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Maintaining low inflation: Money, interest rates, and policy stance ☆

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Abstract

This paper presents a systematic empirical relationship between money and subsequent prices and output, using US, euro area and Swiss data since the 1960–1970s. Monetary developments, unlike interest rate stance measures, are shown to provide qualitative and quantitative information on subsequent inflation. The usefulness of monetary analysis is contrasted to weaknesses in modeling monetary policy and inflation with respectively short-term interest rates and real activity measures. The analysis sheds light on the recent change in inflation volatility and persistence as well as on the Phillips curve flattening, and reveals drawbacks in pursuing a low inflation target without considering monetary aggregates.

JEL classification: E52; E58; E41; E3

Keywords: Monetary policy; Monetary aggregates; Inflation; Output; Taylor rule; Equilibrium interest rate

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1. Introduction

There is nowadays a large gap between mainstream monetary policy analysis and policymakers' concerns. Most models currently used for policy analysis or forecasting are linearized or normalized around an inflation steady state or trend. In these models, the central bank announces an inflation target, the public believes in the ability of policymakers to reach this target, and central bankers know how to move a short-term interest rate as a function of unobservable real equilibrium interest rate and economic shocks in order to remain on that target and conduct optimal cyclical policy. These "normalized" monetary policy analyses and estimations are in fact focusing on small inflation deviations from an exogenously given steady-state or "trend inflation".

In order to fit the data, which are characterized by substantial and long-lasting inflation swings, different assumptions have been made regarding "trend inflation". Sometimes, a constant steady-state inflation is assumed, with major inflation fluctuations "explained" by "sunspot equilibria". Sometimes, "trend inflation" is modeled as an exogenous random walk or is identified as a model residual once "structural" restrictions have been imposed on the data, and is interpreted as a moving inflation target with however no evidence of a correspondence between the resulting "trend inflation" and actual central banks' objectives. In empirical work, inflation is usually detrended, in a deterministic or stochastic way. Analyses are thus trying to explain only one part of inflation movements, which moreover have been decomposed in an arbitrary way. At the other extreme of assuming a constant steady-state inflation, every inflation movement could be attributed to a change in policy target!

An implication of those analyses is that policymakers' preferences can be expressed in the form of a loss function: central banks in that world care about minimizing inflation deviations around a given target and output deviations around its potential. Such a loss function has been explicitly derived from theoretical models and is extensively used in monetary policy analysis.

Such an analysis is at odds with policymakers' concerns and behavior. The main concern of central banks and of the population in general, and what matters for welfare, is not small inflation deviations around a given steady state but rather a drifting away from low inflation toward higher inflation or deflation. Whether inflation is at 1.7% rather than 1.3% is not of much importance. Monetary policy cannot fine-tune and control such small orders of magnitudes, and inflation is not perfectly measured anyway. Nowadays, most central banks have, implicitly or explicitly, an admissible range for inflation, and their concern is to prevent inflation from drifting substantially and persistently above or below that range. The position of the inflation rate within that range is not important as long as it is and is forecasted to remain in the desirable range. Thus, the inflation developments which need to be explained are the high inflation of the 1970s, the subsequent disinflation, the temporary inflation increase in the late 1980s/early 1990s, as well as the low and stable inflation thereafter. It is however evident from policymakers' public statements that it is neither clear where the neutral interest rate is, nor how far one should be from it in a given economic situation in order to obtain a desired inflation rate.

Monetary policymakers need to have some quantitative guidelines regarding price developments after policy lags—which are one regularity documented in this paper—have taken effect, in order to avoid the substantial and long-lasting inflation swings characterizing any country's time series data. A wait-and-see approach carries the risk of "being behind the curve" or, on the opposite, "overdoing it". This paper assesses the usefulness of monetary aggregates in providing these guidelines and contrasts monetary analysis to the current mainstream monetary policy analysis.

The paper presents a systematic empirical relationship between money and subsequent prices and output that many empirical studies have claimed to be non-existent, provides an explanation for these latter results, discusses the usefulness of monetary developments as monetary policy stance measures, and contrasts monetary analysis to current mainstream monetary policy analysis and inflation dynamics modeling. As argued by Orphanides (2003), given our limited knowledge of economic dynamics and the resulting fact that various models with different implications for inflation dynamics coexist in the literature, evaluating stance measures based on historical macroeconomic developments for practical monetary policy purposes requires an analysis that is not dependent on specific models. In addition, the stylized facts presented in this paper suggest inherent instability of reduced-form estimated inflation equations. Furthermore, as discussed above, existing macroeconomic models that have tried to incorporate microeconomic foundations are linearized around a given "trend inflation", which is not appropriate to address the issues of interest for this study. This analysis is of course no substitute for structural model building, but it provides stylized facts that structural models designed to model inflation dynamics and address monetary policy issues should be able to replicate.

I use US, euro area and Swiss data. These economies have had different structures and policy regimes. The Federal Reserve has a dual mandate with no explicit inflation target and has been confronted with very different inflation environments during the post-war period. The euro area is an aggregation of individual countries with different pre-euro policies and experiences. Finally, the Swiss National Bank had monetary targets till the end of the 1990s and has been characterized as a precursor of the inflation targeting approach (see Bernanke, 1998). The Swiss case is also interesting as there have been several distinct inflation environments even though average inflation has remained one of the lowest in the world. The samples considered are thus from low inflation economies, with however significant changes in inflation environments and monetary policy responses. These characteristics allow us to address critiques that the relationship between money and inflation is weaker in lower inflation environments and depends on monetary policy regimes.

In Section 2, I first show that using interest rates as a measure of policy stance, i.e. the gap between the observed 3-month interest rate and the prescribed Taylor rule interest rate, does not provide useful information regarding subsequent inflation rates. Focusing on interest rate developments relative to a "neutral" rate is thus not helpful for central bankers who want to achieve a given inflation objective. Moreover, the evidence points to empirical weaknesses of modeling monetary policy with a short-term interest rate. Analytically, the average or steady-state inflation rate in such models is determined by the central bank's objective specified explicitly in the Taylor rule. However, the facts presented here reveal that observed inflation deviates substantially and persistently from the implied inflation objective. In other words, the equilibrium real interest rate that a central bank would have to assume in order for average inflation to equal the inflation target does not take plausible values. Considerations on trend inflation and equilibrium interest rate have been overlooked in monetary policy analyses. I question the usual interpretation of Clarida, Galí and Gertler's (CGG, 2000) results, which is that the 1970s in the US provide an empirical example of a high average inflation and a low real interest rate as a result of too soft an interest rate reaction to expected inflation increases.

Section 3 presents a systematic empirical relationship between money and subsequent prices and output. In contrast to interest rate stance measures, monetary developments provide qualitative and quantitative information on subsequent price level and inflation developments. Two elements have to be taken into account however. First, monetary aggregates must be adjusted by equilibrium velocity changes, which can be approximated with a backward-looking filter, to account for the fact that people decrease their real money balances when inflation and interest rates increase, and vice versa, inducing money movements without corresponding effects on subsequent inflation. Second, an important stylized fact is that in the economies and periods considered, in contrast to money levels, price levels do not decrease. This asymmetric price behavior induces a source of bias in linear econometric estimates of studies assessing the effect of money growth or real activity measures on inflation and complicates the use of money growth rates to assess inflation risks. Therefore, analyses of money and price levels are necessary for shorter-term policy purposes.

It is commonly argued that the long-term relationship between money growth and inflation comes only from a money demand relationship and that, even with a stable money demand, money is not useful for horizons of interest to central banks. It is also claimed that short-term velocity movements due to implicitly accommodated money demand shocks—i.e. through an interest rate based policy—or to monetary policy reacting to other fundamental economic shocks blur the short-term relationship between money and prices, especially in low inflation economies. It is further argued that, as a result, with a successful inflation targeting strategy the link between money growth and inflation should vanish. In contrast to those claims, this paper shows that when the relationship between prices and money is characterized in a way that accounts for equilibrium velocity changes and prices asymmetric behavior, significant monetary developments are in every case followed by corresponding price developments. Furthermore, we do not observe significant price movements not preceded by corresponding monetary movements. Contrary to what is usually argued and modeled, what are considered as velocity "shocks" provide information on subsequent price levels and output, pointing to a weakness of models that represent policy actions with a short-term interest rate only. Moreover, the quantitative importance of other economic shocks to inflation is small in the samples considered. Consequently, a successful inflation targeting strategy would result in money (adjusted by potential output) and prices growing at the same rate. In summary, monetary developments can be used to characterize inflation trends as well as fluctuations around these trends, and provide early information on these inflation developments.

In Section 4, monetary regularities are used to assess the forecasting efficiency of Phillips curves (PCs) and to shed light on recent changes in inflation patterns and estimated relationships, i.e. on inflation reduced persistence and volatility as well as on the flattening of the PC. Seen from the angle of monetary aggregates, monetary policies since the early 1990s have been rather restrictive in terms of low money levels relative to price levels. Given the asymmetric price behavior, this has kept the inflation rate at a relatively constant low value while output has mostly been below potential, contributing to a weaker relationship between output gaps and inflation. In other words, more liquidity could have been provided to sustain real activity without resulting in significantly higher inflation. This reveals drawbacks in pursuing a low inflation target without considering monetary aggregates: given that we observe price increases when policy is expansive but do not observe price decreases when policy is restrictive, a focus on a low inflation target without considering monetary aggregates runs the risk of being too restrictive on average as policy effects on output appear to be symmetrical.

2. Empirical weakness of interest rate rules and stance measures

This section presents issues with modeling monetary policy with a short-term interest rate and with assessing monetary policy stance with interest rate deviations from interest rate rules or from a "neutral" rate. The standard Taylor rule (Taylor, 1993) can be expressed as

$$i = r^* + \pi^* + 1.5(\pi - \pi^*) + 0.5(y - y^*), \tag{1}$$

where i is a short-term nominal interest rate, r^* is the equilibrium real interest rate assumed by the monetary authority, π is the inflation rate, π^* is the inflation objective or target of the central bank, y is (log) real output and y^* is (log) real potential output. The timing of variables differs across studies, which consider past, current or future deviations from steady state or trend.

The usefulness of such a type of rule, for central bankers as well as economic and econometric modelers, depends on the correspondence between the inflation objective π^* and actual inflation at a horizon relevant for monetary policy. Policymakers want to have some guidance on where to set a short-term interest rate in order to obtain a given inflation target at a given horizon. This issue has been overlooked by focusing on business cycle analyses around exogenous inflation trends, and by trying to fit variations of this rule to observed interest rates without considering the relationship between the implicit inflation objective π^* and actual inflation.

