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Money and inflation in Switzerland

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Abstract

This paper characterizes the relationship between monetary aggregates, inflation and economic activity in Switzerland since the mid-1970s. Traditional forms of money demand and quantity theory relationships have remained stable over the whole period. Broad money excesses over trend values, accounting for a secular decline in interest rates and thus in trend velocity, have been followed by persistently higher inflation and output with the usual monetary policy transmission lags. Money and exchange rate fluctuations can explain the major inflation developments in Switzerland over the past four decades.

Keywords: Monetary policy, Monetary aggregates, Inflation, Trend velocity

JEL Classification: E52, E58, E41, E30

1 Introduction

In the 1990s, with the emergence of the Taylor rule and issues related to monetary targeting implementation and communication, the monetary policy research focus drifted away from monetary aggregates towards interest rates which have since then been used to summarize the monetary policy stance.[1] Since the Global Financial Crisis (GFC) however, monetary policy interest rates have mostly been at their effective lower bound and central banks have turned to quantitative policies with direct effects on broad monetary aggregates. The need to assess monetary policy stance in terms of quantities has thus come back on the economics research agenda.

This paper presents a clear relationship between a measure of monetary policy stance based on broad monetary aggregates and subsequent developments in economic activity and inflation in Switzerland, a small open economy, during the past four decades. Traditional forms of money demand and quantity theory relationships have remained stable over the whole period, despite the recent low interest rate environment. Accounting for the secular decline in interest rates and thus in trend velocity, which started in the first part of the 1990s and continued after the GFC, broad money excesses over trend values have been followed by persistently higher inflation and output with the usual monetary policy transmission lags. Money and exchange rate fluctuations can explain the major inflation developments in Switzerland over the past four decades.

The relationship between money and inflation before the 1960s has of course been well documented by Friedman and Schwartz (1963). Nelson (2003) reviews the monetarist literature, relates it to the modern New Keynesian dynamic stochastic general equilibrium (DSGE) models used for monetary policy analysis, and concludes that the information content of money found in empirical studies comes from its ability to proxy

[1] For example, in the U.S., the money measure used by the Fed as its main indicator became unstable in the 1990s (see, e.g., Carlson et al. 2000), while in Switzerand monetary targeting implemention became difficult to communicate (see, e.g., Jordan et al. 2001; Rich 2007). When appropriately defined and interpreted, money has continued to play a useful role as an indicator for inflation developments (see, e.g., Carlson et al. 2000; Nelson 2003; Reynard 2006, 2007).

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for various asset yields and their effects on aggregate demand.[2]

The analysis of this paper is based on the P* approach developed by Hallman et al. (1991), which relates inflation to observed money deviations from a long-term money demand equation. The basic idea of this approach is that when the money level is higher than the level that is required for the economy to sustain long-term values of output and velocity, this should lead to upward pressures on inflation. The historical roots of P* analyses can be found in Humphrey (1989), with the statistical tests dating back to the study of Working (1923). More recent applications of this framework from different perspectives can be found in Orphanides and Porter (2000) and Belongia and Ireland (2015).

The econometric relationship between monetary aggregates and inflation has also been well documented in the cases of the euro area and Switzerland by various studies. For example, Gerlach and Svensson (2003) find support for a P* model in the context of the euro area, and related concepts are used to analyze monetary developments in Masuch et al. (2001) and Dreger and Wolters (2014).

The usefulness of money in explaining Swiss inflation is analyzed, for example, in Jordan et al. (2001) and in Gerlach-Kristen (2007), who assesses the effects of trend money growth and output gaps on inflation, and includes an extended literature review on the impact of money and real economic activity on inflation in Switzerland.

This paper extends the analysis of Reynard (2007), who derives a monetary policy stance measure based on monetary aggregates that can be used as an indicator enabling avoidance of a persistent increase in inflation above the monetary policy objective. We show that the relationship between broad money and inflation that Reynard found in the cases of United States (U.S.), euro area and Switzerland between the 1960s or 1970s and 2006 has not been affected by the GFC. Moreover, we assess the stability of money demand, characterize the macroeconomic dynamic effects of that monetary policy stance measure, and quantify its relative influence on inflation and economic activity in Switzerland since the mid-1970s.

Our econometric results on the effects of monetary shocks on economic activity are consistent with the narrative account of Friedman (1968) and the benchmark estimated effects of monetary policy shocks documented in Christiano et al. (2005). We follow the latter paper's approach of characterizing the effects of monetary policy shocks in terms of vector autoregression (VAR) impulse responses and variance decompositions. Shocks to a monetary policy stance measure based on broad monetary aggregates lead to output gap and inflation exhibiting hump-shaped responses, which are delayed and longer-lasting for inflation.

[2] For recent developments on including the financial sector and different yields in DSGE models, see, e.g., Adrian and Shin (2009), Brunnermeier and Sannikov (2014), or Coenen et al. (2018). However, bank deposits are not included in the empirical analysis of those papers.

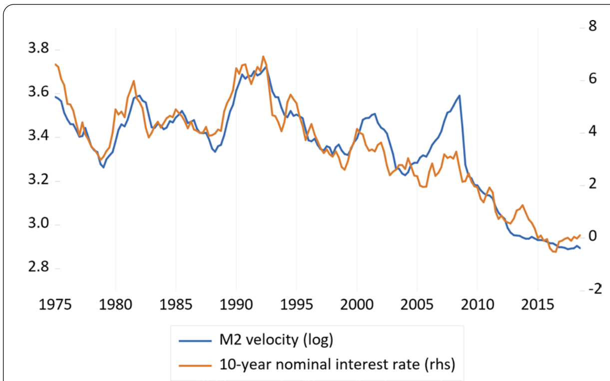

Fig. 1 Money velocity

Section 2 analyzes money demand and the effect of the substantial decline in nominal interest rates since the 1990s. Then, Sect. 3 presents a monetary policy stance measure, the real money gap (RMG). The econometric properties of the RMG are analyzed in details in Sect. 4. In Sect. 5, using a historical decomposition, we characterize the effects of the three most important shocks in Switzerland, namely, the RMG, cost-push and real exchange rate shocks, on inflation developments. Finally, Sect. 6 concludes.

2 Money demand and trend velocity

In this section, we assess and estimate Swiss money demand. The estimated coefficients of this money demand will then be used to compute the RMG in Sect. 3.

2.1 Money and interest rates

Figure 1 displays the (log) velocity of M2 and the 10-year nominal interest rate (in %). The velocity of money is defined as the nominal Gross Domestic Product (GDP) divided by the money level. Money is represented by a broad monetary aggregate and is defined as M2. It includes cash and zero-maturity deposits that can be used directly (e.g., transaction deposits via credit card) or indirectly (via immediate transfers at par, such as transfers from savings accounts) to buy goods and services. It is defined as coins, banknotes, as well as customers' sight deposits, transaction accounts and savings deposits at commercial banks.

