - d_p(K,T) \\
&= -(1-\alpha) \left[d_p(K,T) - G_y d_y(K,T) \right]
\end{aligned}$$

$$ry_{T+K} = \sum_{i=1}^{K} AA_{23}(K-i)u_{3T+i} - d_y(K,T)$$

$$= \sum_{i=1}^{K} \left[\alpha \frac{AA_{23}(K-i)AA_{13}(K-i)}{\sum_{j=0}^{K-1} AA_{13}^2(j)} d_p(K,T) + (1-\alpha) \frac{AA_{23}(K-i)AA_{23}(K-i)}{\sum_{j=0}^{K-1} AA_{23}^2(j)} d_y(K,T) \right] - d_y(K,T)$$

$$= \alpha G_p d_p(K,T) + (1-\alpha) d_y(K,T) - d_y(K,T)$$

$$= -\alpha \left[d_y(K,T) - G_p d_p(K,T) \right]$$

The deviation of the K period ahead log price and log output level from the target path is revised every period according to the shocks hitting the economy. This, in turn leads to a revision of the monetary policy shock sequence and leads to monetary policy caused variability of the K-period ahead change of the log price and log output level. In order to calculate this variability, we first note that the deviations of the unconditional forecasts from their targets are given by:

$$d_p(K,T) = -\sum_{l \neq 3} AA_{1l}(K) u_{lT}$$
$$d_y(K,T) = -\sum_{l \neq 3} AA_{2l}(K) u_{lT}$$

where we assume that the policy shock is equal to zero as of time T.

Substituting these expressions into the responses of the price and output levels to the policy shocks yields:

$$rp_{T+K} = (1-\alpha) \sum_{l \neq 3} \left[AA_{1l}(K) - G_y AA_{2l}(K) \right] u_{lT}$$

$$ry_{T+K} = \alpha \sum_{l \neq 3} \left[AA_{2l}(K) - G_p AA_{1l}(K) \right] u_{lT}$$

The corresponding conditional variances (given information of time *T-1*) are given by the following expressions:

$$Var_T(rp_{T+K}) = (1-\alpha)^2 \sum_{l \neq 3} \left[AA_{1l}(K) - G_y AA_{2l}(K) \right]^2$$
$$Var_T(ry_{T+K}) = \alpha^2 \sum_{l \neq 3} \left[AA_{2l}(K) - G_p AA_{1l}(K) \right]^2$$

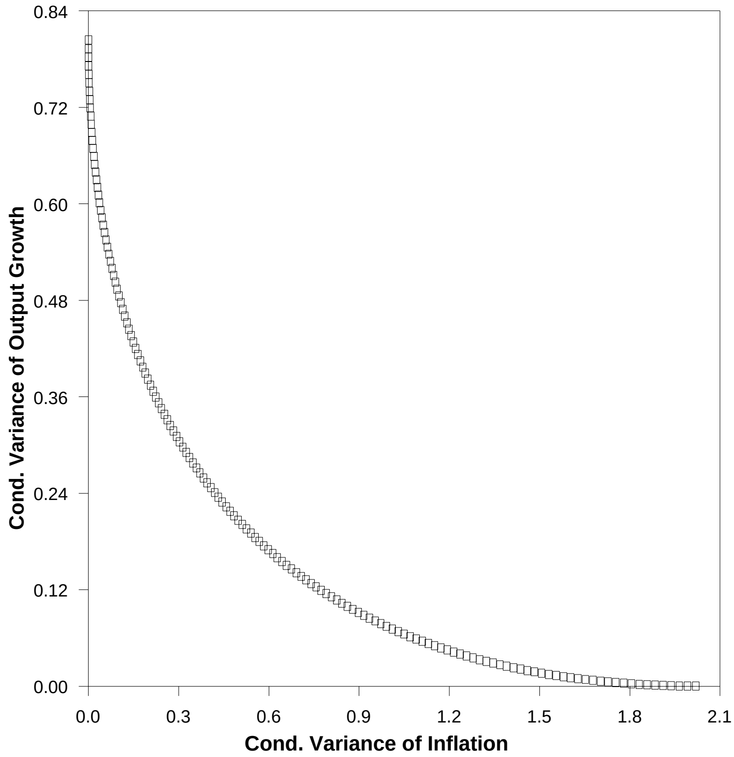
This implies a linear trade-off in the standard deviations of the output and price level responses. Of course this conditional variance is zero for inflation (growth) when α is 1 (0) otherwise both variances are larger than zero.

