A Two-Pillar Phillips Curve for Switzerland

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1. Introduction

Inflation is commonly seen as a monetary phenomenon. Despite this, it has been argued that money growth is not a useful predictor of changes in the price level in economies with low inflation.[1] As a consequence, most central banks in such economies attach little importance to money in setting interest rates. Two important exceptions are the European Central Bank (ECB) and the Swiss National Bank (SNB), which continue to emphasise the role of monetary aggregates in their inflation analysis.

The ECB's policy strategy relies on a "two-pillar" framework to keep the rate of increase of the harmonised index of consumer prices below two percent.[2] The first pillar assigns money "a prominent role" in guiding the Governing Council's policy decisions. In particular, M3 growth in excess of the reference value of 4.5% is taken as indicating inflationary pressures, but does not trigger automatic policy responses. The second pillar combines "a wide range of economic and financial variables" to assess future price developments. In its review of the monetary policy strategy published in 2003, the ECB argues that the second pillar is useful for judging the impact of demand and supply factors on inflation in the

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1 See e.g. De Grauwe and Polan (2005). Nelson (2003) presents a contrary view.

2 The ECB's first Monthly Bulletin (ECB, 1999) reviews its monetary policy strategy in detail. See also ECB (1998a and 1998b).

short run. The first pillar, by contrast, helps explain inflation in the medium to long run and is used to "cross-check" the implications of the real-side analysis (ECB, 2003, and ISSING, 2005).

Money has historically played an important role also in Swiss monetary policy. From the collapse of the Bretton Woods system until the end of 1999 the SNB used growth targets for monetary aggregates.[3] This strategy was temporarily suspended in 1979, when the Swiss franc appreciated strongly against the German mark, but was re-introduced at the end of that year. In 2000 a new framework was adopted that abandoned monetary targets.[4] The new concept aims at maintaining price stability defined as an annual rate of increase of the consumer price index of under two percent. Policy decisions draw on formal model-based forecasts of inflation as well as on two sets of indicators that are informative about future price developments. JORDAN, PEYTRIGNET and RICH (2001) describe the first set as containing variables that are "useful for forecasting short-run price developments", such as the output gap, labour market data and the real exchange rate. The second set comprises monetary aggregates, which the SNB sees as "provid[ing] useful leading information on long-run price developments" (SNB, 1999). In contrast to the ECB, the SNB does not analyse monetary and real factors in two separate pillars. Instead, the information from these two sets of indicators is combined with the output from the econometric models (which typically include monetary aggregates) to yield the inflation forecast on which policy decisions are based. This obviates the need for cross-checking as at the ECB and does not require the use of a reference value for the growth rate of M3.[5]

There are three broad views in the literature on the role of money growth for forecasting inflation. The first, mentioned above, is that money growth does not impact on inflation at all at low rates of inflation. According to this view, money growth can be excluded from the inflation forecast. For instance, BEGG, CANOVA, DE GRAUWE, FATAS and LANE (2002) argue that money does not seem to matter for prices in the euro area and suggest that the ECB's first pillar therefore is superfluous. The second view is that long-term trends in money growth impact on the average rate of inflation, but not short-term fluctuations. ASSENMACHER-WESCHE and GERLACH (2006b), BRUGGEMAN, CAMBA-MENDEZ, FISCHER and SOUSA (2005), GERLACH (2003 and 2004), GREIBER and NEUMANN (2004) and

3 PEYTRIGNET (1999) and RICH (2003) provide detailed discussions of Swiss monetary policy before 2000. HILDEBRAND (2004) reviews the SNB's strategy before and after the introduction of the new framework.

4 See MEYER (1999) for the announcement of the new policy framework.

5 JORDAN, PEYTRIGNET and RICH (2001) argue that the SNB's difficulties in reaching its money growth targets before 2000 rendered a numerical reference value unattractive.

Neumann (2003) propose Phillips curve models in which inflation depends on the low-frequency component of changes in M3, which they argue represents the first pillar, and on the output gap, which captures the second pillar. These models fit the inflation dynamics in the euro area rather well, and the analysis presented below uses the same approach for Switzerland. The third view is that money growth explains movements in inflation also in the short run. Nelson (2003) argues that changes in money growth affect inflation at all time horizons by impacting on aggregate demand. However, since the output gap measures aggregate demand and since shifts in velocity may obscure the short-run link between money growth and inflation, it is possible that the output gap, rather than money growth, is significant in the Phillips curve.

This paper studies the role of money growth for inflation in Switzerland using quarterly data spanning 1979:4 to 2007:1, where the starting date is chosen to coincide with the SNB's return to monetary targets. We consider M2 and M3 growth in the analysis. Since nominal interest rates declined over the sample, causing a fall in velocity, it is possible that the relationship between money growth and inflation is not detectable in the original data. We therefore adjust money growth for this decline in the level of interest rates (see details below) and consider in the estimation both original and interest rate adjusted data.

In the econometric work, we first demonstrate that headline money growth is a poor predictor of inflation in Switzerland. However, since headline money growth displays many fluctuations, some of which may be irrelevant for inflation, we next study the role of trend money growth, which we obtain by "filtering" headline money growth, and show that it predicts inflation in a simple forecasting regression. We then estimate the two-pillar Phillips curve proposed by Gerlach (2003), which assumes that trend, not headline, money growth matters for inflation and which estimates the degree of filtering. We show that in this setup, adjusted M2 and M3 growth impacts on inflation. Unadjusted money growth is insignificant.