We use M2 instead of M1 because funds in savings accounts which are included in M2 but not in M1 can mostly be transferred on demand and without penalty. The upper limit on these transfers, which is typically

Swiss franc (CHF) 50,000 yearly without a 3-month advance notice, is relatively high. Thus these accounts are close substitutes for customers' sight deposits.

M2 is chosen instead of M3 because the assets included in M2 are closer to the transaction concept of money; thus assets included in M2 are empirically more likely to exhibit a stable and close relationship with inflation and economic activity. Our consideration of M3 in the empirical analysis confirms this. M3 includes time deposits with maturities up to several years, and early withdrawals from time deposits are subject to a penalty. Thus the relationship between M3 and purchases of goods and services is weaker.

Money differs from bonds and from other assets in that it is the only means of payment. Bonds can be sold relatively quickly in exchange for money, either directly or via a repurchase agreement, but it is costly to do so. As a consequence, people hold a total of over CHF 1 trillion in M2 monetary assets that are earning very little or no interest, which was the case even before the GFC when the general level of interest rates was higher.

We use the 10-year nominal interest rate as the opportunity cost of money. As discussed in Nelson (2003), the monetarist literature has used long-term interest rates to account for the role of the term structure in portfolio adjustments and for the information of money not contained in short-term interest rates.[3] There is no sign of money demand instability when the 10-year nominal interest rate gets close to zero.

As it is apparent from Fig. 1 and econometrically tested below, money demand has been stable since the mid-1970s, and there is no shift due to the GFC. The only unusual monetary fluctuation was a strong decline in M2, thus a particularly sharp increase in velocity, when interest rates increased in 2006–2007.

A prominent feature of this graph is the velocity decline since the 1990s. The sharp decline in interest rates since the early 1990s is due to both a substantial and persistent decline in inflation and a decline in equilibrium real interest rates. As a result of the decline in opportunity cost, people now hold about 50% more money for a given transaction (nominal GDP) level as in the mid-1980s. As discussed in Sect. 3, such changes in trend velocity, whether due to changes in the inflation environment or in equilibrium real interest rates, have important implications for monetary analysis and must be accounted for.

2.2 Money demand econometric estimates

In this subsection we present the money demand estimates obtained using M2 data. The estimated money demand equation includes the log of M2 (m_t), the log of the consumer price index (CPI) (p_t), the log of real GDP (y_t), as well as the 10-year nominal interest rate (i_t) over the period 1975–2018, and can be expressed[4] as

$$m_t - p_t - y_t = b_0 + b_1 i_t + \varepsilon_t. \quad (1)$$

The unit root tests indicate that the series are I(1), and we use two cointegration regression methods, namely Fully Modified Ordinary Least Squares (FMOLS) and Dynamic Ordinary Least Squares (DOLS). With the latter method, the lag and lead length were selected according to Akaike Information Criterion (AIC). The corresponding results are reported in Table 1. Two aspects of these results are noteworthy. First, both methods lead to nearly identical results with high statistical significance and *R*-squared values, and indicate an interest rate semi-elasticity close to −0.12. Second, the null hypothesis of no cointegration can be clearly rejected at the 5% level.

Table 1 Estimates of M2 demand function (1975Q1–2018Q3)

Method	b_0	b_1	R^2	DW	Cointegration test
FMOLS	− 2.959***	− 0.1156***	0.8597	0.2362	− 3.602**
	(0.0256)	(0.00672)			Phillips–Ouliaris
DOLS	− 2.953***	− 0.1173***	0.8833	0.2362	− 3.970***
	(0.0262)	(0.00688)			Engle–Granger

Newey–West standard errors in parentheses

*, **, ***indicates significance at the 10, 5 and 1% level, respectively

Figure 2 shows the actual and fitted values as well as the residuals of the FMOLS regression, illustrating that these residuals have a good fit and a stationary appearance.

Moreover, we re-estimated the equation using OLS and tested sequentially for multiple breaks according to the method of Bai and Perron. The estimation results are essentially the same as those reported in Table 1, and we find no break at the 5% significance level. All these results indicate that our money demand estimates are stable.

3 A measure of excess money

This section presents a measure of excess money, the RMG. In Sect. 4, the dynamic econometric properties of this measure will be analyzed, and Sect. 5 will present

[3] Gerlach and Svensson (2003) also use a long-term interest rate in euro area money demand estimation.

[4] We follow Lucas (1988) and estimate money demand in its simplest theoretical form with unitary income elasticity. We have also estimated an unrestricted money demand function in which the coefficients of income and price levels are not restricted to unity. The no-cointegration hypothesis is clearly rejected, and the coefficients of CPI and real GDP are statistically insignificantly different from unity. Moreover, the hypothesis that these two coefficients are equal cannot be rejected.

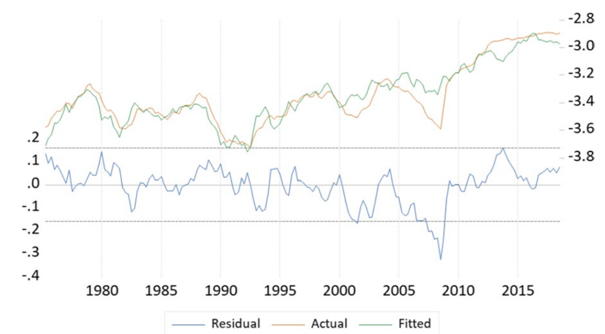

Fig. 2 Fit of FMOLS regression for M2 demand

the role of this measure in a historical decomposition of inflation.

A minimal structure is imposed on the data in the form of long-term adjustments based on the quantity theory of money. The framework is based on the P* concept presented by Hallman et al. (1991), which is equivalent to the RMG concept in Gerlach and Svensson (2003) or the excess liquidity concept in Reynard (2007). The RMG is defined as

$$RMG \equiv \widehat{m}_t - \widehat{m}_t^*, \tag{2}$$

where $\widehat{m}_t \equiv m_t - p_t$ is the real money level, m_t is M2, p_t is the CPI, and $\widehat{m}_t^*$ is the real money level that would be demanded at trend values of output and interest rate, i.e.,

$$\widehat{m}_t^* \equiv b_0 + y_t^* + b_1 i_t^*, \tag{3}$$

where b_0 and b_1 are the constant and interest rate semi-elasticity estimated in the money demand Eq. (1), y^* is the real potential output derived from a production function, and i^* is the low-frequency (HP-filtered) 10-year nominal interest rate. All the variables except interest rates are in logarithms.