In this context it is important to notice that we assume that the expected value of the deviations from target are zero. This means that the target growth rate is known an there is no error with respect to this variable. Of course, this is a very strong assumption given the uncertainty with respect to the growth rate of potential output. In section 5 we consider the consequences of a bias with respects to potential growth of the policy maker.

Figure 2 shows the scatter diagram for the 8 period ahead inflation and output growth conditional variance obtained by varying α between 0 and 1. The eight period time horizon was chosen as it corresponds to the maximum effect of the monetary policy shock on output growth. Thus, this setup is favorable to the growth target as the effect on output is strongest and only half the long run size on the long run effect on prices occurred (compare figure 1). However, it should be mentioned that the results for the 12 quarter horizon for the conduct of monetary policy are qualitatively very similar to those presented below, even though the quantitative effects are sometimes substantial. Furthermore, the study can be extended to include rules where the central bank aims at controlling inflation and output between two time periods in the future.

We see from figure 2 that our SVAR model estimates imply a standard convex efficiency frontier for the conditional variances of inflation and growth. Tolerating a higher variability of growth allows a lower variability of inflation and vice versa. Thereby the maximum variability of inflation is clearly higher than that of growth. This result is caused by the higher persistence of the impact of the monetary shocks on inflation than on growth.

Figure 2: 8 Quarters ahead conditional structural variance of inflation and output scatter



4. The Effect of Measurement Errors in GDP on Inflation and Growth Rate Volatility

In this section we analyze the effects of measurement errors on monetary policy induced volatility of inflation and growth. For CPI inflation measurement errors are not a serious problem given the fact that these data are available on monthly basis practically without delay and are hardly revised. However, measurement errors are clearly a problem for output as Swiss quarterly real GDP figures of the past year are substantially revised in late summer when the result of the annual account for the past year are available. Data for the period 1988 to 1996 show that the measurement error of real time quarterly data for the GDP Growth rate has a mean which is practically zero but has a relatively high standard error of 0.479%. Moreover there is some slight negative autocorrelation which is not statistically significant and which can be neglected for practical purposes[4]. This measurement error may create substantial problems for forecasting output growth and inflation. Indeed for quarterly forecasts we have a minimum of 2 past unknown errors (third quarter forecast) and a maximum of 6 past unknown errors (second quarter forecast). In the sequel we will analyze the effect of these measurement errors.

The effect of the measurement errors *v* for *n* lags on the forecasted *K* period deviation from target can be easily represented by the reduced form impulse response to an output shock denoted by *CC*:

$$e_p(K,T) = \sum_{i=0}^{n-1} CC_{12}(K+i)v_{T-i}$$

$$e_y(K,T) = (CC_{22}(K)-1)v_T + \sum_{i=1}^{n-1} CC_{22}(K+i)v_{T-i}$$

The current measurement error has a special effect on the forecasted target deviation of output as it effects the period *T* as well as the expected period *T+K* value log output. This explains the subtraction of 1 in the first term of the second equation given above.

The above expressions easily allow to calculate the conditional covariance matrix of the measurement error induced deviation from target: These two variables can be written as a linear transformation of the n relevant error terms collected in a Vector *V*, namely *DV*. The

4 The measurement error for the level of log GDP can be represented by an AR(1) process with a coefficient of 0.814 and is, therefore highly persistent and leads to first differences which are close to white noise.

elements of the 2 times n matrix D are obtained by the impulse responses as given above. Thus, the covariance matrix of the two deviations is $D\text{cov}(V)D'$ where $\text{cov}(V)$ is the n times n autocovariance matrix of V which is diagonal given the approximate white noise property of the measurement error. Therefore, the (reduced form) impulse response estimate of our SVAR model variance for the measurement error allow the calculation of the variances and the covariance of the two target deviations. These errors have the same effect on monetary policy as the structural errors discussed before. Therefore, we can calculate the contribution of the measurement error to the variance of K period ahead variance of inflation and output growth in the same manner:

$$Var_T(rp_{T+K}) = \alpha^2 Var_T(e_p(K,T)) + (1-\alpha)^2 G_p^2 Var_T(e_y(K,T)) + 2\alpha(1-\alpha)G_p Cov_T(e_p, e_y)$$
$$Var_T(ry_{T+K}) = \alpha^2 G_y^2 Var_T(e_p(K,T)) + (1-\alpha)^2 Var_T(e_y(K,T)) + 2\alpha(1-\alpha)G_y Cov_T(e_p, e_y)$$

In Figures 3 and 4 the inflation and the output growth variance caused by the measurement error is plotted as function of α for $K = 8$ and $n = 4$. Of course the effects are weaker (stronger) when we do the calculations for $n = 2$ ($n = 6$), but the results are qualitatively the same. We see that the minimum variance in both cases is now obtained with a value of $\alpha = 1$. This result is brought about by the fact that the reduced form impulse response of the log price level to the output shock is weak whereas it is strong for output itself. Thus, strict inflation targeting minimizes the effect of the measurement error on both variables. Indeed as the reduced form impulse response to an output shock after 8 and more periods are very close to zero the effect of the measurement errors on both variables is practically zero in the case of strict inflation targeting.