A central property of New Keynesian models is that average inflation equals the chosen inflation target π^* if policymakers set r^* equal to the equilibrium (average) real interest rate.[1] A policy rule such as Eq. (1) thus "closes" New Keynesian models in the sense that it determines average inflation set by the monetary authority. For example, Woodford (2006, p. 13), replying to a theoretical argument raised by Nelson (2003, Section 2.2), states that "the trend inflation rate is *also* determined within the system: it corresponds to the central bank's target rate, incorporated in the policy rule". I however argue in this section that there is no useful empirical relationship between the implied π^* in an interest rate setting corresponding to Eq. (1) and actual inflation, by analyzing the relationship between these variables under three different but related angles.

2.1. Interest rate stance and inflation objective

The first approach is to evaluate interest rate stance measures by comparing the observed nominal interest rate to the Taylor rule rate given by Eq. (1), where π^* is set to 2%, and contrasting the difference between the two rates to the evolution of the observed inflation relative to the chosen 2% inflation target. A useful stance measure would imply that when the observed interest rate corresponds to the Taylor rule, actual inflation should, potentially after a certain lag, be close to the 2% implicit target. When the rate is above

[1] See McCallum (2001).

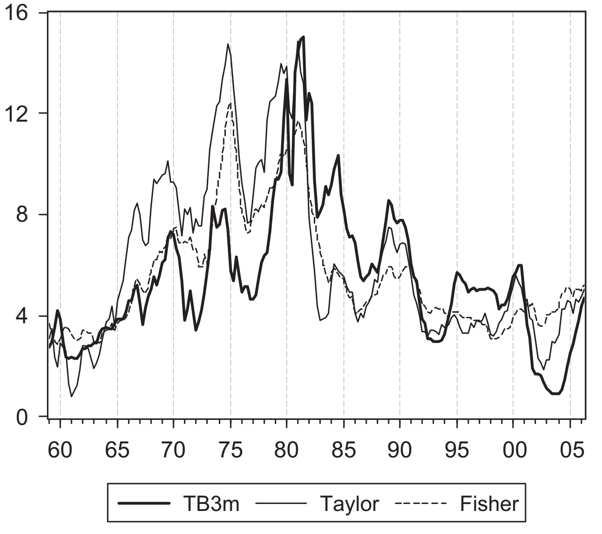

Fig. 1. US interest rates (%).

(below) the rule, inflation is expected to go below (above) 2%. Moreover, there should be no substantial and persistent increase in inflation above target if the observed nominal interest rate is at or above the rule.[2] Fig. 1 displays the 3-month T-bill rate (TB3m) together with the Taylor rule (Taylor) from Eq. (1) and the Fisherian rate $r^* + \pi_t$ (Fisher). r^* and π^* are both set equal to 2% as in the original Taylor rule.[3] Realized inflation thus corresponds to the Fisher variable minus 2% points.

Fig. 1 suggests that this stance measure provides very little information regarding inflation developments. Over the 1980s and 1990s, the 3-month T-bill rate has been consistently above the Taylor rule rate associated with a 2% inflation. Despite that fact, inflation reached 2% only in the late 1990s. In other words, inflation has almost always been above the implied target (2%) without the actual interest rate being below the Taylor rule. There is thus not a useful relationship between the implied inflation target and observed inflation. Moreover, there is no indication why inflation should have picked up to 4% around 1990: the T-bill rate was even above the rule implying 2% inflation before and

[2]My analysis thus goes further than e.g. McCallum (2000) or Taylor (1999) analyses that assess whether observed interest rate settings have been loose or tight relative to a rule when compared to actual inflation outcomes, by relating interest rate deviations from a rule associated with a given inflation target to subsequent discrepancies of observed inflation from that target.

[3]Price series are the GDP price deflator for the US, the harmonized CPI for the euro area, and the CPI for Switzerland. Inflation rates are year-on-year quarterly rates. Potential output is real potential GDP (Congressional Budget Office) for the US, HP filtered log real GDP for the euro area, and is derived from a production function approach (SNB) for Switzerland. Interest rates are 3-month rates. All series except interest rates are seasonally adjusted. The samples considered, chosen according to availability of the data series used in the analysis, are 1959Q1–2006Q2 for the US, 1973Q1–2005Q4 for the euro area, and 1975Q1–2005Q4 for Switzerland. US data are from the Federal Reserve Bank of St. Louis FRED database and are released by the Federal Reserve Board, the Bureau of Economic Analysis and the Bureau of Labor Statistics. Euro area data are from the European Central Bank and Eurostat. Swiss data are from the Swiss National Bank and the Swiss Federal Statistical Office.

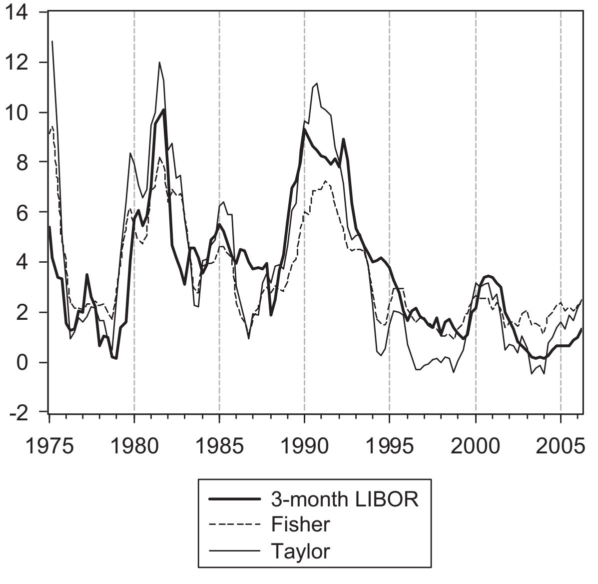

Fig. 2. Swiss interest rates (%).

during this inflation increase. Furthermore, we would have expected a strong decrease in inflation following the high interest rate relative to the Taylor rule seen in the second part of the 1990s. There is also no indication why inflation began to accelerate in the mid-1960s, the beginning of the "Great Inflation", as the T-bill rate was at or above the Taylor prescription just prior to that event. And finally, in the 1970s, it is difficult to assess what inflation observed interest rates would have implied, given that they have been consistently below the Taylor rule. There is thus neither useful qualitative nor quantitative information in that measure of policy stance.[4]

Swiss interest rates, i.e. the short-term (3-month LIBOR) as well as the Taylor and Fisher rates, where r^* is set to 1.2% (average over the past three decades) and π^* is set to 1%, are presented in Fig. 2. Since 2000 the Taylor rule and the actual interest rate have evolved close to each other and inflation has fluctuated around 1%. However, such a rule fails to account for the loose policy stance preceding the two inflationary periods of the early 1980s and early 1990s and provides no quantitative information of subsequent price levels during these episodes. Furthermore, the Taylor rate is constantly and substantially

[4]Similar issues arise when the "natural growth rule" (NGR), i.e. $\Delta i = 0.5(\pi - \pi^*) + 0.5(\Delta y - \Delta y^*)$, discussed by Orphanides (2003) is used to evaluate policy stance. The 3-month T-bill rate follows the rule relatively well over the 1980s and 1990s while inflation was most of the time above target. This measure of stance also missed the inflation increase of the late 1980s. Orphanides argues that the NGR is equivalent to a money growth rule. This however is the case only under his particular assumption that velocity deviations from equilibrium are a function of the interest rate. With a more conventional money demand where velocity itself is a function of the interest rate, a money growth rule implies that the change of the equilibrium nominal interest rate appears in the NGR. Both money demand formulations are equivalent only in the case of constant equilibrium nominal interest rate, which is not plausible with data characterized by long-lasting inflation swings. Moreover, Orphanides disregards the change in the money demand error term, arguing that short-term velocity fluctuations are the suggested drawbacks in considering money. The analysis of this paper, however, will show that these short-term velocity fluctuations contain additional information for price developments that non-monetary analyses miss.

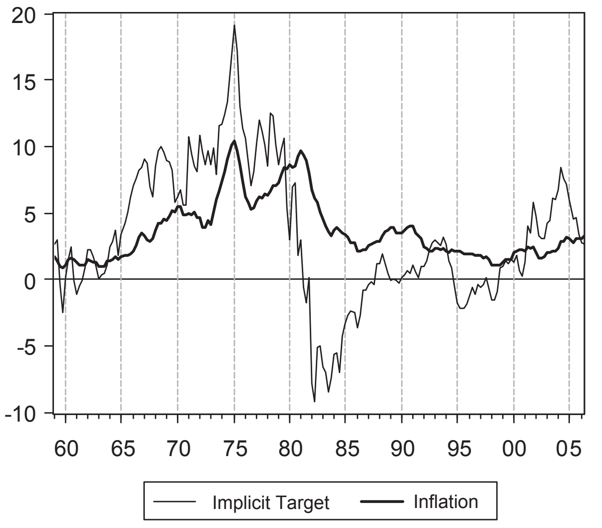

Fig. 3. US inflation and Taylor rule implicit target (%).

below the actual interest rate during the 1990s despite the fact that inflation was reduced to and remained around 1%. I will focus the remainder of this section on US data given space limitations.

2.2. *Implicit vs. realized inflation and equilibrium interest rate assumption*

If deviations from a rule associated with a given inflation target are not good signals of inflation going above or below that target, a natural question to ask is what inflation rate do actual interest rate settings imply. The second approach thus assesses the nominal anchor properties of a Taylor rule, i.e. what inflation we could expect following a given observed interest rate, by plugging the observed 3-month interest rate i_t into the Taylor rule equation (1) and allowing π^* to vary, i.e. computing π_t^* as

$$\pi_t^* = 2(\pi_t + r^* - i_t) + \pi_t + (y_t - y_t^*) \tag{2}$$

with $r^* = 2\%$. I then compare the implied target π_t^* to the observed inflation π_{t+k}.

Fig. 3 presents the implicit inflation target π_t^* (Implicit Target) together with observed inflation (Inflation).[5] Implied inflation was much higher than observed inflation during the 1960s and 1970s, for any reasonable lag, and much lower than any subsequent inflation value during the disinflation period and in the 1980s and 1990s. The discrepancies are substantial and persistent. Implied inflation is on average 4% points higher than observed inflation from the mid-1960s to the late 1970s, and on average more than 4% points lower during the 1980s and 1990s. This cannot be attributed to plausible fluctuations in the real

[5]This analysis does not rely on whether or not the Fed was following a Taylor rule in the 1970s. I adopt a positive perspective relating implicit inflation objective from observed interest rate to subsequent inflation, and thus use actual rather than real-time estimated output. I show that there is a mismatch between implicit and realized inflation both in the 1970s and in the 1980-1990s when the Fed policy has been characterized by Taylor rules. This will be contrasted to a clear relationship between money and inflation irrespective of whether or not central banks used money in their policies.