The RMG is thus the proportion of the observed real broad money level M2 in excess of trend money demand, i.e., the amount of money that would be demanded if output and money velocity were at their trend values. Accounting for potential output ensures that money supply and potential output offset each other with respect to inflation developments. If money grows proportionally to what is needed to sustain the potential growth of the economy, this is neutral for inflation. The low-frequency interest rate or trend velocity adjustment accounts for the fact that when trend velocity decreases, as nominal interest rates decrease during periods of disinflation or when the equilibrium real interest rates decrease, people persistently hold more money. As seen in Fig. 1, given the velocity decline that occurred since the 1990s with a decline in inflation and equilibrium real interest rate, people now hold about 50% more money for a given nominal GDP level as in the mid-1980s.

Both of the potential GDP and trend interest rate adjustments are low-frequency adjustments derived from the quantity theory of money. Their importance was noted by Friedman et al. (1985). Omitting those adjustments, i.e., considering only the error term of the estimated money demand Eq. (1) as RMG, would result in a low-frequency discrepancy between the money supply and price levels. Reynard (2006, 2007) showed that those adjustments are not only important for uncovering a relationship between money and inflation that is useful for monetary policy, but omitting them biases econometric estimates.

Empirically, RMG fluctuations reflect money supply movements around a slow-moving trend money demand level. Historically, as shown in the references at the beginning of this section and later in this paper, when money supply has been above the trend value of money demand, this has been followed by increasing inflation.[5]

4 Econometric properties of RMG

4.1 Model specifications

In this section, we provide structural VAR estimates of the dynamic effects of shocks in the RMG on the 10-year nominal interest rate (IL), the output gap (YG), inflation (INF) and the (log) real effective exchange rate (REER). The latter variable is introduced to control for exchange rate movements which are very important for the highly open Swiss economy. The data are displayed in Fig. 3.

There have been two episodes of high RMG of approximately 15–20% during the late 1970s and late 1980s. During those episodes, expansionary monetary policies and bank lending were followed, after a few years' lag reflecting the monetary policy transmission mechanisms, by a booming economy as well as substantial and persistent increases in inflation reaching over 6% during the early 1980s and early 1990s. Thus, episodes of high RMG have been followed by substantial and persistent increases in inflation, and major increases in inflation have been preceded by high RMG.

[5] Taking the difference of equations (1) and (3), the RMG can be decomposed into an output gap, an interest gap and an error term. Empirically, the money stock and thus the RMG do not necessarily react to interest and output changes, i.e., the error term can offset the interest or output gap movements, as money is in fact created through a monetary policy transmission process involving credit supply and demand. As the central bank lowers the policy interest rate, for example in reaction to a drop in output, commercial banks provide more loans and thus the money stock increases. If the latter increases above what people are willing to hold in the medium term, this has a positive effect on output and inflation after a some lags. As a result, we observe and estimate that the RMG reacts negatively to past output fluctuations and has a positive effect on subsequent output and inflation.

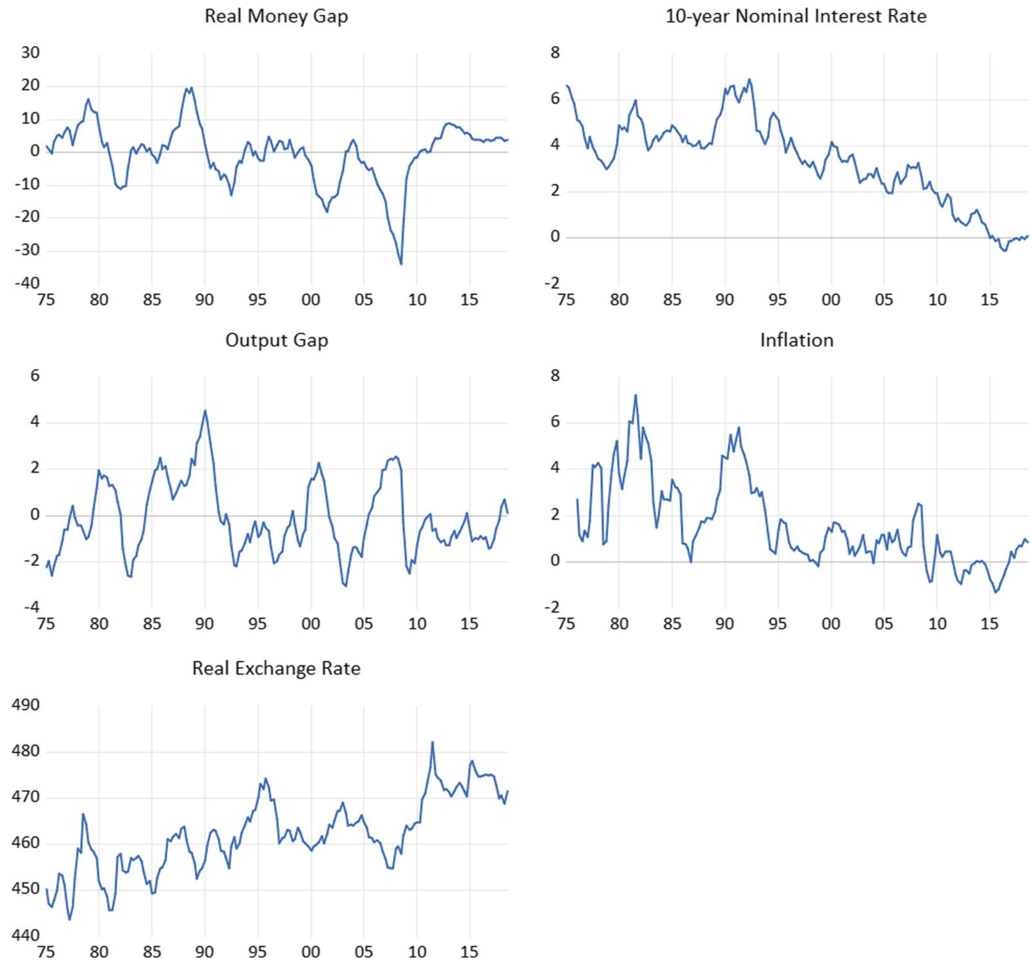

Fig. 3 Real money gap, long-term interest rate, output gap, inflation and real exchange rate, 1976–2018

Table 2 Unit root and stationarity tests (1975–2018, including deterministic trend)

	PP	KPSS
RMG	− 2.90**	0.3001
REER	− 3.731**	0.0768
IL	− 2.343	0.2881***
INF	− 3.404*	0.0517
YG	− 3.673**	0.0576

*, **, *** indicates significance at the 10, 5 and 1% level, respectively

The positive RMG episodes of 1996–1998, 2003–2004 and 2012–2018 were also followed by positive output gaps and increasing inflation, although those relationships were temporarily affected by special events like the commodity price spike in 2008 (which pushed inflation higher) and the removal of the exchange rate floor (which pushed inflation lower) in 2015. However, the RMG remained relatively low since the 1990s, so inflation remained low as well. When the RMG was negative, the output gap subsequently became negative and inflation decreased.[6] These major monetary expansion and tightness episodes correspond to the findings of the analysis of Baltensperger and Kugler (2017), who examine Swiss monetary history since the early nineteenth century.[7]

