FORECASTING INFLATION WITH MONETARY AGGREGATES*

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I am concerned that this encouraging but brief period of success will foster the opinion, already widely held, that the [ECB's] monetary pillar is superfluous, and lead monetary policy analysis back to the kind of muddled eclecticism that brought us the 1970s inflation.

Lucas (2006)

Although few would disagree that "inflation is always and everywhere a monetary phenomenon" (Friedman 1963), the last decades have seen a diminished role assigned to money in the conduct of monetary policy. On one hand, mainstream so-called New-Keynesian monetary analysis lives in cashless economies where money demand is considered redundant given an interest rate policy (see, *e.g.*, Woodford 2007a) or, similarly, the long-run relation between money and inflation is seen as just one among many steady-state relations (see Galí 2002). This does not come without criticisms as steady state inflation is taken as exogenous (the central bank target), independent of money supply (see Nelson 2008). On the other hand, issues of instability of money demand and the fact that money seems useless in forecasting inflation (see *e.g.*, Estrella and Mishkin 1997 for an earlier reference) contribute to the de-emphasis of the role of money in monetary policy analysis. In any case, there is broad recognition of the long-run relation between money growth and inflation.

The voluminous literature on inflation forecasting points to the fact that, in the words of Stock and Watson (2007), "inflation has become both easier and harder to forecast" since the early 1980's. Easier in the sense that forecast errors have been smaller, and harder because it has become extremely difficult to beat simple univariate forecasts. The use of large panels does not help and Phillips curve forecasts are in bad shape (Stock and Watson 2008) whereas Ang, Bekaert and Wei (2007) ironically conclude that survey forecasts (especially the Philadelphia survey of professional forecasters) deliver inflation forecasts that are superior to a host of alternative methods.

Against this background, this article shows how monetary aggregates can be usefully incorporated in forecasts of US inflation and how these dominate a wide range of competing forecasts. The crucial aspect of our approach comes from fully disregarding the high-frequency fluctuations blurring the money/inflation relation. This has the flavour of the exercise in Lucas (1980), where focusing on low frequencies reveals in a clearer way the relation between inflation and money growth. With a suitably designed projection we are able to explore that clear relation in the production of timely forecasts.

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The novelty of our approach justifies the striking tension in the literature between the characterization of the money/inflation relation, including the conclusions of Granger causality (of money to inflation) at low frequencies (see, *e.g.*, Assenmacher-Wesche and Gerlach 2008a, 2008b), and the lack of marginal predictive power of money with respect to inflation in out-of-sample forecasting exercises (see *e.g.*, Ang, Bekaert and Wei 2007 for a recent overview). We will note that in the euro area case this evidence vanishes and discuss reasons for why this occurs.

We thus contend with Woodford's (2007a) view that "it might be thought that the existence of a long-run relation between money growth and inflation should imply that measures of money growth will be valuable in forecasting inflation, over the "medium-to-long-run" even if not at shorter horizons. But this is not the case". We will show this is the case, at least in the US. We would agree that the existence of a long run relation does not preclude a special role for money in forecasting inflation, except if there was evidence that money leads inflation. We will show this is the case as did Assenmacher-Wesche and Gerlach (2008a, 2008b) while taking on their challenge on "...how to best make use of the low-frequency information in money growth to construct out-of-sample forecasts of inflation [...]".

The remainder of the article is organized as follows. In Section 2 we review the money/inflation relation, giving special attention to the estimation of the lead from money to inflation at low frequencies. We also make clear how the projections in the article are constructed. Section 3 presents a pseudo out-of-sample forecasting exercise, comparing money based forecasts with a host of alternatives. Section 4 discusses the results, confronting them with theory, and Section 5 offers a summary of the main conclusions.