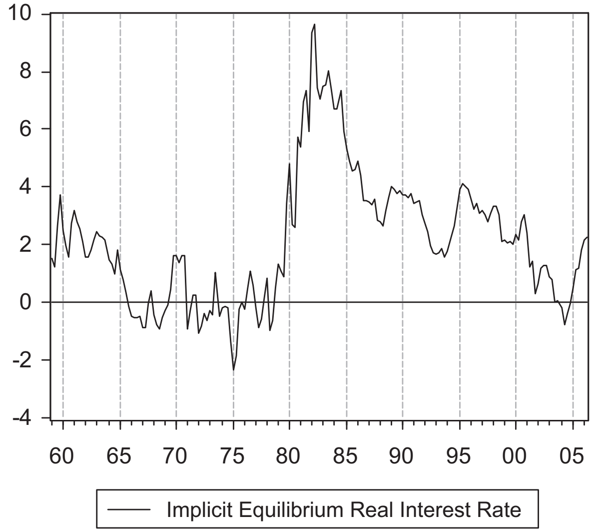

Fig. 4. US implicit equilibrium real interest rate.

interest rate, as discussed below. Attributing this to economic shocks seems difficult given the persistence and patterns of deviations. Potential candidates would have to have had persistent negative effects of inflation during the 1970s, persistent positive effects on inflation during the 1980s and 1990s, and positive effects since the early 2000s.[6]

A third but related question is to ask which would be the value of the real rate r_t^* that would equalize the inflation target π_t^* with observed inflation π_t or (an average of) observed future inflation π_{t+k}. Fig. 4 displays r_t^* computed from Eq. (1) as $r_t^* = i_t - \pi_t^* - 1.5(\pi_t - \pi_t^*) - 0.5(y_t - y_t^*)$, where π_t^* has been set equal to π_t. Setting π_t^* equal to leading inflation values instead, e.g. inflation 3 or 5 years ahead (i.e. π_{t+12} or π_{t+20}), does not affect the evolution of the implied real rate significantly, and the implications from the evolution of r_t^* in Fig. 4 apply to inflation averages or trends as well.

A crucial property of New Keynesian models is that if the central bank appropriately chooses the equilibrium (average) real interest rate r_t^*, then actual average inflation equals inflation target π_t^*. For example, Woodford (2006, p. 8) states that "r_t^* represents the central bank's view of the economy's equilibrium (or natural) real rate of interest, and hence its estimate of where the intercept needs to be in order for this policy rule to be consistent with the inflation target". However, the evolution of the implicit real rate of Fig. 4 needed to match observed inflation with target does not look anything like a plausible equilibrium real interest rate, as estimated e.g. in Laubach and Williams (2003), nor to what the Fed could have assumed as an equilibrium interest rate. r_t^* is close to 0% from the mid-1960 to the late 1970s, then jumps to almost 10% in the early 1980s, and subsequently decreases to 0% in recent years. Thus, the values that the central bank would have to choose as estimates of the "natural" or equilibrium real interest rate in order for average inflation to equal target evolve in an implausible way.

[6]One could of course perfectly fit objective and realized inflation with high enough inflation coefficients; every inflation movement would be interpreted as a target change, which is not plausible. What is needed, and what is missing, is a correspondence between implicit targets and subsequent inflation developments.

2.3. Implications for monetary policy analysis and practice

The analysis above suggests that assessing monetary policy stance with interest rates does not provide useful information and guidance regarding subsequent inflation developments. Moreover, the inflation objective π_t^*, supposed to pin down "trend inflation" in New Keynesian models, is not related to observed inflation for plausible assumptions on equilibrium real interest rates. In other words, there is no useful practical guideline for interest rate settings in order to reach a chosen inflation objective, and the fact that one has to make implausible assumptions regarding the equilibrium rate interest rate points to incompleteness or misspecification of New Keynesian models that could come from modeling monetary policy with only a short-term nominal interest rate. The fact that interest rate rules not empirically related to inflation objectives are describing monetary policy in many models used for analysis or forecasting should be concerning.

These considerations on mean or trend inflation and equilibrium real interest rates have been overlooked in monetary policy analysis. For example, CGG argue that the Federal Reserve was reacting less to expected inflation deviations from target before Volker's chairmanship period than during and after it. They divide the sample in two sub-periods, 1960–1979 and 1979–1996, and set the equilibrium real interest rate r^* equal to the observed sub-sample averages. Although not mentioned in their paper, the average real rate over the 1960–1979 period is 0.5%. There are two issues with this low real rate assumption.

First, it is unlikely that the monetary authority would have chosen such a low value as its assumed real rate during that period. Second, the estimated less than one-for-one reaction of nominal interest rate to inflation deviations from target is often interpreted as a cause of the high inflation average and low observed real interest rate of the 1970s. But this low real rate is precisely what has already been assumed in the rule considered! The assumed real rate over the 1960–1979 period is about 3% points lower than for the 1979–1996 sample, corresponding to the ex-post sub-sample averages. Moreover, the inflation objective π^* for the former period is estimated to be 4.2%, which appears high for the beginning of the sample as inflation was around 1.5% during the first half of the 1960s and reached that estimated target only in the late 1960s when the "Great Inflation" was already well under way.[7] In fact, the observed nominal interest rate during the 1960–1970s can be characterized by an increasing inflation objective and a higher reaction to inflation deviations.[8] An increasing target is plausible because the Federal Reserve inflation objective was probably increasing during the 1970s as output/inflation trade-off ideas were still widespread. Similarly, monetary authorities probably did not want to "kill the

[7]One estimated inflation target by CGG during the 1960–1969 sample is even 7.15%, i.e. on average about 5% points above observed rates. In contrast, in a similar historical analysis, Taylor (1999) sets the real interest rate at 2% and estimates an inflation target of about 0.5% for the 1960–1979 sample, which seems rather low for a period when inflation/output trade-off ideas were still present, and is below observed inflation during the whole period. Taylor's findings are awkward in the sense that the estimated inflation target was lower for the 1960–1979 period than for the 1987–1997 period, i.e. 0.5% and 1.5% respectively, which represents the Fed in the 1970s as tougher on average inflation but softer on inflation deviations from target.

[8]For descriptive purposes, this interpretation can be complementary to Orphanides' analysis (2003)—which assumes a constant inflation target—resulting in a stronger estimated reaction to inflation when output gaps are underestimated. For positive purposes, actual rather than estimated output gaps should be used when comparing implied inflation objective from observed interest rate with subsequent inflation.

economy'' by adopting too low an inflation target too early during the disinflation period of the 1980s, and it is thus plausible to assume a decreasing target during that period. Modeling a constant inflation target during the 1980–1990s, as in CGG for example with a target of 3.6%, while reflecting average inflation, has the unappealing feature of the target being almost always above observed inflation after the disinflation episode. The monetary analysis of the next section will show that the higher inflation rates of the 1970s are related to higher money growth, and that inflation peaks have always been preceded by corresponding money growth peaks, casting doubts on the explanation of self-fulfilling changes in expectations due to a central bank reacting too little to inflation increases.

3. Money, prices and output

3.1. Monetary aggregate choice and adjustments

The monetary variable considered is defined as

$$m_t^* \equiv c + m_t - y_t^* + \beta i_t^*, \tag{3}$$

where c is a normalization constant, whose meaning and usefulness will be discussed below; m is the observed money level; y^* is real potential output; β is an estimated interest rate semi-elasticity of a real money demand equation where a unitary income elasticity has been imposed; and i^* is a low-frequency filtered short-term interest rate or opportunity cost of money.[9] All variables except interest rates are in logarithms. Conceptual considerations underlying the computation of m^* and the choice of monetary aggregate are presented in Reynard (2006), thus only a brief description is provided in the next paragraphs.[10] Money demand estimates used for the required low-frequency level adjustments are presented in Appendix A.

[9]Monetary aggregates are M2− for the US, M2 for the euro area, and M2 for Switzerland. Some results will also be presented with the euro area M3 aggregate adjusted by portfolio shifts, as the ECB assigns an explicit role on that aggregate in its strategy. US M2− corresponds to M2 minus small time deposits, and includes cash, demand and checking deposits, savings accounts, money market deposit accounts, and retail money market funds. Euro area M2 includes currency, overnight deposits, deposits with an agreed maturity up to 2 years, and deposits redeemable at a period of notice up to 3 months. Euro area M3 consists of M2 plus debt securities up to 2 years, repurchase agreements and money market funds. Swiss M2 includes cash, sight and savings deposits. The interest rate used is the opportunity cost of money (3-month rate minus the weighted average of rates paid on the different monetary assets) when available, i.e. for US M2− and euro area M3, and the 3-month rate otherwise, i.e. for Swiss and euro area M2.

[10]The definition of m^* is equivalent to the variable labeled p^* in P^*-models, initially presented by Hallman et al. (1991), and the difference between m^* and the actual price level, i.e. $m_t^* - p_t$, corresponds to a measure of excess liquidity used, for example, in analyses of monetary developments by Fed, ECB and SNB economists (see e.g. Orphanides and Porter, 2001; Masuch et al., 2001; Peytrignet and Reynard, 2004): using Eq. (3), the difference between m_t^* and p_t can be expressed as $m_t^* - p_t = m_t - \widehat{m}_t$, where $\widehat{m}_t$ is the money demand that would prevail at equilibrium output and interest rate, given the current price level, i.e. $\widehat{m}_t = -c + p_t + y_t^* - \beta i_t^*$. The difference between m_t^* and p_t thus represents a measure of excess liquidity, i.e. money in excess of an estimated long-run equilibrium money demand. The interpretation of money and price developments in this paper however differs from P^*-models' interpretation of excess liquidity and its relationship to inflation. Moreover, the relative developments of the variables considered, and thus excess liquidity measures, differ as well given different treatments of equilibrium velocity and in some instances a different choice of monetary aggregate concept. These differences will be discussed below.

I consider an asset as monetary if it yields an interest rate below the 3-month risk-free rate and provides direct or indirect transaction services. An aggregate composed of such assets is the most likely to exhibit a close and stable relationship to nominal GDP. Moreover, such an aggregate gives the right monetary policy stance signal, i.e. it increases when the policy rate decreases and vice versa, as interest rates paid on transaction accounts are relatively sticky and move only with persistent changes in the 3-month market rate. Broader monetary aggregates do not necessarily provide the right stance signal, as the additional assets included in them with yields at or above the 3-month rate are positively correlated with the policy rate.[11] Monetary aggregates defined according to this transaction concept are characterized by an estimated unitary income elasticity, which is not the case of broader aggregates. The latter aggregates are generally associated with an income elasticity above unity and sample-dependent. My preferred approach regarding the choice of monetary aggregate is not to switch from one aggregate to the other as apparent instability occurs, but rather to choose an aggregate that is closely related to the transaction concept and then identify and explain apparent aggregate instability episodes. The aggregates chosen in this paper have been stable over the sample periods considered, except for two episodes in the US case where aggregate instability is clearly related to changes in extensive margins of money demand.[12] A discussion of how to account for instability is provided in Appendix A. It has been argued that the usefulness of money depends on a money demand cointegrated relationship holding at all times. I disagree with this argument on similar grounds as McCallum (1993). Money demand is a remarkably stable empirical relationship over very long time periods, and rare money demand instability episodes should not be arguments for disregarding the clear relationships between money, output and prices presented below. Thus, this paper directly addresses the main recent criticisms that even with a stable money demand there is no usefulness of money for monetary policy.