Table 2 shows the Phillips Perron (PP) unit root and Kwiatkowski Phillips Schmidt Shin (KPSS) stationarity tests. For RMG, REER, INF and YG, the results support the stationarity assumption. For IL, the tests indicate non-stationarity. However, this might be the result of a historically limited sample with extraordinary interest rate fluctuations. According to Sims et al. (1990), VAR estimates remain consistent in the cases of some unit roots, and the coefficient estimates of stationary

[6] The sharp decrease in RMG in 2006–2007 was due to the abnormally large decrease in M2 following the increase in interest rates, as shown in Figs. 1 and 2.

[7] See, for example, p. 160.

right-hand variables have standard asymptotic distributions. Thus, the Granger causality tests shown below would even be valid with a non-stationary IL, except in the cases of the tests involving the influence of IL on the other variables. Moreover, we can expect that the confidence interval of the impulse responses will only be mildly distorted, as we only have a few IL coefficients involved in the calculations.

We set a lag length in the VAR of two, which is optimal according to the Hannan–Quinn information criterion. First, Table 3 shows the test results of the lagged interactions of the five variables ("Granger causality" test). The table reports a chi-squared statistic for each of the other four variables (with two degrees of freedom) as well as for all of the variables jointly (with 8 degrees of freedom), and the corresponding marginal significance level. We find highly statistically significant influences of the output gap and the interest rate on the RMG. Moreover, the interest rate is dynamically influenced by the RMG and the output gap, at least at the 1% significance level, whereas for the output gap and inflation we find a statistically significant influence of the RMG. Moreover, there is a dynamic influence of the real exchange rate on the output gap and on inflation.

In addition, an examination of the correlation matrix of the VAR residuals (Table 4) shows strong contemporaneous relationship between the five variables. In particular, the VAR residuals of RMG and those of IL, YG and INF (and the real exchange rate) are strongly negatively (positively) correlated. The most plausible cause of this pattern is the reaction of monetary policy to changes in the output gap and inflation as well as to changes in the real exchange rate.

Given this correlation pattern, we use the following structural VAR model to identify reasonable structural shocks (u) from reduced form shocks (e), $e_t = Bu_t$ with the following zero restrictions:

$$\begin{matrix} x & x & 0 & 0 & x \\ x & x & 0 & 0 & x \\ 0 & 0 & x & 0 & x \\ 0 & 0 & 0 & x & x \\ x & 0 & 0 & 0 & x \end{matrix}$$

The matrix has the same rows and columns as Table 4, and x means that the coefficient is unknown, i.e., could be non-zero, and has to be estimated.

This model allows for a simultaneous interdependence between the RMG, the interest rate and the real exchange rate, whereas the reaction of these variables to the output gap and inflation is lagged. Consistent with the monetary literature on monetary policy effects, we assume that the RMG and the interest rate

Table 3 VAR granger causality/block exogeneity Wald tests, 1976Q3–2018Q3

	Chi-sq.	Prob.
Dependent variable: RMG		
Excluded		
IL	23.64874	0.0000
YG	6.731453	0.0345
INF	0.210304	0.9002
REER	5.494405	0.0641
All	53.17393	0.0000
Dependent variable: IL		
Excluded		
RMG	26.91932	0.0000
YG	12.40613	0.0020
INF	2.752130	0.2526
REER	2.737233	0.3053
All	40.19516	0.0000
Dependent variable: YG		
Excluded		
RMG	12.79512	0.0017
IL	5.015600	0.0814
INF	7.016553	0.0299
REER	8.200706	0.0166
All	33.02824	0.0001
Dependent variable: INF		
Excluded		
RMG	10.51591	0.0052
IL	1.702294	0.4269
YG	3.771470	0.1517
REER	9.321947	0.0095
All	27.74591	0.0005
Dependent variable: REER		
Excluded		
RMG	5.837611	0.0540
IL	1.652028	0.4378
YG	0.054130	0.9733
INF	0.845982	0.6551
All	10.26243	0.2471

Table 4 Correlation matrix of VAR-residuals (1976Q3–2018Q3)

	RMG	INT	YG	INF	REER
RMG	1	− 0.331	− .280	− .236	.297
IL	− .331	1	.225	.113	− .259
YG	− .280	.225	1	.050	− .360
INF	− .236	.113	.050	1	− .175
REER	.297	− .259	− .360	− .175	1