2. MONEY AND INFLATION

Cross-country analyses of the long-run relation between money and inflation (see *e.g.*, McCandless and Weber 1995, King 2002 and Haug and Dewald 2004) typically show that long averages of both variables concentrate around a 45 degrees line (an exception is de Grawe and Polan 2001, see criticisms to their analysis in Nelson 2003). Frequency domain analyses of the money/inflation relation (*e.g.*, in Thoma 1994, Jaeger 2003, Benati 2005, Brugemann *et al.*, 2005 Assenmacher-Wesche and Gerlach 2007, 2008a and 2008b) show typically a high correlation at low frequencies. It is true that uncovering these relations does not lend by itself a special role for money in the conduct of monetary policy or as an indicator of policy stance. We thus agree with Woodford (2007a): "But the mere fact that a long literature has established a fairly robust long-run relationship between money growth and inflation does not, in itself, imply that monetary statistics must be important sources of information when assessing the risks to price stability". But what if, besides the long-run relation, money leads inflation, even if only at low frequencies?

2.1. In-sample characterization in the frequency domain

We focus here on in-sample evidence of the lead of money with respect to inflation. This is the first step towards investigating if money has predictive power over inflation. Here and throughout, we take into consideration a few aspects in the choice of variables and data treatment that are typically associated with the search for a stable demand function for real money balances. Specifically:

i. the monetary aggregates should clearly reflect transactions motives hence our focus on the aggregates M2, M2(-) and MZM (Money Zero Maturity, see Teles and Zhou 2004 for a discussion of the stability of MZM demand). In the euro area case we must resort to M3, which contains a much wider array of instruments, some with a loose connection with transactions motives;

ii. we focus often on the difference between money growth and output growth (*i.e.*, we implicitly impose a unitary income elasticity in the demand for real money balances), although results hold strong without this adjustment;

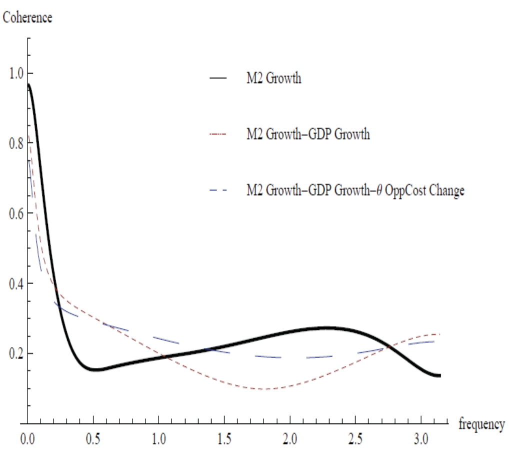
iii. it is often helpful, but not crucial, to control for changes in velocity by including in the projections measures of the opportunity cost of holding money, defined as the difference between the own rate on the aggregate and a short term interest rate (3-month T bill rate in the US case only).

Chart 1 presents coherence (a measure of the correlation at each frequency[1]) and chart 2 the phase shift (the time delay between the series at each frequency) between inflation, π_t and mg_t in the US case. π_t^1 is quarter on quarter inflation, *i.e.*, $\pi_t^1 = \ln(P_t / P_{t-1})$ where P_t is the price level (measured by the GDP deflator) whereas mg_t is either: $\ln(M_t / M_{t-1})$, $\ln(M_t / M_{t-1}) - \ln(y_t / y_{t-1})$ or $\ln(M_t / M_{t-1}) - \ln(y_t / y_{t-1}) - \theta\left(R_t - R_{t-1}\right)$ where M_t is the monetary aggregate (M2 in this case, results for other aggregates are similar), y_t is output (measured by real Gross Domestic Product, GDP), R_t is a measure of the opportunity cost of holding the instruments in the aggregates and θ is a semi-elasticity of the demand for real balances with respect to R_t. In the back of our minds we