According to Eq. (3), the money level considered has been adjusted by potential output and equilibrium velocity, i.e. by low-frequency changes in the opportunity cost of money, where the estimated long-run interest rate semi-elasticity of money demand is used to make the adjustment. The latter protracted cost-driven changes in money holdings, or equilibrium velocity movements, reflect mainly changes in inflationary environments, i.e. Fisher effects, but could also reflect real equilibrium interest rate changes. For example, during a disinflation period, the inflation rate decreases by more than the money growth rate, as interest rates decrease. Given this negative correlation between money growth and interest rates, not accounting for equilibrium interest rate movements blurs the money/price relationship and biases econometric results in the form of less than one-for-one

[11] For the euro area, M2 does not exactly correspond to my preferred concept, as it includes some time deposits with maturity over 3 months. Moreover, it does not include money market funds, contrary to M2− in the US. However, whether or not these latter assets are included does not matter much empirically for money demand or the money/price relationship; issues arise mainly when assets with yields close to checking or transaction accounts are not included, and/or if significant amounts of assets with yields above the 3-month interest rate are included. Euro area M3 contains in addition debt securities, which are not related to the transaction concept, but M3 information value for inflation is considered, as its growth rate is an explicit element of the ECB strategy.

[12] Changes in extensive margins are measured by changes in financial market participation, i.e. in the fraction of households holding non-monetary assets, like stocks or bonds, as part of their portfolio. An increase in that fraction means that some households who were holding only monetary assets decide to invest part of their financial wealth in non-monetary assets, thus affecting money demand via the extensive margins. For more details on the measurement, causes and effects of extensive margin changes, see Reynard (2004).

(except in short disinflation or accelerating inflation samples, where this results in above one-for-one) and often non-significant relationships between money growth and inflation found in the literature.[13] However, using US and euro area data, Reynard (2006) shows that, in contrast, adjusting money growth for equilibrium velocity changes results in significant estimated dynamic relationships between money growth and subsequent inflation in various VAR specifications and in a one-for-one low frequency relationship. It is an empirical issue of drawing the line between low-frequency, cost-driven velocity adjustments and policy-induced liquidity effects affecting subsequent price developments; but empirical analysis shows that Hodrick–Prescott (HP, 1997) or backward-looking Cogley (2002) filter adjustments are well suited to distinguish between these two effects. The analysis in the main text is done with the HP filter, and Appendix B illustrates the effects of equilibrium velocity adjustment with HP and Cogley's filters. There are some small quantitative differences, but the timing of stance signals are similar; thus the equilibrium velocity adjustment can be applied in real time. The second adjustment of Eq. (3), i.e. the potential output adjustment, ensures that if money and potential output offset each other, no influence on prices follows.[14] I use a unitary income elasticity, a result that clearly emerges from the data when changes in extensive margins (US) and sample issues (related to the euro area disinflation) as well as the choice of monetary aggregate are dealt with correctly.

3.2. Characterizing the money–output–price empirical relationship

When changes in equilibrium velocity and potential output are accounted for, there is a one-for-one relationship between money growth and inflation average rates, i.e. between μ^* and π averages, where $\mu_t^* = 400\left(m_t^* - m_{t-1}^*\right)$. Table 1 presents annualized quarterly inflation and money growth rate averages, together with other variables discussed in Section 4, for different sub-samples. Periods of high/low inflation rates are associated with corresponding high/low money growth rates. These averages are already useful for policy in contrast to the persistent and substantial discrepancies between implicit Taylor target and actual inflation rates presented in Section 2. However, these medium-run averages are not useful enough for central banks which want to control inflation over shorter horizons and they do not provide any indication of the dynamics of the variables considered.

Same sub-sample values for μ^* and π averages mean that the difference between m^* and the (log) price level p is stationary. The normalization constant c is chosen (practically as the negative of a long-run money demand equation constant) so that both m^* and p levels are equal on average, which corresponds to a stationary real (adjusted) money level. I will characterize graphically the dynamic relationships between money, prices and output when deviations from that stationary level occur, and explain unfavorable empirical results in the literature. This approach also helps to design practical ways of accounting for money information in policy analysis and to address theoretical critiques on the usefulness of money. In the analysis of this paper, monetary aggregates represent a "quantity-side" measure of monetary conditions induced by monetary policy, a terminology used in

[13]See e.g. Friedman and Kuttner (1992) or De Grauwe and Polan (2005).

[14]The analysis is not affected by different potential output measure choices as differences are quantitatively small relative to the amplitude of money and price fluctuations. This also means that real-time potential output estimates can be used.

Table 1
Sub-sample averages (%) for the US, Switzerland (CH) and the euro area (EA)

	π	μ^*	$\Delta\pi$	$y-y^*$	m^*-p
US					
1959–1979	4.22	4.42	0.09	0.46	1.93
1970–1979	6.41	6.21	0.12	−0.42	2.94
1979–2006	3.18	3.01	−0.06	−1.26	−2.41
1959–2006	3.63	3.62	0.01	−0.52	−0.54
1985–2006	2.45	2.46	0.01	−0.67	−0.77
1990–2006	2.29	2.31	0.01	−0.84	−1.30
1994–2006	2.11	1.52	0.02	−0.55	−0.83
CH					
1976–1993	3.21	3.36	0.00	−0.19	0.65
1976–2002	2.42	2.56	0.00	−0.65	−0.72
1985–2002	2.00	1.68	−0.04	−0.40	−1.88
1994–2002	0.85	0.96	0.01	−1.56	−3.47
EA					
1973–1979	9.33	9.95	0.09	0.18	−0.53
1980–2003	3.69	3.75	−0.09	0.00	−0.57
1973–2003	4.97	5.15	−0.05	0.04	−0.56
1985–2003	2.58	2.90	−0.04	0.00	−0.69
1994–2003	1.93	2.43	−0.01	−0.06	−1.39

Nelson (2003, p. 1043), in the sense that money movements implicitly—i.e. given the operating procedure and regime—represent monetary policy exogenous shocks as well as endogenous reactions to various variables and shocks.

Figs. 5–8 present the levels (log, upper part, rhs) and growth rates (percent, bottom part, lhs) of monetary aggregates and prices for Switzerland, the US, and the euro area with my preferred measure M2 as well as the official aggregate M3 adjusted for portfolio shifts by ECB staff.[15] These figures also display the variable $p_t^y \equiv p_t + (y_t - y_t^*)$; the difference between p_t^y and the price level p_t thus represents the output gap.[16] These observed reduced-form relationships between money, output and prices can be characterized as follows.

On one hand, when m_t^* *increases above* p_t, thereby raising the money/price level ratio above its stationary level, it is followed by a proportional increase in the price level. However, there is a lag before prices start reacting to this money increase, and the upward price adjustment pace or period length is time-varying, with faster price adjustment speed in high than in low inflation environments. Moreover, after a lag following the money increase, output increases above its potential, i.e. $p_t + (y_t - y_t^*) > p_t$. On the other hand, when the money level decreases or when it is below the price level, i.e. $m_t^* < p_t$, there is no decline in the price level but the inflation rate decreases after a lag. Whether money levels

[15] This series has been computed back to 1980 only. See ECB (2004).

[16] p_t^y is not represented on the euro area M2 graph for graphical clarity and is almost indistinguishable on the M3 graph, but a lead of money on output gaps is also present.

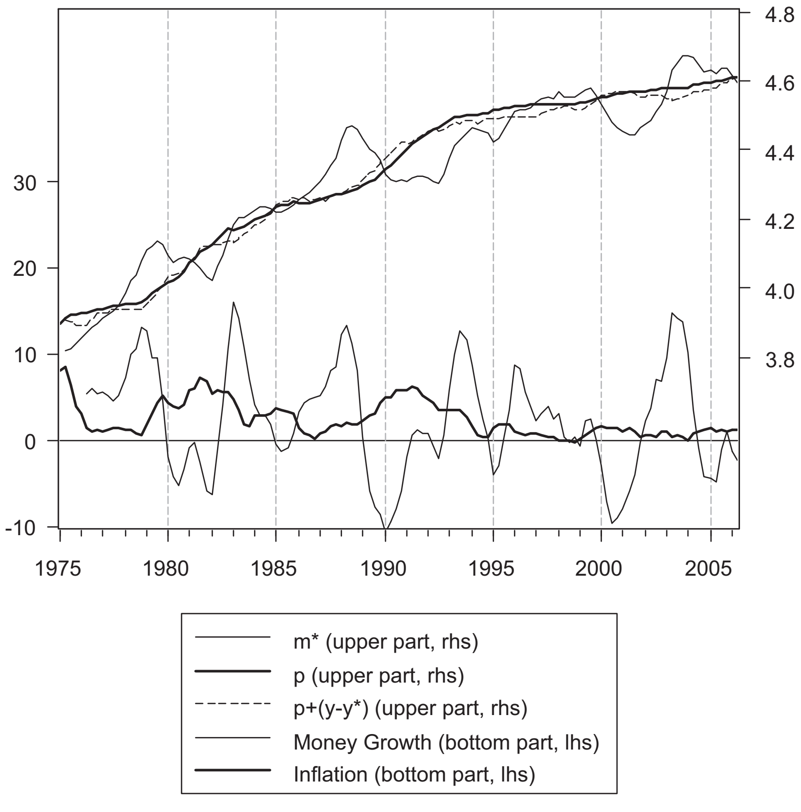

Fig. 5. Swiss money (M2), prices and output.

increase or decrease while $m_t^* < p_t$ does not affect price developments in different ways. Thus, m^* "draws" the *price level* upwards when m^* increases above p_t, but a decreasing or relatively low money level with respect to prices (i.e. $m_t^* < p_t$) is followed by a decrease in the *inflation rate* only; no significant downward price level movement has been observed in the samples considered. Thus, after prices have adjusted upwards to a relatively higher money level, prices do not adjust downwards to m_t^* if the latter is below the new price level. There is an asymmetric price behavior, which could be caused by various frictions. The fact that a distinction has to be made between the cases $m_t^* > p_t$ or $m_t^* < p_t$ regarding whether an increase in money is followed by a proportional increase in prices or no movements at all has serious consequences when interpreting money growth rate signals or when estimating empirical inflation/money growth rates relationships. When $m_t^* < p_t$, output decreases below its potential, after a lag. There is thus a clear correspondence between m_t^* being above/below p_t and subsequent output gaps turning positive/negative, contradicting the claim that correlations between money growth and real activity have broken down at business cycle frequencies since the 1980s.[17]

These observations are consistent with quantity-theoretic mechanisms, given frictions accounting for lags and for the fact that prices do not decrease. The stationary real money

[17]See e.g. Woodford (2006, p. 16), who refers to Friedman and Kuttner (1992) and Walsh (2003).