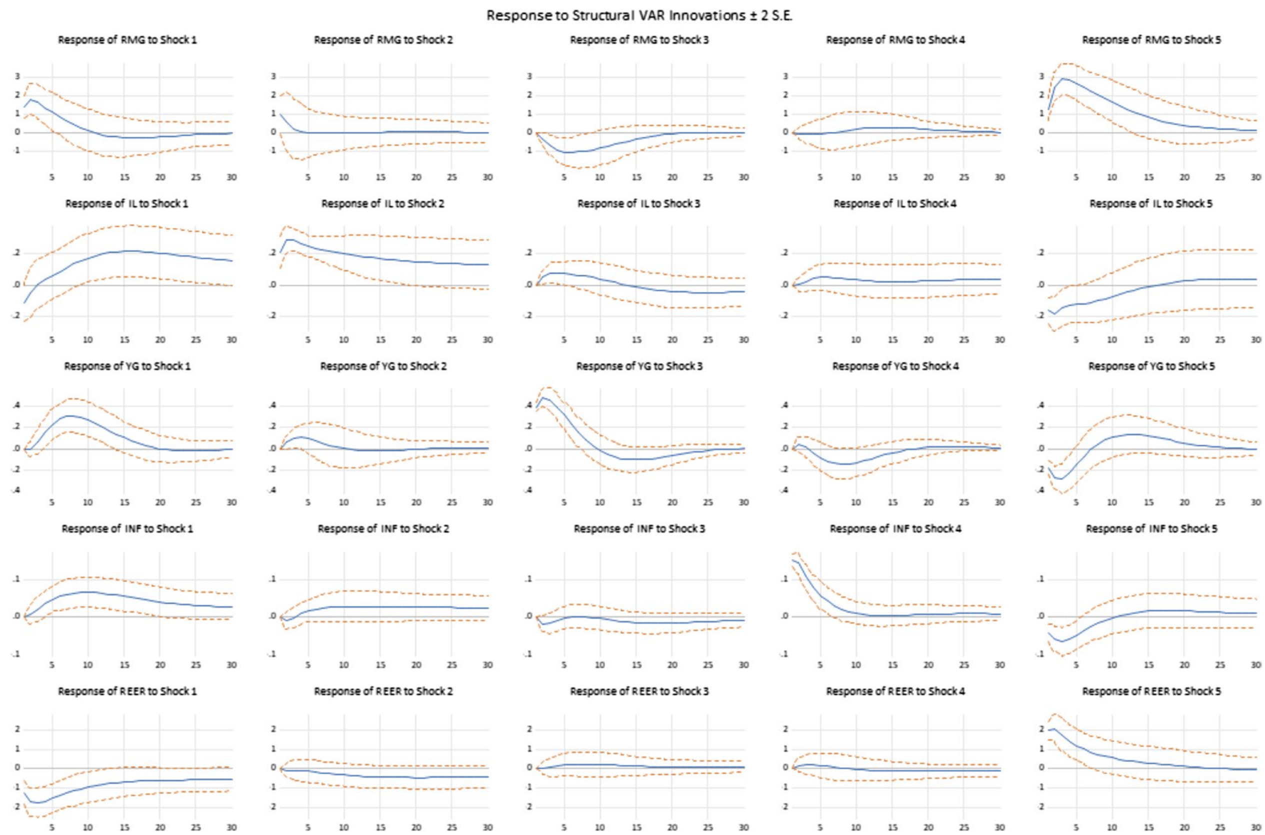

Fig. 4 Impulse Responses, SVAR 1976Q3–2018Q3

do not affect inflation and real output contemporaneously. Moreover, the real exchange rate may impact the output gap and inflation immediately.

This model is over-identified and the chi-square test of the corresponding restrictions provides a value of 2.372, which is not statistically significant at the usual significance levels with 3 degrees of freedom (marginal significance level 0.498); thus, the model is validated.

4.2 RMG dynamics

The impulse responses for the u-shocks with two standard error confidence bands are displayed in Fig. 4. We see that most of the impulse responses are statistically significant, and they confirm our a priori expectations.

$u1$ appears as an exogenous change in monetary policy or RMG; it leads to a short-term decrease in the long-term interest rate, which is then reversed by increasing inflation expectations. The output gap and inflation exhibit a hump-shaped adjustment pattern, and this pattern is more delayed and longer lasting for inflation.

These results are consistent with the claims made by Friedman (1968) as well as with the findings of Christiano et al. (2005): after an expansionary monetary policy shock, output and inflation respond with a hump-shaped adjustment pattern. Output peaks approximately one and a half years after the shock and returns to pre-shock levels after approximately 3 years, and inflation peaks approximately 2 years after the shock.

$u2$ is interpreted as a shock to the long rate; however, this shock has no significant effect on output gap, inflation or the real exchange rate. The impulse responses to $u3$ suggest that it is a demand shock that triggers a restrictive monetary policy. $u4$ appears to be a cost-push inflation shock that leads to a restrictive monetary policy and correspondingly to a negative influence on the output gap. Finally, the impulse responses to $u5$ show that an exogenous appreciation of the real exchange rate has a negative influence on the output gap and inflation. An expansionary monetary policy mitigates this real exchange rate change, and we see a decline in the interest rate as a result. Note that all the impulse responses converge to zero

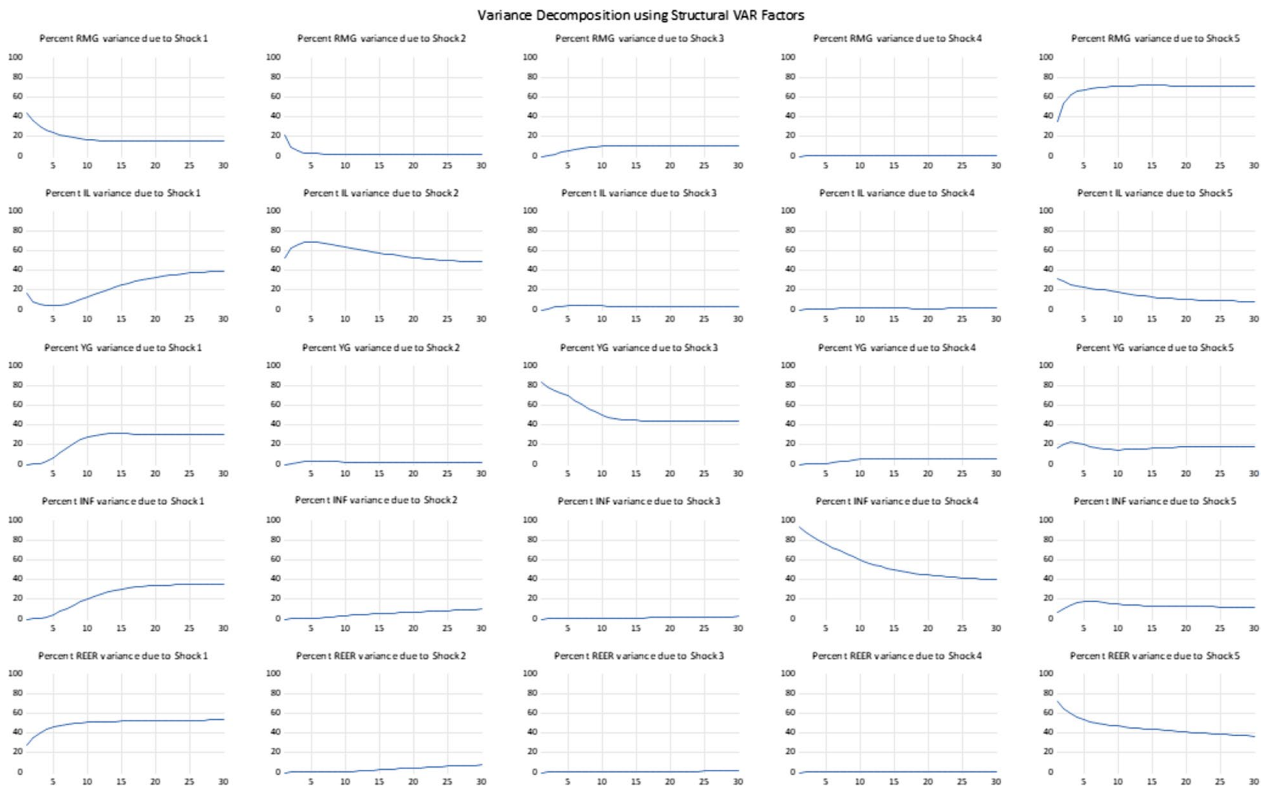

Fig. 5 Variance decomposition, SVAR 1976Q3–2018Q3

within 30 quarters; therefore, we see no sign of non-stationarity in our series.