The paper contributes to the literature in two ways. First, our findings support the notion that money impacts on prices in Switzerland. Second, the results show that M3 growth forecasts future inflation better than M2 growth. This is compatible with findings for the euro area (see Nicoletti-Altimari, 2001) and arguably is due to the higher interest rate sensitivity of M2. Our simple method of adjusting money growth for shifts in the level of interest rates may not capture the impact of interest rates on M2 growth completely.

The rest of the paper is structured as follows. Section 2 reviews the literature on inflation equations for Switzerland. There are relatively few papers estimating Phillips curves on Swiss data, and money growth does typically not enter them. Section 3 presents the data used in the analysis. We also briefly review a change in the computation of the Swiss consumer price index in May 2000 and discuss how to handle the downward trend of nominal interest rates over the sample. Section 4 presents some preliminary evidence on the link between money growth and inflation in Switzerland. It is shown that headline money growth is a rather poor predictor of inflation, whereas trend money growth appears to forecast inflation several years ahead. The output gap predicts inflation only at short horizons. Section 5 presents the two-pillar Phillips curve and estimates, rather than assumes, the trend in money growth that impacts on inflation. It is shown that including money growth in the forecasting equation reduces the root mean squared error by up to 15%. Section 6 concludes.

2. Literature

Empirical Phillips curves link the current rate of inflation to economic activity and inflation. In these models, high activity, as measured by either low unemployment or a large positive output gap, is associated with higher inflation. Several authors have estimated Phillips curves for Switzerland. Zanetti (1998), in a study on the Swiss NAIRU, uses unemployment as a measure of activity and finds that it has a significant impact on inflation in a backward-looking Phillips curve over the period 1978 to 1997. Luescher (1999) estimates a Phillips curve that combines forward and backward-looking elements for the years 1978 to 1993 and finds that lagged inflation, inflation expectations from a consumer survey and the output gap are significant predictors of future price movements. The focus of that paper is on non-linearities in the Phillips curve, which seem present and for which Wyplosz (2001) provides further evidence. He considers data for four European countries spanning 1962 to 1999 and shows that inflation in Switzerland depends on its own past value, import price changes, unemployment and inflation expectations as proxied by the difference between a long-term bond yield and a measure of the world real interest rate. Laubach and Posen (1997) examine in a data set of eight industrial countries whether the introduction of an inflation target alters the reaction of inflation to real economic variables. Switzerland is used as a control country and a Phillips curve is estimated on data from 1971 to 1990. It includes as significant variables lagged inflation, the output gap and the nominal effective exchange rate. Money growth does not enter these Phillips curves directly.

A number of authors have studied the impact of money on inflation in Switzerland without using the concept of the Phillips curve. Baltensperger, Jordan and Savioz (2001) consider inflation equations that comprise money growth and the difference between actual and equilibrium money demand. Using data spanning 1978 to 1999, they find that both the growth rate of money and the deviation of money demand from equilibrium impact on annual inflation one to three years ahead and on cumulative inflation over the same horizons. Jordan, Peytrignet and Rich (2001) estimate a similar model for the years 1975 to 2000 and show that M3 growth forecasts inflation well over long horizons while money in excess of equilibrium demand predicts price movements up to three years. Peytrignet and Stahel (1998) study a vector error correction model for Switzerland and present an inflation equation for the period 1977 to 1997 that includes as significant variables the growth rate of real GDP, the German inflation rate and the deviation of M3 from long-run money demand. Jordan and Savioz (2003) discuss a number of unrestricted VARs for the period 1974 to 2000 that include consumer price inflation, the growth rates of M3, real GDP and loans as well as the change in long-run interest rates. They show that models that consider money seem to perform well over forecast horizons spanning one to three years. Finally, Kugler and Jordan (2004) present a structural VAR that includes consumer price inflation, the growth rates of real GDP and M1 and the change in the three-month interest rate. Using data spanning 1974 to 2002, they demonstrate that money growth impacts on inflation. Overall, these papers suggest that money growth is linked to future inflation in Switzerland.

The paper most closely related to ours is Assenmacher-Wesche and Gerlach (2006a). They use spectral techniques to estimate a Phillips curve for Switzerland that includes money growth and establish that low-frequency M3 growth impacts on long-run inflation, whereas short-term movements in inflation seem to be explained by the output gap.

For a central bank whose task it is to stabilise inflation, empirical Phillips curves are an important tool in the inflation forecasting process. Jordan and Peytrignet (2001) provide an overview of the different models used at the SNB.[6] One important consideration in specifying inflation forecasting equations for monetary policy purposes is that they must not involve future data. New Keynesian Phillips curves, which are theoretically attractive because of their micro foundation, are forward looking and thus of limited use in forecasting exercises.[7] A second consideration in choosing the modeling framework is

6 See Stalder (2001) for a more detailed model discussion.

7 On estimating New Keynesian Phillips curves, see for instance Gali and Gertler (1999) and Gali, Gertler and Lopez-Salido (2001).

complexity. While band-spectrum analyses as in ASSENMACHER-WESCHE and GERLACH (2006a) are intuitively appealing, there appears to be no established way in which to construct out-of-sample forecasts from such models. The simple backward-looking Phillips curve presented below only relies on known data and lends itself to forecasting, which makes it attractive from a practical central banking perspective.