Chart 1

ESTIMATED COHERENCE BETWEEN INFLATION AND M2 GROWTH UNDER VARIOUS ADJUSTMENTS FOR US

Period 1984Q1-2009Q3

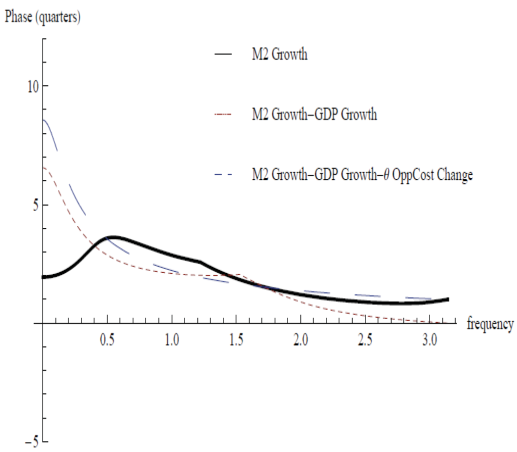


Source: Authors' calculations based on data from Federal Reserve Bank of St. Louis (FRED).
Note: Inflation measured by GDP deflator growth.

Chart 2

ESTIMATED PHASE BETWEEN INFLATION AND M2 GROWTH UNDER VARIOUS ADJUSTMENTS FOR US

Period 1984Q1-2009Q3



Source: Authors' calculations based on data from Federal Reserve Bank of St. Louis (FRED).
Note: Inflation measured by GDP deflator growth.

(1) Low frequencies correspond to fluctuations with high period, *i.e.*, the long waves of the time series.

have thus a Cagan (1956) demand for real balances with unitary income elasticity. We report results for the sample 1984Q1-2009Q3, after Atkeson and Ohanian (2001).

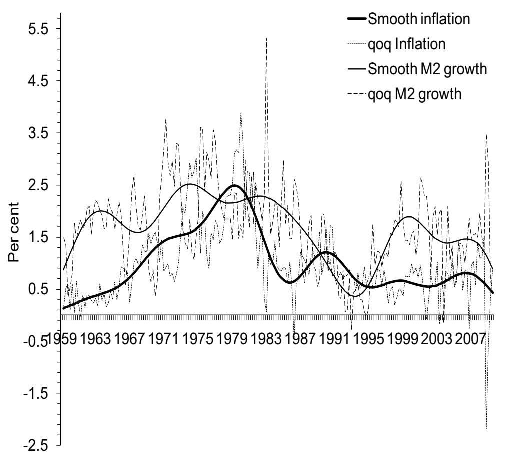
As easily concluded from chart 1, coherence is lower if money growth is adjusted for real GDP growth and even lower, at low frequencies if we adjust for the change in the opportunity cost. In all cases, coherence is very high but only at low frequencies, moving towards 1 when the frequency goes to zero only when no adjustment is made. On the other hand, the phase effect is positive, decreasing in the frequencies and highest if both adjustments are performed. The fact that it is positive reveals immediately that money growth leads inflation.

The characterization above is well documented in the literature (in terms of coherence, we are not aware of the estimation of phase, only of Granger causality tests for different frequencies), so that begs the question: Why isn't this information useful when forecasting inflation? Our conjecture is that the consideration of the noisy information at high frequencies obscures the signal provided by money growth. We will thus project only low frequencies of inflation on money growth. This amounts to targeting a smooth version of inflation. Smooth versions of GDP deflator inflation and M2 growth, disregarding fluctuations with period below 8 years (or 32 quarters), are plotted in chart 3. Despite the well-know correlation between these smoothed series, an obvious problem arises in practice for forecasting since these moving averages, being two-sided, cannot be computed in real-time. That is, the dependent variable in a projection would not be available in real-time. We deal with this issue in the next session.

In the euro area case the conclusions above do not hold. Although coherence between HICP (Harmonised index of consumer prices) inflation and M3 growth is high at low frequencies (see charts 4 and 5) the estimated phase effect is only slightly positive at the very low frequencies (chart 6). These