The variance decomposition is displayed in Fig. 5. This figure shows the percentages of the contributions of all five shocks to the forecasting variance of all the variables for different horizons. In the short term, this variance is mostly dominated by the "own" shock, but the other shocks play an important role in the cases of most of the variables over the long term. This is particularly true for the RMG, as the variance share of the exchange rate shock for this variable increases to nearly 70% with an increasing horizon, while the demand shock reaches 10%. This corresponds to the high importance of the real exchange rate for Swiss monetary policy.

For the output gap and inflation, we observe a long-term variance share of approximately one third for the RMG. This is larger than the percentage variance of inflation and output resulting from U.S. monetary policy (interest rate) shocks of 7% and 14%, respectively, which are estimated by Christiano et al. (2005). Moreover, RMG shocks appear very important for the real exchange rate over the long term, as they have a variance share of nearly 60%.

4.3 Robustness tests

To test the stability of our structural VAR (SVAR) model over time, we estimated this model using a sample split in 2007Q3. Therefore, we have three estimates, namely, the full sample, 1976Q3–2007Q3 and 2007Q4–2018Q3. This allows us to calculate a log likelihood for the model with and without a break.

If the hypothesis of no break is correct, then twice the difference of the log likelihood is distributed with 67 degrees of freedom, i.e., the total number of SVAR parameters estimated. This approach produces a test statistic equal to 80.46, which is not statistically significant, even at the 10% level. Therefore, this result indicates that our model is stable over the past 10 years despite the financial and government debt crises as well as the unconventional monetary policy responses to them.

Table 5 presents stability tests of the inflation VAR equation. First, we consider the standard Chow statistic with a break in 2007Q3. Second, we present results for the Bai Perron sequential multiple break test, testing for the stability of all coefficients and of only the coefficients of lagged RMG, respectively.

Table 5 Stability tests of the inflation VAR equation

Chow	*F*-statistic	*P* value
	1.127	0.345
Bai–Perron	Scaled *F*-statistic 0 versus 1 break	5% critical value
All coefficient	14.44	25.77
Only RMG coefficients	5.62	5.62

Trimming percentage 25%, Bai–Perron (2003) critical values

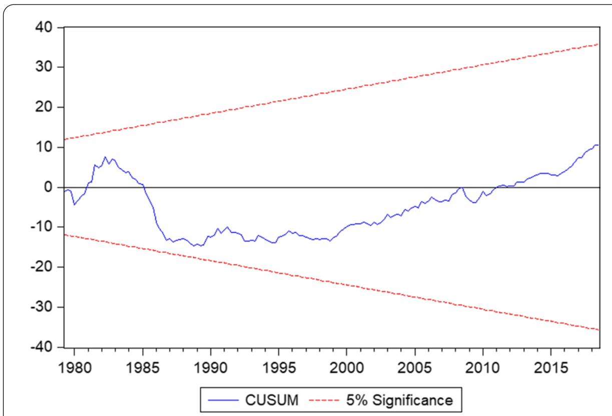

Fig. 6 CUSUM test of recursive residuals of inflation VAR equation

According to Table 5, we find no evidence of a structural break in the inflation equation, as the stability hypothesis cannot be rejected at any reasonable significance level. This conclusion is supported by the result of the cumulated sum of recursive residuals (CUSUM) displayed in Fig. 6. This statistic remains always clearly within its 95% confidence band under the stability hypothesis.

These latter tests of the stability of a single equation of a VAR system are however of limited value as such a model has to be evaluated including all its dynamic interactions. Moreover, the coefficient estimates of a VAR system are difficult to interpret quantitatively. For example, a shock to the RMG can affect inflation dynamically via the output gap or a combination of variables. Therefore, we have used the log likelihood test at the beginning of this Sect. 4.3 and we will now present the impulse responses of two sub-samples in order to evaluate the properties of the VAR model.