3. Data

In this section we review the data and discuss the computation of trend money growth and the interest rate adjustment for money growth. We use quarterly data from 1979:4 to 2007:1 in the estimation below. Figure 1 shows annualised quarterly CPI inflation and an adjusted inflation measure from ASSENMACHER-WESCHE and PESARAN (2005). The latter, which we use in the work below, is adjusted for seasonal patterns and controls for a change in the computation of the CPI in May 2000. The original data show an increase in volatility after that date, which is due to the impact of sales prices for clothing and shoes. Such sales were not captured in the CPI before May 2000.[8] Over the sample period, inflation displayed a downward trend.[9] Figure 2 plots the output gap, g_t, which is computed as the difference between the logarithm of real GDP and a Hodrick-Prescott filtered measure thereof, and the change in the nominal effective exchange rate, Δe_t. We include this variable to account for cost-push shocks.[10]

Figure 3 shows different measures of money growth, μ_t. The left plot in the upper panel plots deseasonalised and annualised quarterly headline growth. It is a priori not clear whether M2 or M3 growth is better able to capture inflation dynamics in Switzerland.[11] RICH (2003) establishes that M3 growth was a useful indicator for Swiss inflation in the 1990s, but FISCHER and PEYTRIGNET (1990) show that it was a poor predictor for inflation until the end-1980s. We therefore

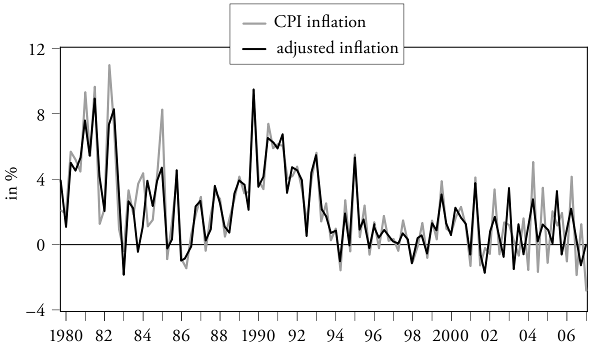
8 The working paper version of this paper discusses the change in the CPI computation in detail (see GERLACH-KRISTEN, 2006).

9 The hypothesis that inflation has a unit root is rejected both in an augmented Dickey-Fuller test (p-value of 0.09) and a Phillips-Perron test (0.00).

10 Other variables capturing cost-push shocks, such as oil price inflation and a dummy for the introduction of the VAT, were insignificant in preliminary regressions and are therefore not included.

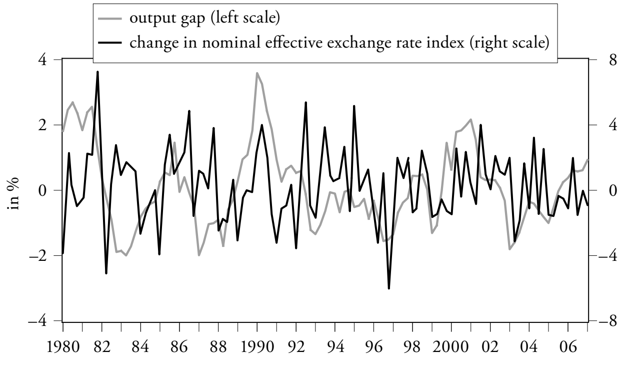
11 Both GERLACH (2004) and NEUMANN (2003) use M3 to measure money in the euro area since the ECB's reference value is defined in terms of the growth rate of that monetary aggregate.

Figure 1: Inflation Data



Note: 1979:4 to 2007:1. Adjusted inflation has been deseasonalised and corrected for the change in the computation of the CPI in May 2000.

Figure 2: Output Gap and Nominal Effective Exchange Rate



Note: 1979:4 to 2007:1. The output gap based on the Hodrick-Prescott filter is computed using a smoothing parameter 1600.

consider M2 as well as M3 growth in the analysis.[12] The Figure shows that headline M2 growth is more volatile than headline M3 growth.[13] The reason for this is that M2 responds if consumers shift from e.g. cash holdings to time deposits. M3, by contrast, includes all forms of deposits and therefore is not affected by such substitutions. The two measures have a correlation of 0.51, so it is clear that they contain different information.

Headline money growth is typically insignificant in inflation equations. It has, however, been suggested that long-term trends in money growth impact on the level of inflation, whereas short-term movements do not matter. The right plot in the upper panel shows "trend" money growth, $\tilde{\mu}_t$, which is computed using a one-sided exponential filter as

$$\begin{aligned}\tilde{\mu}_t &= \lambda\mu_t + (1-\lambda)\tilde{\mu}_{t-1} \\ &= \lambda\sum_{n=0}^{\infty}(1-\lambda)^n \mu_{t-n}\end{aligned} \tag{1}$$

where the smoothing parameter λ is bounded between zero and unity. COGLEY (2002) proposes this filter to obtain a measure of core inflation. Equation (1) shows that trend money growth is a weighted average of current and past money growth, where the weights decrease over time.[14] We initially set $\lambda = 0.075$, which implies a half-life of 9.2 quarters, but estimate λ in the final version of the two-pillar Phillips curve below.[15] Not surprisingly, trend money growth evolves more smoothly than headline growth.