Chart 3

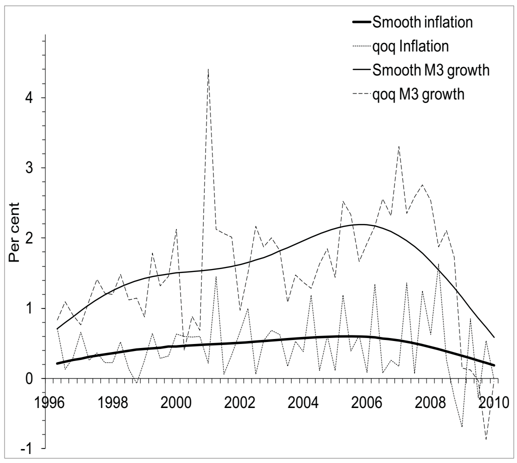
INFLATION, M2 GROWTH AND FILTERED VERSIONS OF BOTH SERIES FOR US
Period 1959Q2-2009Q3



Sources: *Federal Reserve Bank of St. Louis (FRED)* and authors' calculations.
Notes: Inflation measured by GDP deflator growth. The smooth version of a series is obtained disregarding from the series fluctuations with period below 32 quarters.

Chart 4

INFLATION, M3 GROWTH AND FILTERED VERSIONS OF BOTH SERIES FOR EURO AREA
Period 1996Q2-2010Q1

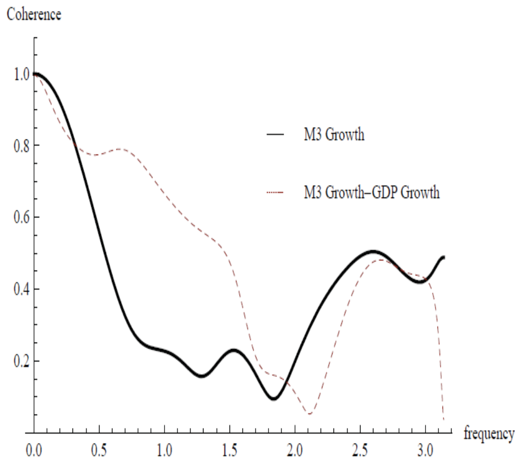


Sources: European Central Bank (Statistical Data Warehouse), European Commission (Eurostat) and authors' calculations.
Notes: Inflation measured by HICP growth. The smooth version of a series is obtained disregarding from the series fluctuations with period below 32 quarters.

Chart 5

ESTIMATED COHERENCE BETWEEN INFLATION AND M3 GROWTH WITH AND WITHOUT ADJUSTMENT FOR EURO AREA

Period 1996Q2-2010Q1

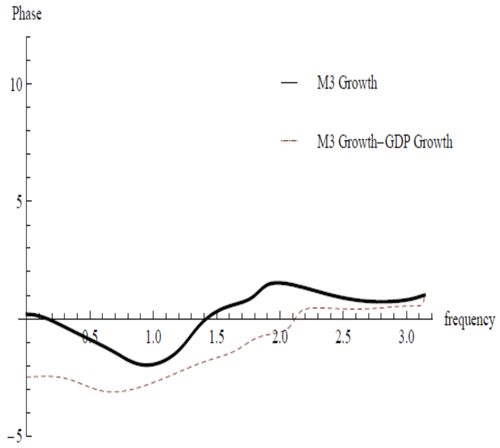


Sources: European Central Bank (Statistical Data Warehouse), European Commission (Eurostat) and authors' calculations.
Note: Inflation measured by HICP growth.

Chart 6

ESTIMATED PHASE BETWEEN INFLATION AND M3 GROWTH WITH AND WITHOUT ADJUSTMENT FOR EURO AREA

Period 1996Q2-2010Q1



Sources: European Central Bank (Statistical Data Warehouse), European Commission (Eurostat) and authors' calculations.
Note: Inflation measured by HICP growth.

estimates are surrounded by great uncertainty due to the short sample size available and to the low variability of inflation during most of the period. In any case, this reveals immediately that one should not expect great results in terms of forecasting inflation using M3 in the euro area, confirming recent findings in, *e.g.* Hofmann (2008) and Lenza (2006).