In Figure 5 we present the scatter diagram for the total conditional variances (structural shocks and measurement errors). We see that there is no longer a convex efficiency frontier if measurement errors in GDP are taken into account: Decreasing the weight of the output target from 1 ($\alpha = 0$) to approximately 0.65 ($\alpha = 0.35$) decreases the conditional variance of inflation and growth. This result is due to the fact that with measurement errors monetary policy reacts too much to noisy data if the weight on output is big as the measurement error has a strong impact on the growth forecast but not on the inflation forecast. Therefore, strict output growth targeting is no longer an efficient monetary policy strategy. In all other regions reduction of both variances go hand in hand. Therefore, taking into account of measurement errors changes the conclusion obtained from section 3 drastically.

Figure 3: 8 Quarters ahead conditional variance of inflation caused by measurement errors of GDP

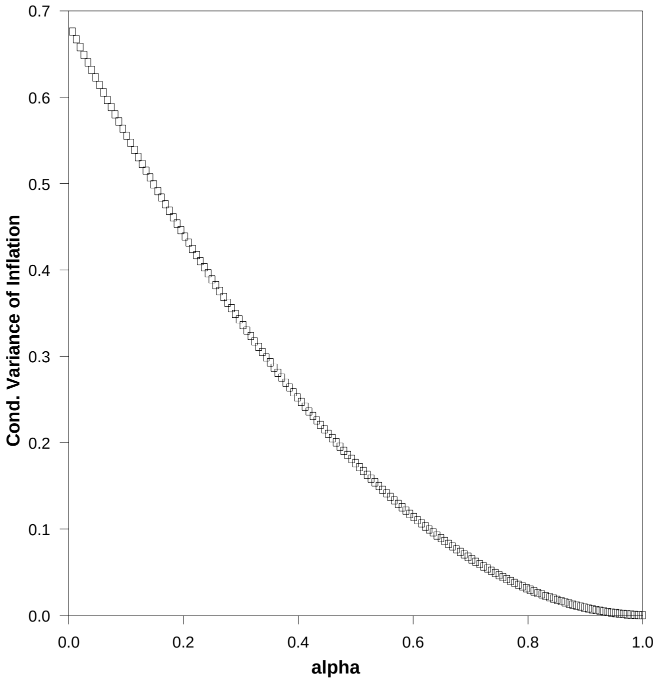


Figure 4: 8 Quarters ahead conditional variance of growth caused by measurement errors of GDP