Figure 4 shows M2 and M3 velocity and the three-month nominal interest rate. All series display a downward trend and the correlations between the interest rate and M2 and M3 velocity are 0.87 and 0.61, respectively. Shifts in velocity may thus account for the poor fit of models involving "raw" money growth data. We therefore consider also measures of money growth that are adjusted for the downward shift in nominal interest rates.[16]

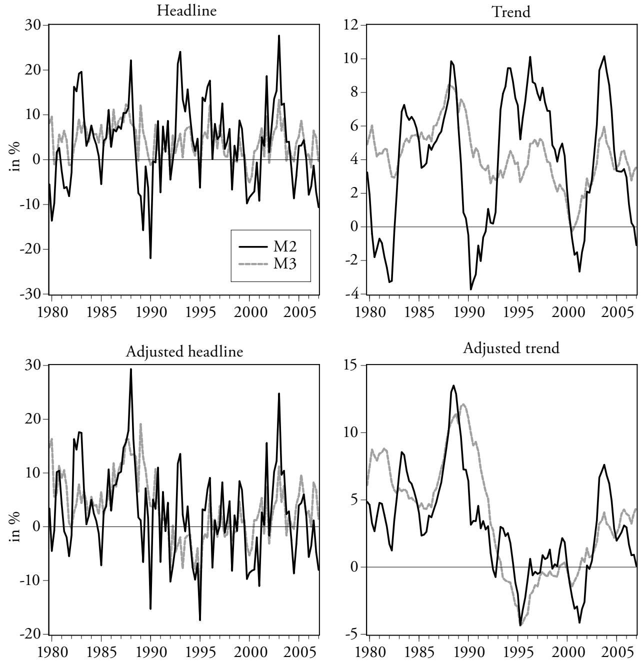
12 JORDAN, KUGLER, LENZ and SAVIOZ (2002) present Granger causality tests in which M1, M2 and M3 all cause future inflation in Switzerland. PEYTRIGNET and STAHEL (1998) argue that M3 is more useful than M2 in forecasting inflation.

13 Neither series appears to contain a unit root, as both the augmented Dickey-Fuller and the Phillips-Perron test yield p-values of 0.00.

14 NEUMANN (2003) uses the Hodrick-Prescott filter to obtain a measure of trend money growth. ASSENMACHER-WESCHE and GERLACH (2006b), BRUGGEMAN, CAMBA-MENDEZ, FISCHER and SOUSA (2005) and JAEGER (2003) apply frequency-domain techniques to compute trend money growth.

15 The half-life is computed as $-\log(0.5)/\lambda =$ 9.2 quarters and reflects how long it takes for a one-unit shock to μ_t to trigger a 0.5 unit reaction in $\tilde{\mu}_t$.

Figure 3: Alternative Measures of Money Growth



Note: 1979:4 to 2007:1. Different measures of money growth. Trend growth rates are computed setting $\lambda = 0.075$ in equation (1).

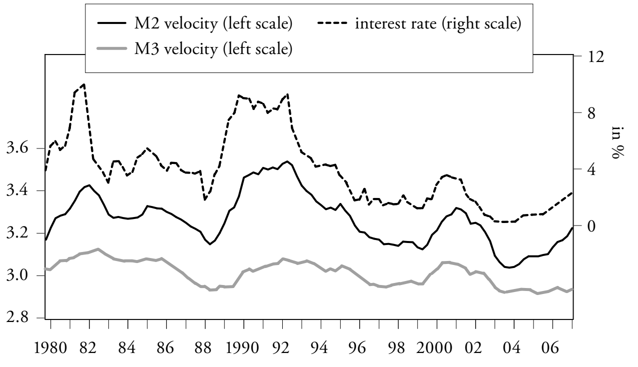
16 Assenmacher-Wesche and Gerlach (2006a) consider the impact of velocity changes on the fit of the Swiss Phillips curve by assuming a correlation between velocity and money growth shocks.

To obtain interest rate adjusted measures of M2 and M3 growth, we employ a variation of the method used by REYNARD (2006). In particular, we regress the logarithm of the monetary aggregate, m_t, on a constant and the three-month interest rate i_t,

$$m_t = c + ai_t + u_t. \tag{2}$$

The interest rate adjusted measure of money, m_t^{adj}, is essentially the residual of equation (2), where we replace in the computation the actual interest rate with its Hodrick-Prescott filtered version.[17] Adjusted money growth is the annualised quarterly growth rate of m_t^{adj}. The lower panel in Figure 3 shows adjusted headline money growth in the left plot and adjusted trend money growth in the right. While adjusted headline growth looks similar to original, or "unadjusted", headline growth, the trend growth rates differ. In particular, they decline over the sample when money growth is adjusted, but not otherwise. Given the downward trend in inflation over the period under consideration, this difference is going to matter critically in the estimation below.

Figure 4: Velocity and Nominal Interest Rate



Note: 1979:4 to 2007:1. Velocity and 3-month nominal interest rate.

17 Using u_t instead of m_t^{adj} to compute adjusted money growth yields series that fit virtually as well in the two-pillar Phillips curve below.