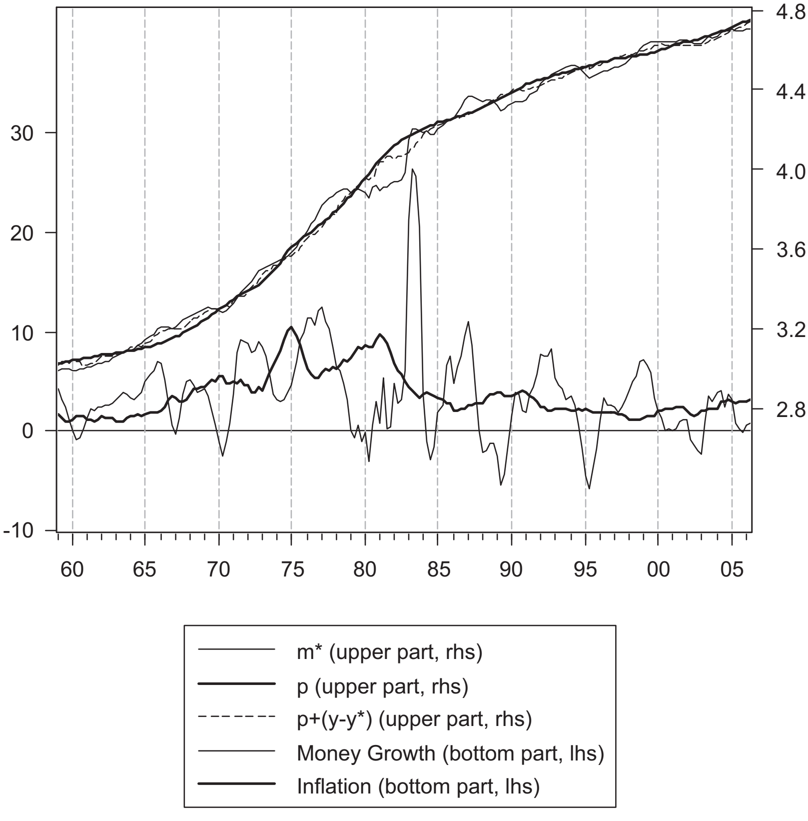

Fig. 6. US money (M2−), prices and output.

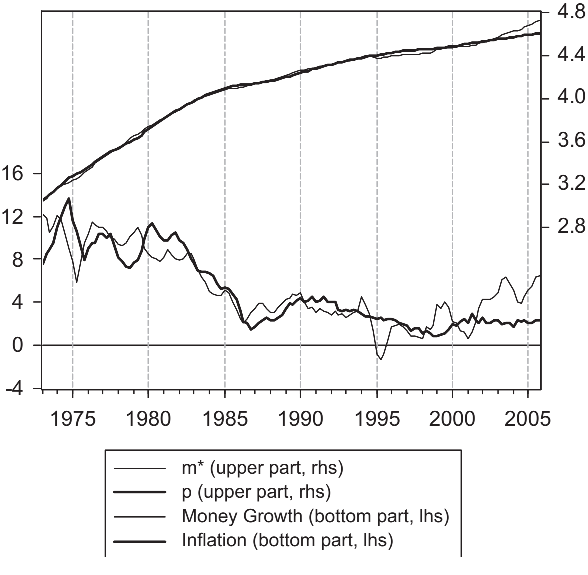

Fig. 7. Euro area money (M2), prices and output.

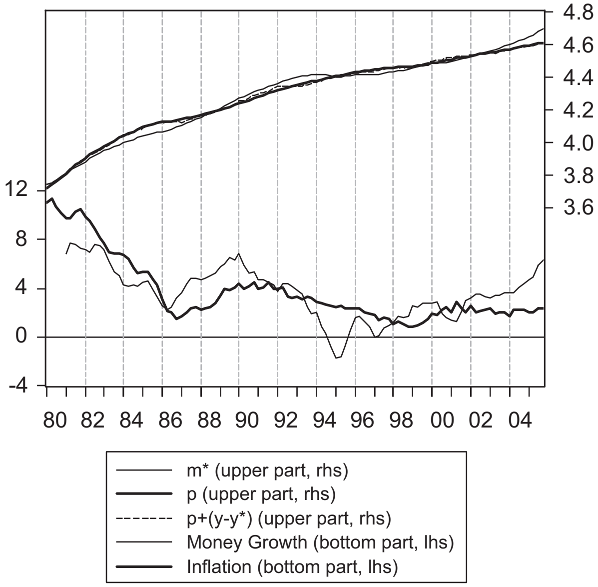

Fig. 8. Euro area money (adjusted M3), prices and output.

level corresponds to a situation where the price level is ‘‘sustained’’ by the monetary level for a given potential output and equilibrium velocity. A rise or fall of money above or below that level is followed, with a lag, by output and price adjustments.[18] These facts do not imply that every price movement is driven by money. However, an exogenous price level shock has to be accommodated in order to become permanent, otherwise this would imply a non-stationary real money level, or in graphical terms the sequence of money–output–price developments would be subject to shifts.[19] Moreover, and very importantly, we do not observe significant price increases without previous corresponding money increases. As the money level has been adjusted by equilibrium velocity and potential output, the non-adjusted money series would diverge from the price level after

[18]The money–output–price regularity does not fit well with forward-looking New Keynesian frameworks where inflation is a function of future output gaps. Moreover, we observe that there is first no effect on inflation, and then price increases reflect closely past money increases. This adjustment pattern does not seem to fit well with an optimal staggered price setting framework. The lag preceding real quantity adjustments could be understood in terms of a liquidity effect or a money demand framework as in Alvarez et al. (2003). However, as discussed below, not only interest rate induced velocity movements but also velocity residuals are responsible for the lag. This means that a framework where velocity is driven by interest rates only is incomplete.

[19]Even if this analysis does not allow a distinction between endogenous and exogenous monetary movements, the only time price levels appear to ‘‘drive’’ money levels, rather than vice versa, is during disinflation periods—which however have been preceded by monetary contractions. This fact, particularly apparent with US data in the early 1980s and with Swiss data in the early 1980s and early 1990s, has already been pointed out for end of hyperinflation episodes by Sargent (1993) and is well illustrated in King (2002), who displays money and price level time series for a few hyperinflation episodes—on King’s chart 5 however, disinflations are not preceded by monetary contractions, which I suspect is due to not accounting for equilibrium velocity changes. It is important to notice that real money balances adjust upward only after the inflation rate has decreased. In these episodes, the money level reaches the price level from below. This is most probably money demand which adjusts to the new price level, as it is difficult to think of monetary authority deliberately adjusting money to a given price level.

permanent productivity shocks. Whether or not these shocks affect prices depends on whether they are offset by money movements. These potential shocks however appear quantitatively small relative to major price developments.

Consider now in detail these relationships in the different economies, starting with the Swiss case in Fig. 5. Even with low average inflation, Swiss data are characterized by two inflationary episodes, i.e. around the early 1980s and early 1990s. Preceding both episodes the money level increased above the price level, starting respectively in 1977 and 1986, and the price level adjusted proportionally. The price levels around 1982 and 1993 ended up, after a relatively rapid increase, at a level close to the money level peaks of 1979 and 1988, respectively. In both cases the price level rate of increase has been slower than the previous money level rate of increase, but prices have eventually adjusted proportionally to previous increases in the money level. The relative inflation increases of the mid-1980s and late 1990s can be characterized in a similar way. All these episodes of money above price levels have been associated with subsequent positive output gaps. In contrast, after money levels have decreased and after they have been below price levels, the inflation rate has decreased and output gaps have become negative. It is also clear that money growth rate fluctuations when m_t^* is below p_t are irrelevant for subsequent inflation movements, thus a level analysis is necessary.

Other important empirical regularities, also common to the other economies considered and discussed further below, clearly emerge. Each time m^* has increased above p, p has adjusted upwards, thus short-term velocity movements are not noise as usually argued, but contain crucial and advanced information on price movements. There has also been no significant price increase which has not been preceded by a corresponding increase in m^* above p. Concerning inflation dynamics, we observe that the main inflation swings reflect monetary fluctuations, and that inflation persistence reflects persistence in the money level increase.

In the US case, as displayed in Fig. 6, increases in m^* above p precede the beginning of the "Great Inflation", each inflation peak of the 1970s, i.e. the peaks of around 1970, 1975 and 1980, as well as the relative inflation increases of the late 1980s and of the recent period. Since the mid-1960s and during the very persistent high inflation of the 1970s, m^* has been almost always above p; in contrast, m^* has been well below p during the disinflation episode of the early 1980s and below p during most of the 1990s. Output-gap movements also follow monetary developments. During each of the inflation increases of the 1970s, the inflation rate approximately matches the preceding money growth rate. Compared to Swiss data, the price level following the late 1970s money increase ended up relatively higher and the price increase during the preceding lag period was faster. As a result of time-varying lags and adjustment periods, the overall increase in the price level from its initial level could be approximately characterized as proportional to the corresponding preceding money increase in addition to the price increase that occurred during the lag period, and the inflation rate during the adjustment may not exactly match the preceding money growth rate. This latter adjustment seems to be faster in high than in low inflation environments, i.e. inflation rates usually match closely previous money growth rates when inflation is high, like in the 1970s, but are lower otherwise.

Euro area are displayed in Figs. 7 and 8. Here also, relatively faster increases in money levels (i.e. $m_t^* \geqslant p_t$) starting in the late 1970s and late 1980s were followed by corresponding upward price adjustments.[20] Inflation follows money growth so closely that it is difficult to

[20]Similar results are obtained if income elasticity is not constrained to unity, as in ECB money demand specifications.

distinguish relative level movements graphically. A discrepancy between money growth and inflation rates appears since the mid-1990s, at the only time when there has been a decline in the money level. As discussed above, this is related to asymmetric price behavior.