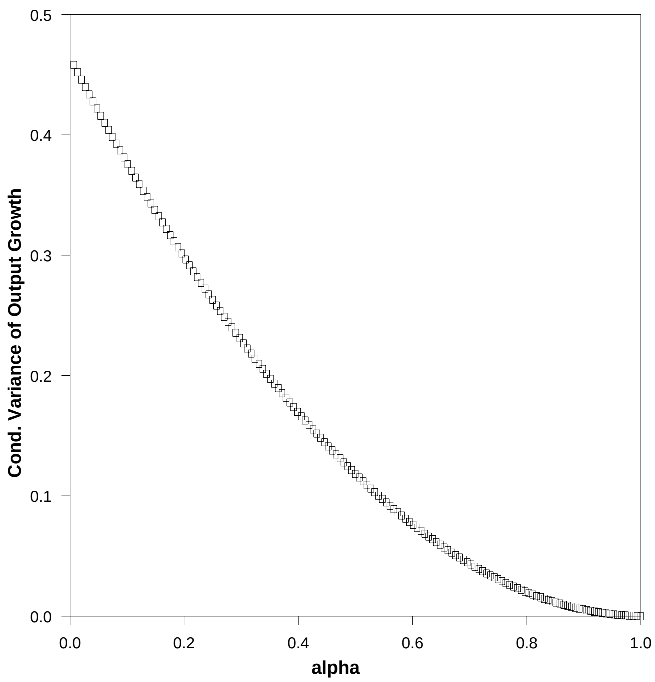
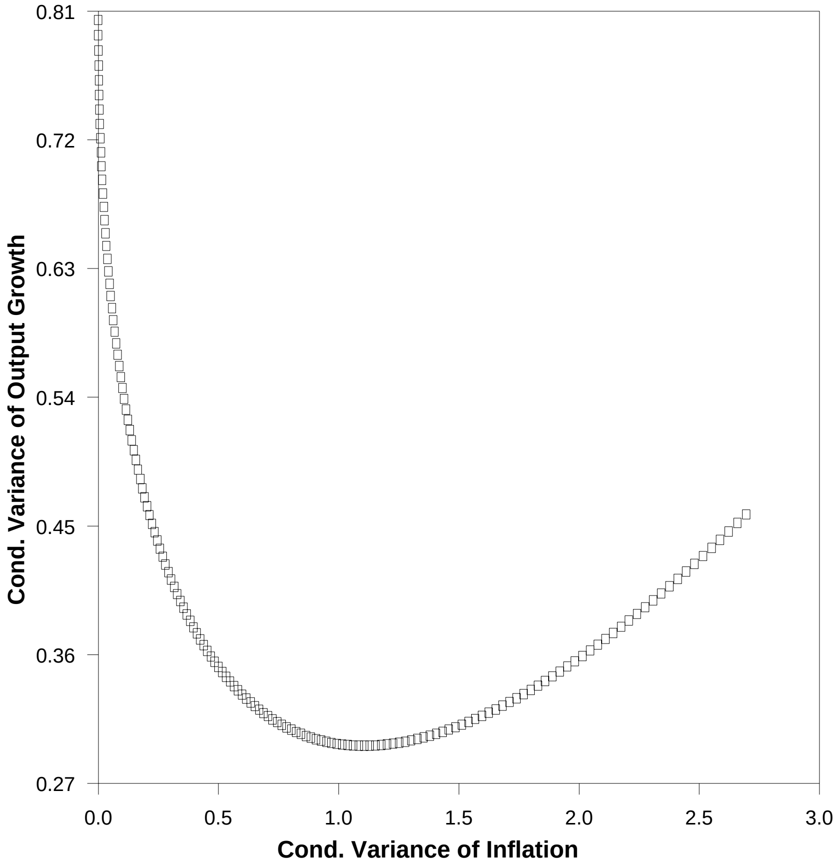


Figure 5: 8 Quarters ahead conditional total (structural and measurement) variance of inflation and output scatter



5. The Effect of an Estimation Bias of Potential Growth Rate

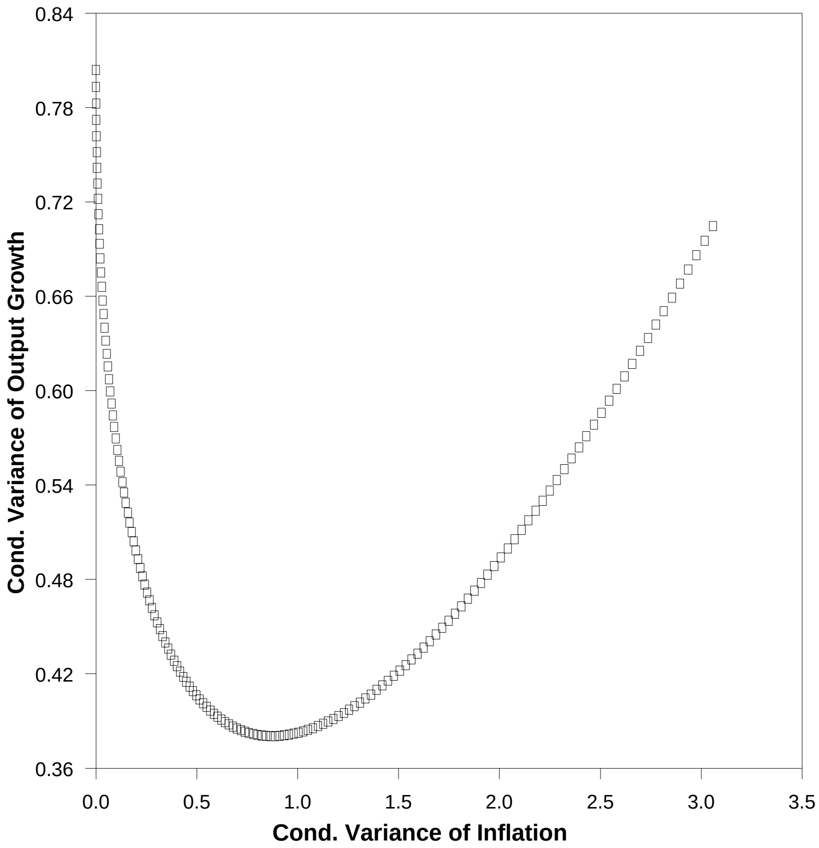
Besides random measurement errors GDP growth targeting may lead to excess volatility of inflation and growth when monetary policy aims at a "wrong" growth rate. In order to explore the implication of such a mistake, which may very well arise given the uncertainty surrounding the potential growth rate.[5] Now let us assume that the bias of potential growth rate is $\Delta\gamma^*$ (measured at a quarterly rate). This gives rise to a systematic component of the deviation from the log output target equal to $K\Delta\gamma^*$. As a consequence the conditionally expected mean squared error of K period ahead growth is relevant for calculating the conditional variance of different degrees of inflation and growth rate targeting. In other words the corresponding conditional variances derived in section 3 have now to be replaced by the following expressions:

$$Var_T(rp_{T+K}) = \alpha^2 Var_T(d_p(K,T)) + (1-\alpha)^2 G_p^2 [Var_T(d_y(K,T)) + (K\Delta\gamma^*)^2] + 2\alpha(1-\alpha)G_p Cov_T(d_p, d_y)$$
$$Var_T(ry_{T+K}) = \alpha^2 G_y^2 Var_T(d_p(K,T)) + (1-\alpha)^2 [Var_T(d_p(K,T)) + (K\Delta\gamma^*)^2] + 2\alpha(1-\alpha)G_y Cov_T(d_p, d_y)$$

Note that the sign of the bias is not relevant for its effect on monetary policy induced variability of inflation and growth. Thus aiming at a too high or too low growth rate will have the same volatility implications in our linear model.

The scatterplot of total inflation and output growth conditional variance (structural shocks, measurement error and bias) obtained with a bias $\Delta\gamma^*$=0.0625 percent is presented in Figure 6 shows that the positively sloping segment of this curve is further increased compared to Figure 5. The third result shows that this effect of measurement errors is reinforced if there is a bias in the estimate of potential output growth: For a bias of 0.25 percentage points at an annual rate we have an increase of both the conditional variance of inflation and growth if the weight of the output target increases from approximately 0.5 ($\alpha = 0.5$) to 1 ($\alpha = 0$). Monetary policy reacts to a wrong signal - similarly as to the measurements errors - and thereby increases the variability of both inflation and output. Thus an output weight above 0.5 is inefficient as it leads to higher inflation and output variability. Finally, we may mention that our results are in line with those obtained by Orphanides et al. (2000) for U.S. monetary policy in the framework of the Taylor rule. These authors show that errors in potential output estimates are crucial for the conduct of U.S. monetary policy in the period 1966 – 1994.

Figure 6: 8 Quarters ahead conditional structural variance of inflation and output scatter with a bias in the growth rate of potential output (0.25% pa)



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[5] Note that no bias can arise in the inflation target because monetary policy controls the long-run behaviour of inflation.

6. Conclusions

In this paper forward-looking rules for Swiss monetary policy are analyzed in a small structural VAR consisting of four variables. First, given the setup of no measurement errors, the paper analyzes the inflation/output volatility trade off for a forward-looking policy aiming at a convex combination of a inflation and output growth target implied by this SVAR model. Second, the paper considers the effect of measurement errors in GDP on this inflation/output volatility trade-off. Third, the paper analyzes to what extent a bias in the estimate of the potential growth rate affects the variability of output and inflation. The paper introduces an analytical method based on the parameters of the impulse response function to solve these questions for the SVAR models. This can be seen as a methodological innovation.

There are three main results of the paper. First, without measurement errors, we obtain a standard convex efficiency frontier for the conditional (time *T*) variance of *K* period ahead average inflation and growth. Second, if measurement errors in GDP are taken into account, there is no longer a convex efficiency frontier: Decreasing the weight of the output target from 1 to approximately 0.65 decreases the conditional variances of both inflation and growth. This result is due to the fact that with measurement errors monetary policy reacts too much to noisy data if the weight on output is big as the measurement error has a strong impact on the growth forecast but not on the inflation forecast. The third result shows that the effect of measurement errors is reinforced if there is a bias in the estimate of potential output growth: For a bias of 0.25 percentage points per annum we have an increase of both the conditional variance of inflation and growth if the weight of the output target increases from approximately 0.5 to 1. Monetary policy reacts to a wrong signal - similarly as to the measurements errors - and thereby increases the variability of both inflation and output. In general, the paper indicates that under realistic assumptions by concentrating on output growth, the central bank induces higher output and inflation variability.

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