4. Preliminary Evidence

Before estimating formal Phillips curve models, we provide in this section some first evidence on the link between money growth and inflation in Switzerland. To gain a sense whether and, if so, over which horizons money growth might contain useful information on future inflation in Switzerland, we regress

$$\pi_{t+k} = a_k + b_k \pi_t + c_k \mu_t + d_k g_t + e_k \Delta e_t + v_{k,t} \tag{3}$$

using GMM, allowing for MA errors of order $k-1$. In the estimation, we let the forecasting horizon increase from $k=1$ to 12, that is from one quarter to three years. Figure 5 shows in the upper row the coefficients on unadjusted and adjusted M2 and M3 growth and in the lower row the coefficients on the output gap for different forecast horizons, in both cases with 95% confidence bands. Since we include current inflation, equation (3) assesses whether money growth contains information about future inflation beyond that embedded in π_t.

Unadjusted money growth contains no such information. Considering adjusted money growth, M2 is significant in the inflation equation from five quarters onwards. Adjusted M3 growth is significant from $k=2$. The output gap forecasts inflation up to six quarters in the equations using adjusted money growth and unadjusted M3 growth.

To explore the hypothesis that trend money growth contains more information on future inflation than headline money growth, we replace in equation (3) μ_t by $\tilde{\mu}_t$ and fit

$$\pi_{t+k} = a_k + b_k \pi_t + c_k \tilde{\mu}_t + d_k g_t + e_k \Delta e_t + v_{k,t}. \tag{4}$$

The estimated coefficients on trend money growth plotted in Figure 6 indicate a much clearer information content of money. While using unadjusted M2 data leads again to insignificant estimates of c_k, the coefficient on the other measures of money growth is significant over all horizons considered. The output gap again helps forecast changes in future inflation over horizons up to roughly six quarters.

Overall, the preliminary evidence suggests that headline money growth is less useful for forecasting inflation in Switzerland than trend money growth and that it contains information beyond that in current inflation. These findings are compatible with Jordan, Peytrignet and Rich (2001), who show that money growth reveals information about Swiss inflation several years ahead. We next formalise the link between money growth and future inflation within the framework of the two-pillar Phillips curve.

Figure 5: Coefficients on Headline Money Growth and the Output Gap in Equation (3)

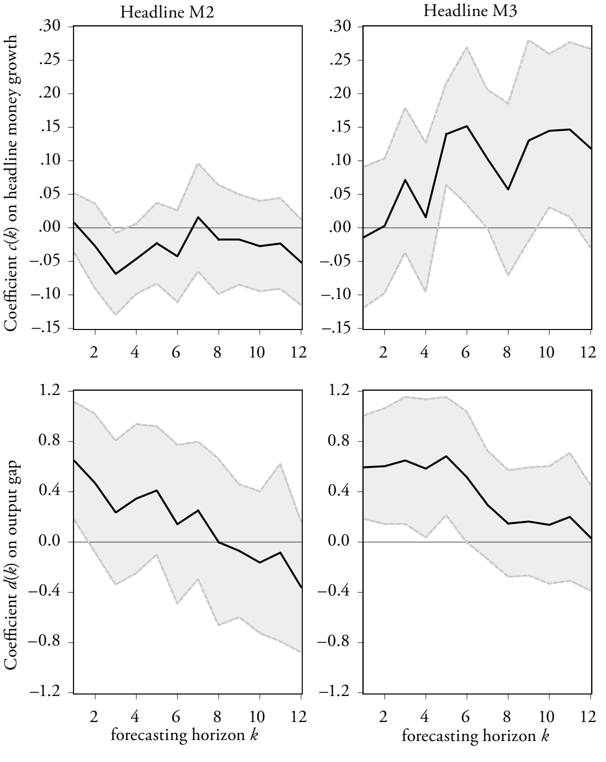
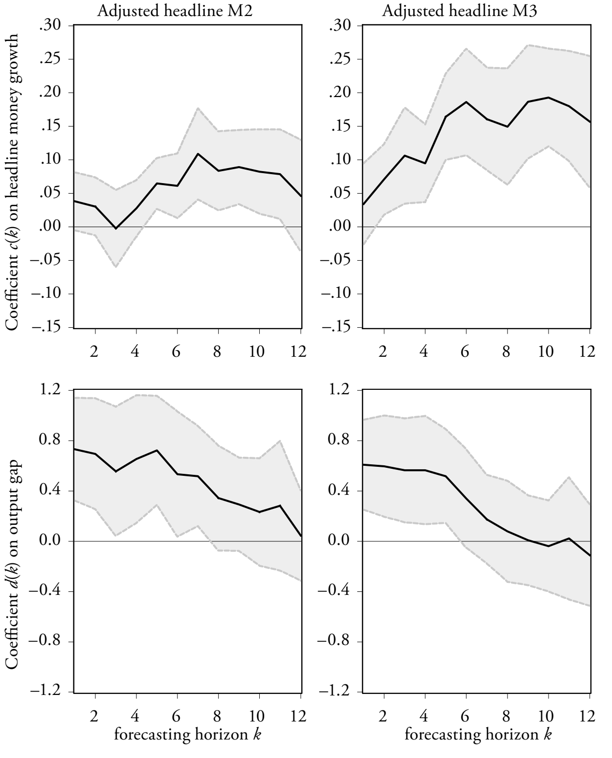


Figure 5 (continued)



Note: 1979:4 to 2007:1. Coefficient estimates on money growth and the output gap in equation (3) with 95% confidence bands.