The monetary regularities presented above help to explain why many empirical studies have not found a significant relationship between money growth and subsequent inflation, and point to several issues in modeling money. First, there is a long lag between money developments and corresponding subsequent price movements and output fluctuations. It is then not surprising that researchers who have included only a few quarterly lags of money growth have claimed that money does not help in explaining or forecasting inflation relative to output gaps or other real variables moving more or less contemporaneously with inflation, although the latter variables provide only a delayed and incomplete signal. The P^* approach, which has usually found supporting evidence for money, suffers from a similar problem, as it assumes that excess liquidity triggers an inflation adjustment as a function of contemporaneous excess liquidity as long as this liquidity, or money demand disequilibrium, persists. In fact, lags before prices start reacting are long, and given these lags, we observe that the price adjustment often occurs well after the money demand disequilibrium has vanished and even as excess liquidity has changed sign.[21] In addition, peak inflation does not correspond to peak excess liquidity; moreover, empirically, the price level adjustment eventually matches the previous money level increase. Focusing on such an error-correction mechanism has another drawback in that ad hoc assumptions on inflation trends must be made. Inflation adjustment specifications are usually of the accelerationist type, like in Hallman et al. (1991), where a higher money level generates an increase in trend inflation rather than an increase in the price level, inducing a price level overshooting and oscillating inflation behavior, or the analyses focus on inflation deviations around an exogenously specified trend, like in Gerlach and Svensson (2003) where a downward inflation trend reflecting central banks assumed objective is modeled.

An additional complication, which affects models with or without money, comes from the asymmetric price behavior. The fact that, when $m_t^* < p_t$, monetary fluctuations are not followed by corresponding price movements, implies that standard linear estimates of the inflation/money growth relationship are biased. Moreover, price adjustment speeds differ in different inflationary environments, and so do lag lengths. Those characteristics depend on structural features. Finally, monetary movements due to equilibrium velocity changes need to be accounted for, as in Eq. (3), and not interpreted as signals of subsequent corresponding price movements.

3.3. Money usefulness in policy and inflation dynamics analyses

A useful measure of monetary policy stance should give qualitative and quantitative information on subsequent inflation trends as well as on fluctuations around these trends. I have argued in Section 2 that interest rate stance measures do not provide such information. The analysis above shows that monetary movements (i.e. m_t^* relative to p_t)

[21] This is, for example, one element that lead Christiano (1989) to criticize P^*-models, based on their prediction regarding the late 1970s US episode, as inflation increased despite an excess liquidity that was small and even turned negative. Moreover, using M2 does not display as a clear monetary impulse as with M2− preceding the inflation peak around 1980; M2 is less useful than M2− in general as a measure of policy stance, as the amount of some assets included in M2, like certificates of deposit, usually increases with policy rate increases, and vice versa, given that their own rates are above the 3-month rate.

precede and validate changes in inflationary environments, on the upside as well as on the downside, as well as transitory inflation fluctuations, and provide quantitative information on subsequent price levels. Monetary developments preceded, validated and provided the successive impulses of the "Great Inflation" of the 1970s in the US and in the euro area, with quantitative information on inflation average and fluctuations. Monetary developments can similarly explain the disinflation and the lower inflation average of the 1980s and 1990s, as well as provide qualitative and quantitative information on the late 1980s inflation increases. Moreover, there is a clear relationship between monetary movements and subsequent output-gap developments.

The framework I have proposed in Section 2 to analyze monetary development involves an equilibrium velocity adjustment, which can be approximated by a backward-looking filter, and a focus on money level increases in the case $m_t^* \geqslant p_t$. The fact that a distinction has to be made between the cases $m_t^* > p_t$ and $m_t^* < p_t$ regarding whether an increase in money is followed by a proportional increase in prices or no movements at all shows that interpreting money growth rates without a level analysis is misleading. The analysis also shows that monetary information offers advanced signals relative to real output gaps.

The danger of persistently deviating or drifting away from low inflation thus arises when monetary policy allows money to accommodate price increases following an initial monetary expansion, with a persistently relatively steep money slope as in the 1970s in the US and euro area for example, rather than restricting liquidity until inflation drops. The fundamental observation is that the high inflation environment of the 1970s in the US and euro area is characterized by relatively steeper money level trends, with money leading inflation. In Switzerland in contrast, monetary policy has not accommodated price increases, i.e. it has reacted restrictively to relatively faster increases in prices, thus average inflation has remained low relative to other countries.[22] If only the level of money is or has been higher, but is not increasing faster, the subsequent relatively faster price level increase is temporary. The rate of price increase in this latter case should depend on time-varying frictions and expectations, and has been higher in high inflation environments.

It is clear from the facts presented above that inflation persistence, in the sense of substantial and long-lasting inflation swings, reflects persistence in money level increases, which occur long before output-gap movements.[23] Moreover, major inflation swings all correspond to preceding monetary swings. If these inflation swings do indeed reflect central banks' inflation target changes, as proponents of New Keynesian models argue, then monetary aggregates should be used to model monetary policy. If these swings do not reflect target changes, then money is a useful advanced indicator of inflation and output fluctuations.

With "trend inflation" determined exogenously, with little dynamics, and a static money demand relegated to models' backgrounds, New Keynesian models imply no role for money in monetary policy. For example, Woodford (2006), using a model where "trend inflation" is specified as a random walk, claims that "[o]ne does not need to monitor money growth to tell if an undesirable long-run inflation trend is developing; measurement of inflation itself suffices for this" (p. 21), arguing that the long-term relationship between

[22]The Swiss National Bank had money growth targets from 1973 to 1999, although it was targeting the monetary base or M1, but not M2, which is presented here.

[23]There has recently been much work on trying to understand and model inflation persistence without much attention paid to monetary aggregates.

money growth and inflation is not useful to guarantee a desired inflation average. Furthermore, he argues that "[w]hat one needs as additional regressors [than current inflation in inflation forecast equations] are stationary variables that are highly correlated with the current departure of inflation from its stochastic trend" (p. 27). The evidence provided in this paper shows that money developments allow us to think in terms of inflation steady-states, transitions from/to a different steady-state, "trend inflation", and temporary fluctuations around "trend inflation"; the notions of steady state or "trend inflation", in fact, become useless. Money provides an advanced signal of inflation developments, with respect to trends as well as fluctuations around trends. Policymakers aimed at keeping inflation below a certain threshold cannot afford to wait and observe inflation picking up before acting, given the monetary policy lags that characterize the data.

Using theoretical models, critiques of monetary aggregates often argue that velocity and other fundamental shocks can weaken the money/price relationship, and that with a successful inflation targeting strategy, the inflation/money growth relationship would disappear. The remainder of this section shows that those claims are not supported by empirical evidence. First, consider equation $m_t = -c + p_t + y_t - \beta i_t + \varepsilon_t$, where ε_t corresponds to the residual of a cointegrating relationship between these variables, usually interpreted as a real money demand equation where a unitary income elasticity has been imposed; ε_t is what is usually referred to as "velocity shock", i.e. money movements not associated with contemporaneous interest rate or output fluctuations, and usually ignored in present day models. In terms of the quantity equation, $\beta i_t + \varepsilon_t$ represents the velocity of money; $\beta(i_t^* - i_t) + \varepsilon_t$ represents deviations from equilibrium velocity or short-term velocity movements, and $\beta(i_t^* - i_t)$ can be interpreted as money movements reflecting contemporaneous policy-induced interest rate movements.[24] I will refer to ε_t as the velocity residual. We can then decompose the difference between the adjusted money level m^* and prices in three different parts, $m_t^* - p_t = (y_t - y_t^*) + \beta(i_t^* - i_t) + \varepsilon_t$, i.e. an output gap, an interest rate gap, and a velocity residual.[25] Thus, the difference $m_t^* - p_t$ represents the sum of output gaps and deviations from equilibrium velocity. As defined above, $p_t^y \equiv p_t + (y_t - y_t^*)$. Therefore, short-term velocity movements can also be expressed as $m_t^* - p_t^y$ in Figs. 5–8.

The correlation between velocity residuals and excess liquidity $(m_t^* - p_t)$ is 0.77 for US data, 0.91 for euro area data and 0.78 for Swiss data. Correlations between interest rate gaps $\beta(i_t^* - i_t)$ and excess liquidity are positive but lower, i.e. 0.39 for the US, 0.01 for the euro area and 0.42 for Switzerland, and correlations between interest gaps and velocity residuals are negative, i.e. −0.14 for the US, −0.30 for the euro area and −0.21 in the Swiss case. What is usually labeled as velocity "shock" and omitted from monetary policy models represents an important part of monetary movements and, as shown above, these latter movements have useful quantitative information for subsequent price movements. A plausible interpretation of these velocity residuals could be that, contrary to what is

[24]Note that even when i_t represents the opportunity cost of money instead of the 3-month rate, $(i_t^* - i_t)$ can still be interpreted as policy-induced interest rate movements as rates paid on deposits are sticky and vary only with persistent changes in market interest rates.

[25]It is standard in the P^*-literature to decompose the difference between actual and equilibrium money balances, i.e. excess liquidity, in three gaps, and to interpret these gaps as causal factors for inflation. This interpretation is however problematic given the observed lead–lag relationship running from velocity to output-gap movements, i.e. these different gaps do not seem to be independent of each other.

usually modeled, the effects of monetary policy cannot be summarized by short-term interest rates only, and these persistent residuals could reflect propagation mechanisms induced by financial frictions.

Nelson (2003) argues that monetary aggregates could act as a proxy for various yields not considered in standard macroeconomic models. Fig. 9 displays the negative of the US velocity residual, i.e. an abnormally low money level not associated with 3-month interest rate or output movements which corresponds to the line being above zero and vice versa, together with bonds average (across 2 to 5-year maturity) ex-post excess returns from Cochrane and Piazzesi (2005). The latter variable represents 1-year excess returns, i.e. borrowing at the 1-year rate, buying a long-term bond, and selling it in 1 year. The evolution of both series display interesting similarities, and velocity residuals often lead excess returns; this of course does not say anything about causality. Correlation coefficients are 0.25 for contemporaneous movements and 0.4 when velocity residuals are lagged by three quarters. A relationship between these variables could be interpreted in the sense that restrictive/expansive monetary policy, in terms of money supply or money as a quantitative measure of monetary conditions, affects various yields and increases/decreases risk premia, i.e. induces higher/lower longer-term yields that are however followed by relatively lower/higher inflation. Another interpretation could be that money demand reacts to additional yields than the short-term yields. Both interpretations would provide an information role for money with respect to the monetary policy transmission mechanism.