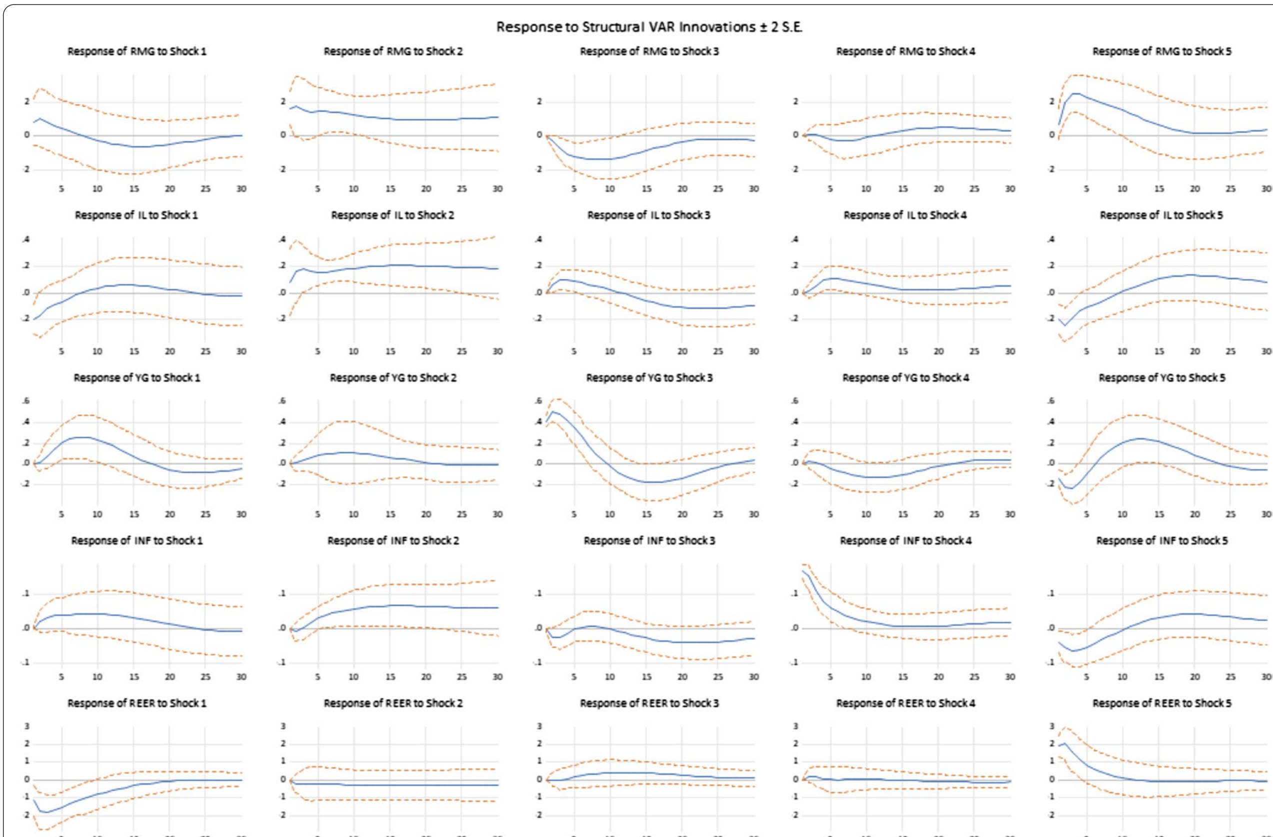

Fig. 7 Impulse responses, SVAR 1976Q3–2007Q3

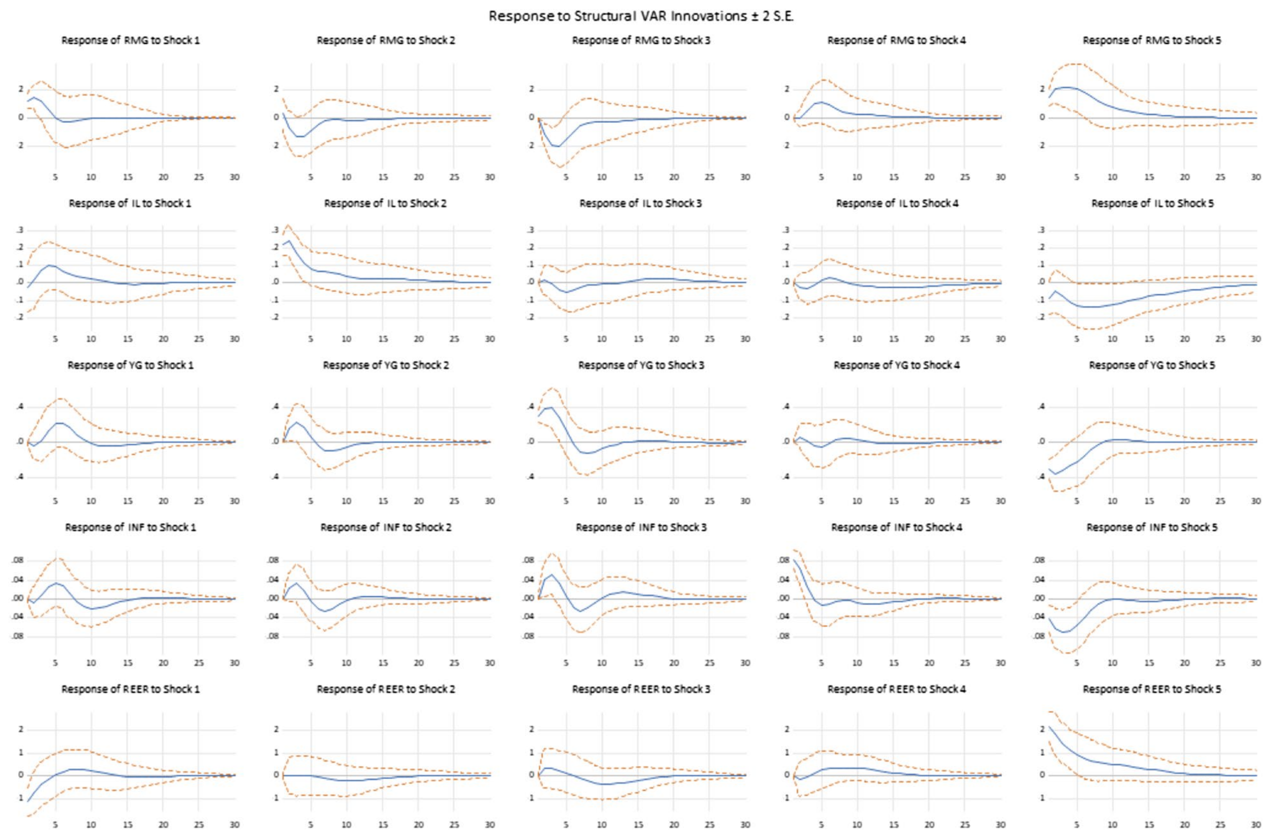

Fig. 8 Impulse responses, SVAR 2007Q4–2018Q3

Figure 7 displays the impulse responses for the reduced sample covering 1976Q3–2007Q3, and the impulse responses for the strongly reduced sample 2007Q4–2018Q3 are provided in Fig. 8. The patterns are very similar in both figures, and similar to the whole sample displayed in Fig. 4. For example, the peak responses of inflation and output to RMG shocks are very similar for all three samples. As expected, we see less statistical significance in the sub-samples, especially in the second one. This is not surprising, as we only have about 10 years of data in the second sub-sample. The impulse responses in Figs. 7 and 8 thus confirm the stability of our VAR model and of the effects of the RMG shocks on inflation and output.

5 Historical contribution of economic shocks

In this section, we present a historical decomposition of the observed time series that shows the effects of the five structural shocks examined on the development of our variables over time. Burbridge and Harrison (1985) provide a short description of this approach and apply it to the case of the Great Depression in the United States. To this end, we use the impulse response functions to calculate the total effect of the shocks on the observed time series over a specific period.

We choose to employ the entire estimation sample from 1976Q3 to 2018Q3 for this exercise, as this sample covers two major inflation episodes and a subsequent disinflation period. During the first step, we calculate the baseline projection assuming that no shock appears after 1976Q3. Then we add the shocks occurring during the fourth quarter of 1976 and calculate their contributions to the time series observed. After this, we add the next quarter's shocks and calculate their impacts on the variables as well as that of the lagged shocks. We repeat this procedure throughout our sample period.

Figure 9 shows the results of this exercise. As it is the case with the impulse response functions, this figure shows a five-by-five matrix of graphs, with the variables in the rows and the shocks in the columns. The blue line represents the baseline projection, which assumes that there is no shock after our sample begins. The red line displays the contribution of the shock in the column to the observed variable in the row. Finally, the