Figure 6: Coefficients on Trend Money Growth and the Output Gap in Equation (4)

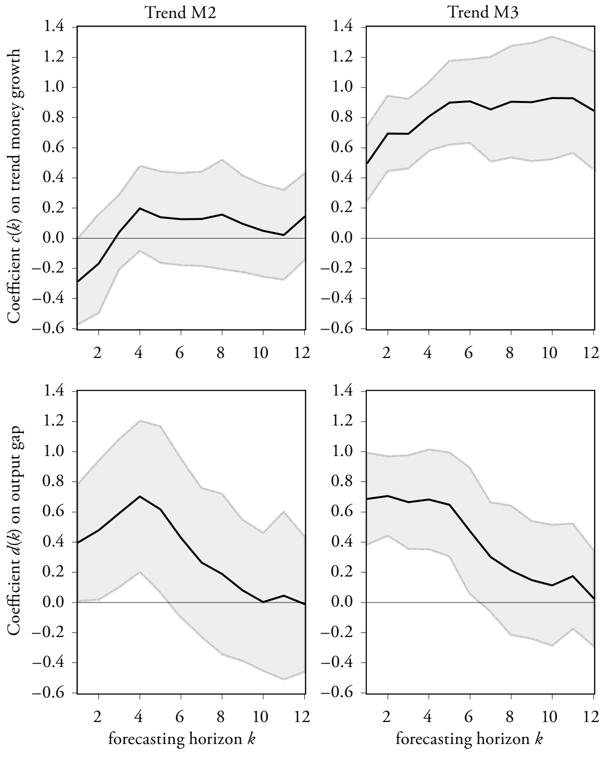
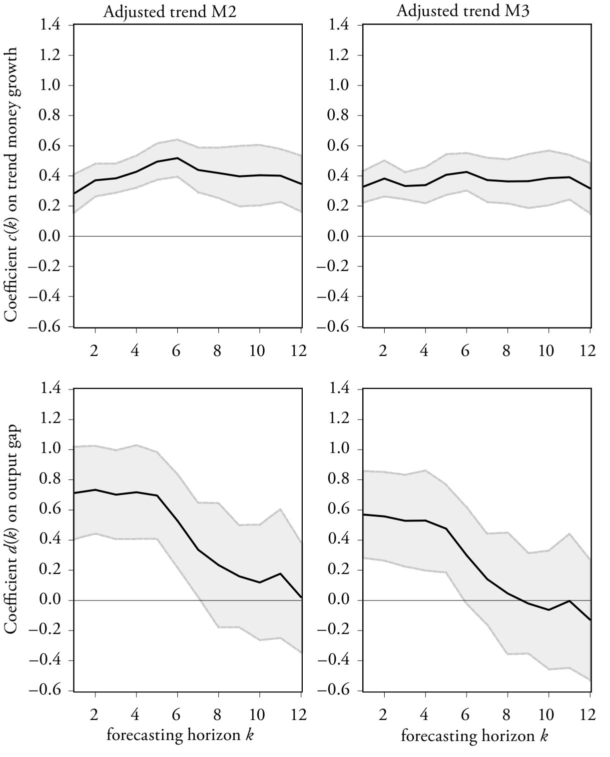


Figure 6 (continued)



Note: 1979:4 to 2007:1. Coefficient estimates on trend money growth and the output gap in equation (4) with 95% confidence bands.

5. The Two-Pillar Phillips Curve

The Phillips curve is an empirical reduced-form model of inflation. In its simplest form, it states that inflation depends on past inflation and the lagged output gap, so that

$$\pi_t = \alpha + \beta\pi_{t-1} + \gamma g_{t-1} + \varepsilon_t,$$

where $\varepsilon_t N(0,\sigma_\varepsilon^2)$. One way to test whether money growth impacts on inflation is to include its past value in the Phillips curve,

$$\pi_t = \alpha + \beta\pi_{t-1} + \gamma g_{t-1} + \delta\mu_{t-1} + \varepsilon_t.$$

In the analysis below, we fit

$$\pi_t = \alpha + \beta\pi_{t-1} + \gamma g_{t-1} + \delta\mu_{t-1} + \theta\Delta e_{t-1} + \varepsilon_t, \tag{5}$$

where we again include the change in the exchange rate to account for cost-push shocks. We estimate equation (5) using OLS for headline M2 and M3 growth with and without interest rate adjustment. Table 1 presents the estimation output.

Table 1: Estimation Output for $\pi_t = \alpha + \beta\pi_{t-1} + \gamma g_{t-1} + \delta\mu_{t-1} + \theta\Delta e_{t-1} + \varepsilon_t$

	Headline M2	Headline M3	Adjusted headline M2	Adjusted headline M3
α	1.378***	1.488***	1.356***	1.328***
	(0.288)	(0.356)	(0.276)	(0.293)
β	0.329***	0.335***	0.304***	0.323***
	(0.090)	(0.089)	(0.091)	(0.090)
γ	0.650***	0.582***	0.724***	0.602***
	(0.224)	(0.188)	(0.195)	(0.177)
δ	0.009	–0.020	0.037	0.027
	(0.028)	(0.055)	(0.027)	(0.035)
θ	–0.180*	–0.180**	–0.177*	–0.165*
	(0.091)	(0.091)	(0.090)	(0.092)
Log likelihood	–232.128	–232.114	–231.183	–231.871

Note: OLS estimates of equation (5), 1979:4 to 2007:1. */**/*** denotes significance at the ten/five/one percent level.