The evidence presented above on the behavior of velocity and the relationship between money, output and prices allows us to address two points raised by critiques of the usefulness of considering monetary aggregates in monetary policy. First, it is generally argued that velocity shocks weaken the information content of money for price developments. This view is related to Poole's (1970) insight that in the presence of relatively large money demand shocks, monetary policy should accommodate these

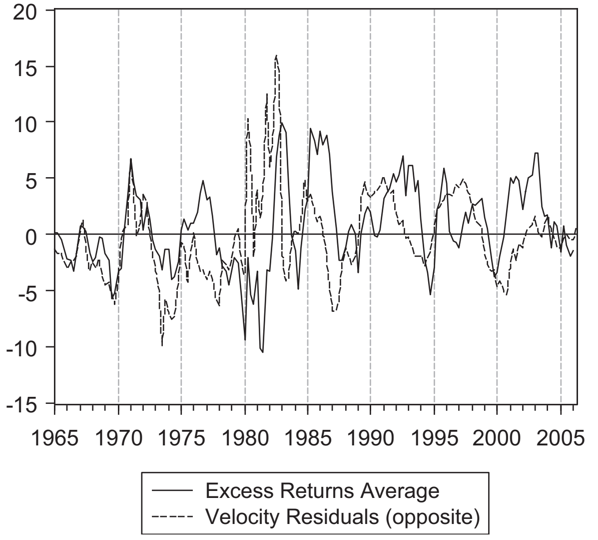

Fig. 9. Bonds excess returns and velocity residuals (%).

shocks. This accommodation should reduce output and price fluctuations as these shocks are assumed to have no influence on inflation or economic activity in contrast to the interest rate movements the shocks would generate if not accommodated. As a result, the link between money and prices, it is argued, should weaken given large velocity residuals. The misconception underlying this critique is due to the assumption that monetary policy is transmitted via short-term interest rates only. Offsetting the velocity movements, i.e. holding interest rates fixed and letting money fluctuate, would in that world lead to less price (and maybe output) fluctuations. The analysis based on Figs. 5–8 has shown that, on the contrary, money movements are always followed by corresponding price movements and real activity fluctuations once price asymmetric behavior is accounted for.

The other criticism is that if money is used to offset other fundamental economic shocks with respect to price developments, the observed relationship between money and prices would vanish. Velocity residuals would this time be interpreted as money offsetting other shocks. However, if these other shocks would have been important for price developments in the samples considered, we would have observed either significant price movements not related to monetary movements if central banks had not used monetary aggregates to offset them, or we would have observed significant money movements not followed by corresponding price movements in case central banks had used money to offset these shocks. When accounting for price asymmetric behavior, we have however observed neither fact, thus these other shocks seem relatively small. The fact that downward money level movements are not followed by downward price movements could be interpreted as money offsetting positive price shocks; this interpretation is however less plausible than downward nominal rigidities, especially given that monetary contractions occurred usually in disinflationary policy periods. There is thus no empirical reason, at least in the economies considered and subject to similar shocks, to think that the information of money for a central bank that closely meets its inflation target would vanish. Given the substantial information provided by short-term velocity movements, the implied low quantitative effects of other fundamental shocks, and the fact that velocity movements provide early information for subsequent price developments not always associated with interest rate or real output measures, using monetary aggregates to measure policy stance and to guide policy decisions should reduce inflation volatility and still result in a one-for-one relationship between money growth and inflation rates.

4. Monetary analysis, Phillips curves, and apparent changes in inflation dynamics

Several issues have recently emerged regarding inflation dynamics.[26] On one hand, inflation is perceived to have been less persistent and less volatile since the mid-1980s than in the 1970s. On the other hand, it is argued that inflation has become more difficult to predict, in the sense that estimated coefficients on unemployment or real activity in inflation equations have declined in absolute value and PCs do not seem to provide additional forecasting information relative to univariate inflation equations. In other words, the PC has flattened and the relationship seems less precise. This section tries to shed light on these issues using the monetary analysis presented above.

[26]See e.g. Atkeson and Ohanian (2001), Roberts (2006) and Stock and Watson (2007).

The standard estimated PC can be represented as

$$\pi_t = \alpha + \rho\pi_{t-1} + \sum_i \delta_i \Delta\pi_{t-i} + \sum_j \gamma_j (y_{t-j} - y^*_{t-j}) + s_t, \tag{4}$$

where π is inflation and $(y_{t-j} - y^*_{t-j})$ represent output gaps, forward looking in standard New Keynesian models but mostly estimated in its backward looking form, and s_t represents what is usually referred to as a "supply shock". Table 1 displays sub-sample averages, representing different inflationary environments, for annualized quarterly inflation and money growth rates, inflation differential, output gap and excess liquidity $(m^*_t - p_t)$.[27] As PCs are usually estimated of the accelerationist type, this should imply a relationship between average output gaps and inflation differentials. While there is a close correspondence between money growth and inflation, no useful relationship appears between output gap and either inflation or inflation differential averages. It can be argued that oil prices should be added to Eq. (4), but while such shocks can explain strong price level movements, they cannot explain the high average inflation rates of the 1970s, for example, which was associated with a negative output-gap average in the US.

In Figs. 5–8, the information of output gaps for inflation is illustrated with the variable $p^y_t \equiv p_t + (y_t - y^*_t)$, which can also be interpreted as the price level that would have prevailed in the absence of frictions that caused real quantity adjustments. The output gap thus corresponds to $p^y_t - p_t$. We observe that output-gap fluctuations sometimes provide slightly advanced information on price developments, sometimes move contemporaneously with prices, but sometimes prices start increasing before a positive output gap appears and keeps increasing after the positive output gap has vanished. Price developments are not always associated with real quantity adjustments. However, short-term velocity movements, i.e. the spread between m^* and p^y, display a much more leading, quantitative, and thus more consistent relationship with price developments.

The first issue with using Eq. (4) to describe and forecast inflation dynamics is that monetary aggregates and velocity developments provide leading information relative to output gaps for price developments. This means that forecasts generated with PCs signal inflation increases with a delay. The estimation problem can however not be solved by adding a few quarterly lags of money growth. Money can lead price developments by several years. Moreover, monetary and output-gap movements may not be independent from each other, as the information value of output gaps for price movements appears to be already included in previous monetary movements; thus estimates would be biased.

The observation that the PC has flattened and inflation has become more difficult to forecast, or in other words, that the coefficients γ's have become smaller and less precisely estimated, could be related to the fact that, as discussed above, we observe both that price levels do not decrease in general and that money levels have been mostly below price levels in the 1990s, which as a stylized fact has been associated with a decline in inflation regardless of the direction of monetary and output-gap movements. Sub-samples in Table 1 represent periods of increasing inflation, disinflation, longer periods including both increasing and decreasing inflation, and post-disinflation periods. Samples starting in

[27] Euro area and Swiss end of samples are adjusted as the policy lag following a money increase should be accounted for, and Swiss beginning of sample is adjusted as there was a strong decrease in price level due to a previously restrictive policy.

1985 and 1994 correspond to low and stable inflation episodes following the "big" and "small" disinflation periods, respectively, and are characterized by low monetary aggregates relative to price levels and by low output gaps.[28] Compared to whole samples, post-disinflation periods are associated with lower excess liquidity and output gaps and with the same (close to zero) change in inflation; in fact, various output-gap movements and averages are associated with a low and stable inflation, i.e. close to zero average inflation changes. Although the relationship is not always precise, given small sub-samples and different disinflation experiences, we observe that the smaller excess liquidity, the smaller the output-gap average for a given inflation differential average. In contrast to disinflation episodes when inflation decreases as money and output contract, we do not observe price declines when money contracts in low inflation periods, and output gaps fluctuate (below zero) without corresponding inflation developments.

The fact that different sub-samples with different output-gap averages have same average inflation changes means that extending the sample affects PC estimated coefficients. It does not in itself imply that output-gap coefficients have decreased in absolute value, as it could be picked up by the estimated constant which would affect the inflation rate of change implied convergence value in forecasting exercises. However, lower output-gap averages are associated with less frequent positive gaps and stronger gap decreases, which, together with the observed price asymmetric behavior, imply lower output-gap coefficients. Thus, the fewer and less persistent positive monetary impulses, i.e. excess liquidity episodes, of the 1980s and 1990s relative to the 1970s can explain the lower output-gap coefficients and the decline in inflation volatility of the post-1980 period, as well as the fact that inflation has been below PCs forecasts since the late 1990s.

Thus, seen from the angle of monetary aggregates, monetary policies since the early 1990s have been rather restrictive in terms of low money levels relative to price levels. Given the asymmetric price behavior, this has kept the inflation rate at a relatively constant low value while output has mostly been below potential. In other words, more liquidity could have been provided to sustain real activity without resulting in significantly higher inflation. There are thus risks of being too restrictive on average associated with a focus on low inflation targeting when monetary aggregate developments are not considered, as we observe price increases when policy is expansive but do not observe price decreases when policy is restrictive, while output appears to be symmetrically affected but lags monetary developments.

Regarding the decline in inflation persistence, i.e. in the estimated ρ, it can also be explained by less frequent and less persistent excess liquidity episodes in the 1980s and 1990s relative to the 1970s, together with the fact that monetary developments sometimes feed into prices without affecting real output. The 1970s period in the US is a typical example, with an increasing inflation and negative output gaps on average.[29] As such a persistent increase in the inflation rate is not explainable by oil shocks either, inflation persistence is econometrically attributed to its own lags. Given the asymmetric price behavior, a period of low inflation with fewer positive monetary impulses will result in a

[28]In the euro area, an always negative excess liquidity is related to the fact that the whole sample is characterized by disinflation. m_t^* was above p_t only before the two inflation spikes of the early 1980s and early 1990s.

[29]One can argue that there are other more accurate output-gap concepts and measures, but it is unlikely that this analysis would be affected.

lower estimated inflation intrinsic persistence. As seen in Figs. 5–8 however, persistently faster price increases reflect persistent preceding faster increases in the money level; ignoring monetary aggregates thus implicitly attributes the persistence of the latter to inflation own persistence, and from the evidence above this can vary across periods.

5. Conclusions

Recently, theoretical as well as empirical models have been based on steady-state normalization or detrended data, disregarding the only variable clearly related to major movements of the general price level, i.e. money. This focus on relative price analysis has had a strong influence on recent arguments and debates regarding inflation developments and prospects. One example is the discussion on global factors, like international competitiveness and energy prices, as explanations of inflation developments. The increased global importance of the Chinese economy has often been mentioned as a factor holding down inflation in the early 2000s and a few years later as a source of rising inflationary pressures.

In order to reconcile current models with major inflation fluctuations, research has been focusing on indeterminacy issues or has attributed these fluctuations to inflation objective changes, without empirical support. However, accounting for equilibrium velocity movements and price asymmetric behavior, significant price movements can always be related to previous corresponding monetary developments, and significant monetary movements are always followed by corresponding price movements.

Seen from the angle of monetary aggregates, monetary policies since the early 1990s have been rather restrictive. This can explain the recent low inflation environment, which however represents a challenge for inflation targeting strategies. Given that we observe price increases when policy is expansive but do not observe price decreases when policy is restrictive, while output appears to be symmetrically affected but lags monetary developments, a focus on a low inflation target without considering monetary aggregates runs the risk of being too restrictive on average.