2.2. How to explore low frequency correlation out-of-sample

Suppose we are interested in forecasting y_t (say, smoothed inflation) that defines a signal on x_t (say, inflation). Suppose we want to isolate the signal in the finite sample $\{x_t\}_{t=1}^{T}$. Suppose also we have c series of covariates $z_1,\ldots,z_c$. The estimate $\hat{y}_t$ of the signal y_t will be a weighted sum of observations of x and of $z_1,\ldots,z_c$:

$$\hat{y}_t = \sum_{j=-f}^{p} \hat{B}_j^{p,f} x_{t-j} + \sum_{s=1}^{c} \sum_{j=-f}^{p} \hat{R}_{s,j}^{p,f} z_{s,t-j} \qquad (1)$$

where p denotes the number of observations in the past that are considered and f the number of observations in the future that are considered. To obtain $\hat{y}_t$ we will choose the weights $\{\hat{B}_j^{p,f}, \hat{R}_{1,j}^{p,f}, \ldots, \hat{R}_{c,j}^{p,f}\}_{j=-f,\ldots,p}$ associated with the series of interest and the available covariates that minimize the mean of the square deviations between y_t and $\hat{y}_t$. Since f is allowed to be negative, it is straightforward to forecast the signal y_{T+k} for $k > 0$. One just needs to set $f = -k$ in the solution, so that only the available information (that is, up to period T in this case) is taken into consideration. We use the solution to this problem discussed in Valle e Azevedo (2010) to approximate smoothed inflation. We will approximate smoothed inflation at various horizons (quarters ahead) and compare its estimates with the actual observations of quarterly inflation. We thus see approximations to smoothed inflation as forecasts of inflation itself.

A choice that has to be made is the cut-off frequency. On one hand, if we exclude more (high) frequencies (or increase smoothness in the target) we will be giving up on more of the variance of inflation. On the other hand, this may lead to more accurate estimation of the relevant projection coefficients since correlation at those frequencies is higher. Given the previous analysis, we chose to eliminate fluctuations with period below 32 quarters. Obviously, the optimal degree of smoothness may vary with the forecast horizon, but results are similar when the cut-off period is between 20 and 40 quarters. We should also add that it would be feasible to construct a forecast combining a projection at low frequencies (with, *e.g.*, money growth as covariate) with an (orthogonal) projection at high frequencies, with measures of supply shocks as covariates. The improvements (if any) are slight.

3. FORECAST RESULTS

3.1. Data and pseudo out-of-sample design

We focus on CPI and GDP deflator inflation in the US case and HICP inflation in the euro area case. We will report forecast results using the monetary aggregates M2 and MZM for the US (results using M2(-) are close to those obtained using MZM) and M3 for the euro area. In some exercises in the US case, we use the activity variables considered more promising by Stock and Watson (1999): the unemployment rate (all, 16+, seasonally adjusted), the capacity utilization rate, housing starts, industrial production index, real disposable income and employees payrolls. All (transformed) data are aggregated quarterly as three months averages. In the euro area case we use the unemployment rate and employment expectations for the months ahead.

Subscript $|t$ on a variable denotes a forecast using information up to time t. We focus throughout the article in year on year quarterly inflation π_t^4. If P_t is the quarterly price level we define $\pi_t^4 = \ln(P_t / P_{t-4})$ whereas we will usually forecast $\pi_t^1 = \ln(P_t / P_{t-1})$ and produce forecasts of π_{t+h}^4 at t, $\pi_{t+h|t}^4$, as the sum of the forecasts $\pi_{t+h|t}^1 + \pi_{t+h-1|t}^1 + \pi_{t+h-2|t}^1 + \pi_{t+h-3|t}^1$ where $\pi_{t+i|t}^1 = \pi_{t+i}^1$ whenever $i \leq 0$. This is just one way of summarizing the forecast performance of the various methods. Nothing changes in terms of conclusions if we focus on forecasts of π_t^1.

All forecasts for all methods simulate a real-time situation: transformations in the data, estimation of projection coefficients, computation of filter weights etc., are done as if the forecaster stood at the forecast moment without further information (the one exception is that we neglect the release delay of GDP, approximately 1 quarter).