We find that past inflation, the output gap and the change in the exchange rate appear to matter for inflation, but that headline money growth is insignificant. This evidence could be interpreted to suggest that money growth does not impact on inflation in Switzerland. However, as we show next, this conclusion is wrong.

Since the preliminary evidence in Section 4 suggests that trend money growth impacts on inflation also in Switzerland, we next fit the simplest version of Gerlach's (2003) two-pillar Phillips curve and thus replace μ_t by $\tilde{\mu}_t$, so that

$$\pi_t = \alpha + \beta\pi_{t-1} + \gamma g_{t-1} + \delta\tilde{\mu}_{t-1} + \theta\Delta e_{t-1} + \varepsilon_t . \tag{6}$$

The output for trend M2 and M3 growth, with and without interest rate adjustment, is reported in Table 2.

Table 2: Estimation Output for $\pi_t = \alpha + \beta\pi_{t-1} + \gamma g_{t-1} + \delta\tilde{\mu}_{t-1} + \theta\Delta e_{t-1} + \varepsilon_t$

	Trend M2	Trend M3	Adjusted trend M2	Adjusted trend M3
α	2.766***	–0.568	0.774**	0.715**
	(0.611)	(0.691)	(0.312)	(0.282)
β	0.244**	0.256***	0.207**	0.093
	(0.094)	(0.089)	(0.091)	(0.093)
γ	0.399**	0.687***	0.714***	0.569***
	(0.192)	(0.171)	(0.169)	(0.158)
δ	–0.285**	0.500***	0.286***	0.330***
	(0.116)	(0.161)	(0.0779	(0.064)
θ	–0.213**	–0.166*	–0.162*	–0.185**
	(0.089)	(0.087)	(0.085)	(0.081)
Log likelihood	–226.932	–225.195	–223.252	–217.677

Note: OLS estimates of equation (6), 1979:4 to 2007:1. */**/*** denotes significance at the ten/five/one percent level.

We now find that the coefficient on trend money growth is significant in all cases. However, δ is, against our expectations, negative for unadjusted trend M2 growth. The coefficients on the output gap and the change in the exchange rate are significantly different from zero for all specifications. Inflation does not seem to matter if adjusted trend M3 growth is used. This suggests that π_t might not contain information useful for forecasting future inflation once money growth data have been taken into account properly.

Next, we release the assumption that λ, which determines how much of the short-term fluctuations in money is "filtered out", equals 0.075 and estimate this coefficient instead.[18] To do so, we combine equations (1) and (6) and obtain

$$\pi_t = \alpha + \beta\pi_{t-1} + \gamma g_{t-1} + \delta\lambda\mu_{t-1} + \delta(1-\lambda)\tilde{\mu}_{t-2} + \theta\Delta e_{t-1} + \varepsilon_t . \qquad (7)$$

Lagging equation (6) once and solving for $\tilde{\mu}_{t-2}$ gives

$$\tilde{\mu}_{t-2} = (\pi_{t-1} - \alpha - \beta\pi_{t-2} - \gamma g_{t-2} - \theta\Delta e_{t-2} - \varepsilon_{t-1}) / \delta.$$

Substituting this into equation (7) and rearranging, we get

$$\begin{aligned} \pi_t = {} & \lambda\alpha + (1-\lambda+\beta)\pi_{t-1} + \gamma g_{t-1} + \theta\Delta e_{t-1} + \delta\lambda\mu_{t-1} \\ & -(1-\lambda)\beta\pi_{t-2} - (1-\lambda)\gamma g_{t-2} - (1-\lambda)\theta\Delta e_{t-2} + \eta_t \end{aligned} \qquad (8)$$

with $\eta_t = \varepsilon_t - (1-\lambda)\varepsilon_{t-1}$. In this equation, trend money growth does not enter anymore, and the smoothing parameter λ is estimated. We treat this equation as a state space model and fit it with maximum likelihood. The estimation output is presented in Table 3.

We find that unadjusted money growth is insignificant, while adjusted money growth seems to impact on inflation. The output gap and the change in the exchange rate are again clearly significant. Past inflation is not significant, suggesting that it does not contain information that is not embedded in money growth. The estimates for the smoothing coefficient λ are significant if adjusted money growth is used. The significant coefficient estimates lie between 0.03 and 0.04, implying a half-life, given by $-\log(0.5)/\lambda$, of between 18 and 26 quarters. Thus, the measure of trend money growth that is relevant for future inflation is that which moves by half a unit roughly five years after an initial unit shock to headline money growth. The movements in money growth that matter for future inflation hence are rather slow.