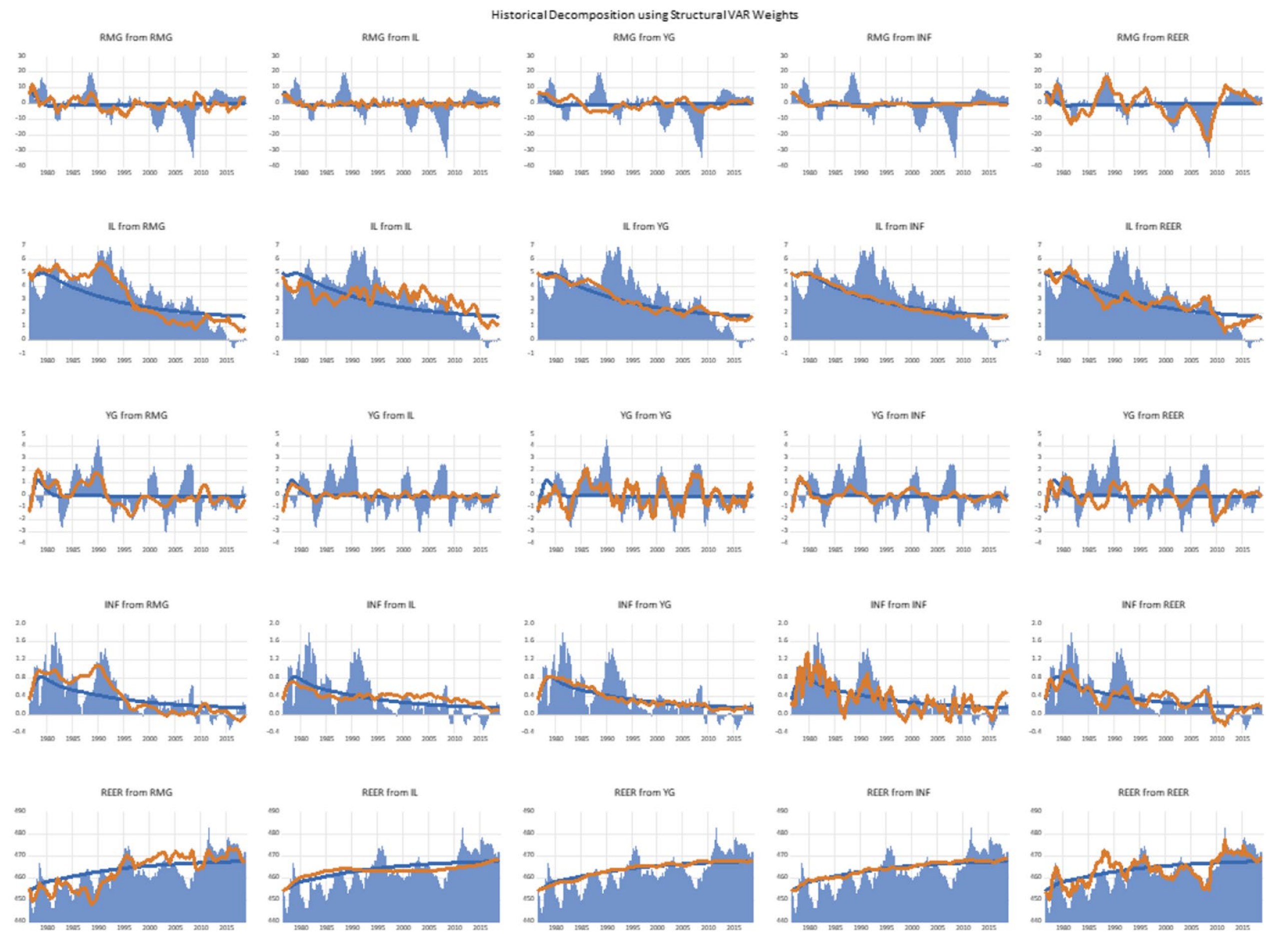

Fig. 9 Historical decomposition, SVAR 1976Q3–2018Q3

gray bars represent the observed values of the variables. Hence, the red lines in column *j* show the hypothetical development of all variables if only shock *j* would have affected the economy and if all the other shocks had been zero.

Here we consider the decomposition of inflation, i.e., the variable of key interest, in details. Panel 4.1 shows a strong, although not perfect, co-movement of actual and only RMG-caused inflation. The same is true for the cost-push shock $u4$ and the real exchange rate shock $u5$, whereas the interest rate shock $u2$ and demand shock $u3$ lead only to minor deviations from the baseline.

Often, all three of these important shocks move inflation in the same direction, but there are episodes in which opposite impacts are observed. For instance, inflation would have been much higher in the late 1980s with only RMG shocks and without the offsetting real exchange rate appreciation shocks. We also observe fairly strong effects of RMG shocks on the long-term interest rate, output gap and real exchange rate.

Since the financial crisis, the main drivers of negative output gaps and low inflation have been RMG, demand and exchange rate shocks. In a low interest rate environment, negative RMG shocks can occur more frequently than they do in a high interest rate environment, as the capacity to lower monetary policy interest rates is lessened. Monetary policy can, however, support a small open economy by limiting exchange rate shocks. The SNB's willingness to intervene in the foreign exchange (FX) market is not modeled here, but it has contributed to the limitation of negative exchange rate shocks, thus contributing to the stabilization of inflation.

The first row of Fig. 9 shows that the RMG is not greatly affected by exogenous monetary policy or by banking transmission shocks ($u1$). Additionally, the RMG is not greatly affected by the interest rate, demand or cost-push shocks either. Not surprisingly, the real exchange rate shock is the main driver of the RMG. Exchange rate shocks thus induce monetary policy responses; these responses, through monetary policy transmission via the banking system, can offset the effects of exchange rate shocks on import prices, net exports and output gaps in the highly open Swiss economy.

6 Conclusions

Traditional forms of money demand and quantity theory relationships have remained stable in Switzerland, a small open economy, since the end of the Bretton Woods system in the mid-1970s, even through the GFC and despite the recent low interest rate environment. Accounting for the secular decline in interest rates, and thus in trend velocity, which started in the first half of the 1990s and continued after the GFC, broad money excesses over trend values have consistently been followed by higher inflation and output with the usual monetary policy transmission lags.

Our results on the dynamic effects of money on inflation and output are consistent with those of the existing literature. Output and inflation respond with a delay to monetary impulses, with the main impact occurring after approximately 2 years and additional substantial effects lasting several more years. According to our econometric model, in addition to the RMG, which reflects monetary policy actions as well as the banking sector's transmission of monetary policy, exchange rate shocks are the main drivers of inflation in the small open Swiss economy.

Abbreviations

SSES: Swiss Society of Economics and Statistics; SNB: Swiss National Bank; GFC: Global financial crisis; DSGE: Dynamic stochastic general equilibrium; U.S.: United States; VAR: Vector autoregression; RMG: Real money gap; SVAR: Structural VAR; GDP: Gross domestic product; CHF: Swiss franc; CPI: Consumer price index; FMOLS: Fully modified ordinary least squares; DOLS: Dynamic ordinary least squares; AIC: Akaike information criterion; IL: 10-year nominal interest rate; YG: Output gap; INF: Inflation; REER: Real effective exchange rate; PP: Phillips Perron; KPSS: Kwiatkowski Phillips Schmidt Shin; FX: Foreign exchange.

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Authors' contributions

Peter Kugler and Samuel Reynard (corresponding author) contributed equally to this work. All authors read and approved the final manuscript.

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Declarations

Competing interests

The authors declare that they have no competing interests.

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