Using monetary aggregates is not straightforward and requires careful analysis, as aggregate money demand instability can occur, and it is certainly wise to base monetary policy decisions on a broad source of indicators and models and to communicate in terms of an inflation objective. However, given the evidence presented, neglecting money, i.e. relegating it to models' backgrounds, and opposing using the evidence to improve models and policy making, is certainly not the best way of making the best use of all available information, nor of improving our understanding of inflation dynamics and avoiding major policy mistakes.

Appendix A. Money demand

Figs. 10–12 display velocity and opportunity cost for Switzerland, the US and the euro area, respectively. As presented in Reynard (2006), using dynamic least squares (Stock and Watson, 1993), an income elasticity not significantly different from unity is found with US and euro area data, once changes in US financial market participation in the 1970s and checking accounts substitutes introduced in the early 1980s are accounted for, and when the euro area sample includes the 1970s; Swiss data can be characterized by a unitary income elasticity as well. This elasticity is thus imposed for the three (groups of)

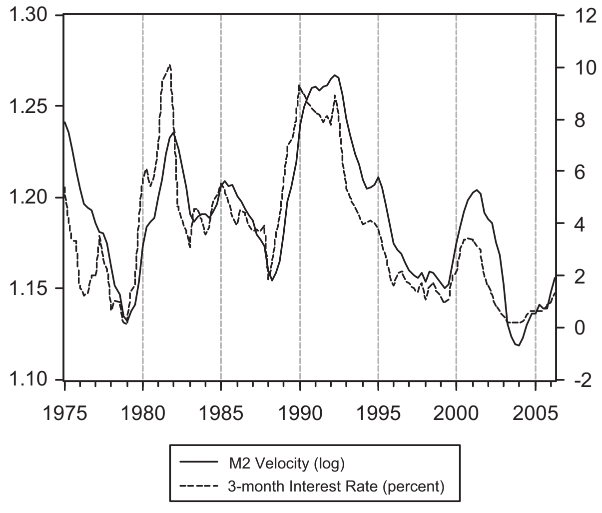

Fig. 10. Swiss money demand.

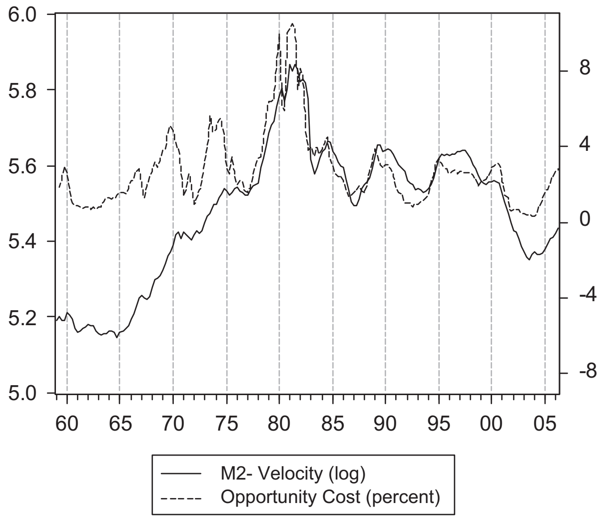

Fig. 11. US money demand.

economies.[30] Table 2 shows the corresponding interest rate semi-elasticity, β, estimated by OLS. Similar results are obtained with dynamic least squares regressions. The resulting error term is not used for inference, but as a measure of money movements not associated with contemporaneous interest rate or output fluctuations, referred to as ''velocity

[30]Reynard (2006) presents money demand results using a log–log instead of a semi-log specification. The analysis is not significantly affected by this specification choice. However, a semi-log specification seems more appropriate given recent US money demand developments.

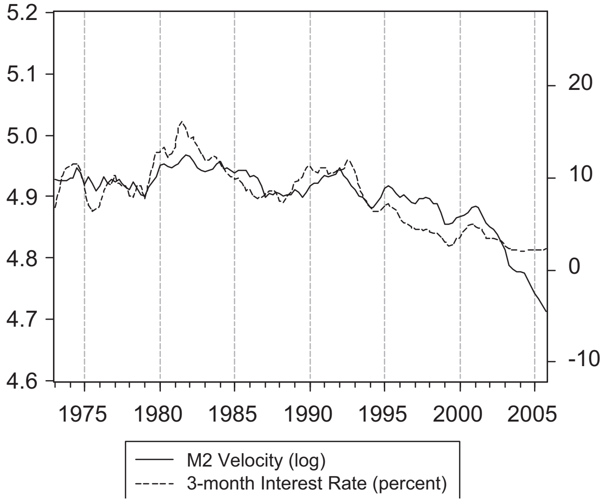

Fig. 12. Euro area money demand.

Table 2
Interest rate semi-elasticity estimates

	β	Sample
US M2−	3.08	1959Q1–2006Q2
Euro area M2	1.22	1973Q1–2005Q4
Euro area adjusted M3	3.66	1980Q1–2005Q4
Swiss M2	3.89	1975Q1–2006Q2

residuals'' in the text. Table 2 also includes the euro area M3 adjusted by portfolio shifts. Sample periods are chosen according to data availability.

In the US case, two broken trends in real money demand are estimated and used to adjust the monetary variable m^* in order to account for two distinct aggregate instability episodes. One trend covers the period 1965Q1–1977Q1 to account for the change in money demand extensive margins due to the increase in financial market participation, i.e. an increase in the fraction of US households holding non-monetary assets like stocks and bonds, that occurred during that period, as documented in Reynard (2004). The other trend covers the period 2001Q1–2003Q1, where another apparent aggregate instability occurred, also related to extensive margins. Between the 2001 and 2004 Surveys of Consumer Finances,[31] financial market participation decrease from over 40% to about 35%; this is the first time such a significant decrease in financial market participation happens since these surveys started in 1962, and this could be related to the decline in equity markets prices. While these trend adjustments are relatively ad hoc, they yield plausible outcomes. However, more work is needed to quantify these changes in extensive

[31]These surveys are available on the Federal Reserve Board internet site.

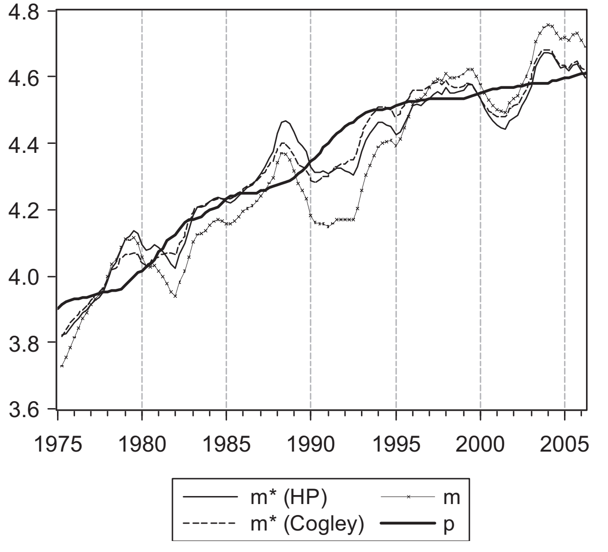

Fig. 13. Swiss money and price levels.

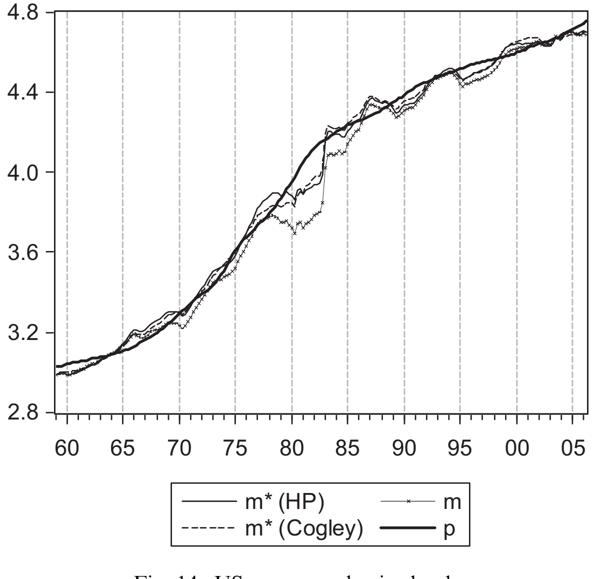

Fig. 14. US money and price levels.

margins in real time.[32] Practical examples of dealing with instability in real time include Orphanides and Porter (2000), who suggest using regression trees to account for real-time

[32]A complementary approach would be to monitor additional aggregates to detect shifts and for robustness considerations. For example, in the US during the 1970s, M2 was relatively less affected than M2− by changes in financial market participation. However, the overall empirical relationship of broader aggregates with prices and output is less clear.

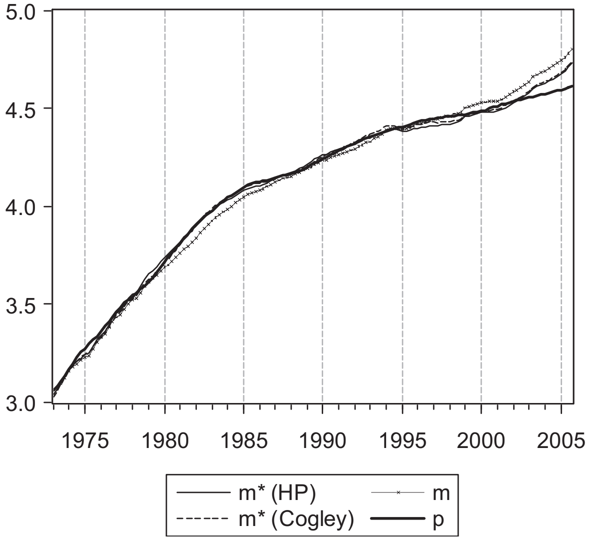

Fig. 15. Euro area money (M2) and price levels.

velocity shifts, and the analysis presented by ECB staff (ECB, 2004) to account in real time for the particular financial market developments which occurred in between 2001 and 2003 and resulting in the series M3 adjusted by measured portfolio shifts analyzed in Fig. 8.

Appendix B. Equilibrium velocity adjustment

To illustrate the effect of the equilibrium velocity adjustment, Figs. 13–15 display the non-velocity-adjusted (m, i.e. $c + m_t - y_t^*$) and velocity-adjusted (m^*, i.e. $c + m_t - y_t^* + \beta i_t^*$) money levels with both HP ($\lambda = 1600$) and Cogley ($\lambda = 0.125$) filters, together with the price level (p). In Switzerland, people decreased their real money balances with the early 1980s and early 1990s inflation episodes, and increased their real money holdings with the 1990s disinflation. In the US, people held relatively fewer real money balances as inflation increased in the 1960s and 1970s, and relatively more money as inflation decreased in the 1980s and 1990s. In the euro area, people held relatively fewer real money balances in the 1970s and relatively more money as inflation and interest rates decreased since the early 1980s.

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