While the analysis suggests that long-term movements in adjusted money growth impact on prices, the question arises by how much inflation forecasts improve if money is included. To evaluate this, we construct the optimally smoothed money growth rate, μ_t^*, for adjusted M2 and M3 using the estimated λ reported in Table 3. We then estimate

18 Since $0 \leq \lambda \leq 1$, we use HARVEY's (1989) approach to test the hypothesis that $\lambda = 0$.

Table 3: Estimation Output for

$$\pi_t = \lambda\alpha + (1-\lambda+\beta)\pi_{t-1} + \gamma g_{t-1} + \theta\Delta e_{t-1} + \delta\lambda\mu_{t-1} - (1-\lambda)\beta\pi_{t-2} - (1-\lambda)\gamma g_{t-2} - (1-\lambda)\theta\Delta e_{t-2} + \eta_t$$

with $\eta_t = \varepsilon_t - (1-\lambda)\varepsilon_{t-1}$

	Headline M2	Headline M3	Adjusted headline M2	Adjusted headline M3
α	5.937 (4.682)	–2.697 (3.283)	–0.422 (1.364)	0.092 (0.743)
β	0.088 (0.116)	0.143 (0.103)	0.099 (0.100)	0.055 (0.098)
γ	0.469*** (0.166)	0.654*** (0.172)	0.719*** (0.152)	0.603*** (0.157)
δ	–1.496 (1.739)	0.800 (0.535)	0.509** (0.248)	0.406*** (0.131)
θ	–0.246*** (0.086)	–0.188** (0.084)	–0.187** (0.083)	–0.194** (0.081)
λ	0.012	0.023	0.027*	0.038**
Log likelihood	–221.053	–222.820	–220.612	–218.177

Note: Maximum likelihood estimates of equation (8), 1979:4 to 2007:1. */**/*** denotes significance at the ten/five/one percent level.

$$\pi_{t+k} = a_k + b_k\pi_t + c_k\mu_t^* + d_k g_t + e_k\Delta e_t + v_{k,t} \tag{9}$$

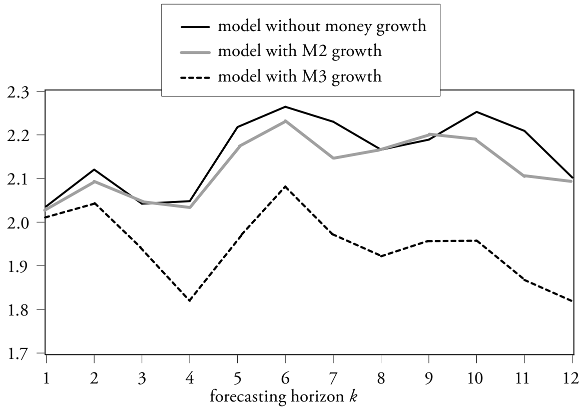
for $k = 1$ to 12 quarters. For reasons of comparison, we also consider the same equation without μ_t^*, i.e.

$$\pi_{t+k} = a_k + b_k\pi_t + d_k g_t + e_k\Delta e_t + v_{k,t}. \tag{10}$$

Based on these estimates, we compute static in-sample forecasts and record the root mean squared error (RMSE) for each forecasting horizon. The RMSEs of the models are plotted in Figure 7 and suggest that using the measure of μ_t^* based on M3 growth yields better forecasts than if M2 growth is used. At the three-year horizon, the in-sample RMSE is by 15% smaller for the regression with M3 growth than for equation (10). If instead the optimally smoothed measure of adjusted M2 growth is considered, there is virtually no improvement at the three-year horizon. The largest reduction (by 5%) in RMSE for this specification is found for a horizon of 11 quarters.

The finding that M3 performs better in forecasting inflation in Switzerland is compatible with Nicoletti-Altimari (2001), who reports the same for the euro area. Arguably, one reason why the model with M2 growth performs less well is that the adjustment for the downward shift in interest rates performed in Section 3 does not fully neutralise the changes in velocity. Since M2 is more interest-rate sensitive than M3, any imperfection in the adjustment method is likely to matter more.

Figure 7: RMSEs for Different Forecasting Equations



Note: In-sample root mean squared errors for static forecasts with and without optimally smoothed adjusted money growth, equations (9) and (10). Smoothing parameter from Table 3.

6. Conclusions

The SNB attaches considerable weight to monetary aggregates in forecasting inflation and setting interest rates. However, headline money growth is insignificant in a traditional Phillips curve. This paper shows that trend money growth, which abstracts from short-term fluctuations, impacts on Swiss inflation, and that the link becomes clearer once money growth is adjusted for the downward trend in interest rates over the sample.

Since it is a priori not clear which monetary aggregate is more informative about future inflation, we consider both M2 and M3 growth rates. While both are significant in the final specification of the Phillips curve, in-sample forecasts suggest that M3 predicts changes in prices more accurately.

In sum, this paper shows that trend money growth is an important determinant of inflation in Switzerland and provides strong support for the emphasis attached by the SNB to monetary aggregates in setting policy.

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SUMMARY

Monetary aggregates have historically been important in Swiss monetary policy. The Swiss National Bank used money growth targets until 1999. The new policy framework introduced in 2000 focuses on an inflation forecast that relies on money growth as an indicator. How useful is money growth for explaining inflation in Switzerland? Using data spanning 1979 to 2007, we estimate a Phillips curve model that incorporates a measure of "trend" money growth and find that it impacts on inflation if one takes the downward shift in nominal interest rates over the sample into account. Including money growth reduces the in-sample forecasting errors by 15%.