3.2. Competing forecasts

The results obtained with the multivariate approximation to smooth inflation (denoted *Multivariate Filter*) aimed at exploring the low-frequency relation between inflation and the growth in the monetary aggregates, will be confronted with those obtained with several alternative methods and models (in the euro area case only a few methods will be used due to data constraints):

- Random walk forecast $\pi^4_{t+h|t} = \pi^4_t$, analyzed by Atkeson and Ohanian (2001), denoted *AO*. The focus there was on $h = 4$ but since it is essentially a random walk forecast we use it for all h.

- Recursive mean forecast as $\pi^4_{t+h|t} = \frac{1}{t}\sum_{j=1}^{t}\pi^4_j$ for all h, denoted *Mean*;

- Median forecasts from the Philadelphia *Survey of Professional Forecasters* (US case only);

- Recursive direct autoregressive forecasts, denoted *Recursive*, computed from the model $\pi^1_{t+h} = \mu^h + \beta^h(L)\pi^1_t + \lambda^h(L)x_t + \varepsilon_{t+h}$, where $\beta^h(L)$ and $\lambda^h(L)$ are polynomials in the lag operator L. Lag length is chosen by AIC and parameters are estimated by OLS. We consider restricted/unrestricted versions of $\beta^h(L)$ to account for a unit-root in π^1_t. The chosen variables x_t are the unemployment rate (all, 16+, seasonally adjusted), the capacity utilization rate, housing starts, industrial production index, real disposable income and employees payrolls for the US and the unemployment rate and employment expectations for the months ahead for the euro area;

- Integrated moving average (IMA) model for inflation, that is, $\pi^1_t - \pi^1_{t-1} = \varepsilon_t - \theta\varepsilon_{t-1}$, where $\theta = 0.65$ as in Stock and Watson (2007) for the post 1984 period. Forecasts are obtained with the Kalman filter. Stock and Watson set a different θ for the sub-sample 1960-1984. The more general setting is an unobserved components model with time-varying variances where $\pi_t = \tau_t + u_t$, where $\tau_t = \tau_{t-1} + \upsilon_t$ and $\upsilon_t \sim N(0,\sigma^2_{\upsilon,t})$ and $u_t \sim N(0,\sigma^2_{u,t})$. θ can be recovered from the ratio of these variances and seems stable for the post 1984 period in the US. We fix it but it should be noted that it cannot be seen as a real-time forecast. This is useful for our purpose as it makes it a tough competitor;

- In order to check whether results are driven by the method employed we also apply the *Multivariate Filter* approximation using the activity indicators;

- Gordon's (1982) triangle model with a constant natural rate of unemployment $\pi^1_t = \beta(L)\pi_{t-1} + \lambda(L)(u_t - u^*) + \gamma(L)z_t + \varepsilon_{t+h}$, where $\beta(L)$ and $\lambda(L)$ are polynomials in the lag operator L whereas u^* is the natural rate and z_t is a measure of supply shocks (we consider oil prices here). Again, we consider restricted/unrestricted versions of $\beta(L)$ to account for a unit root in π^1_t. To produce forecasts using this model the right hand side variables are forecasted with an auto-regressive model, while projection coefficients are estimated by OLS.

With respect to the forecasts that use monetary aggregates we consider some variations in the settings:

- we use the growth rate of the monetary aggregate or the growth of the monetary aggregate adjusted for real GDP growth (*i.e.*, the difference between money growth and real GDP growth);

- we include in the projection the change in the opportunity cost of holding the instruments contained in the aggregates.

3.3. Results

A summary of the results for the US is in Table 1 for the period 1989Q1 - 2008Q3. Several conclusions emerge:

- Survey forecasts (only available for CPI inflation and $h \leq 4$) have a poor performance when $h = 1,2$ but prove hard to beat when $h = 4$, confirming results in Ang, Bekaert and Wei (2007);

- *Recursive* activity based forecasts are only useful when $h = 1,2$ with the notable exception of housing starts when $h = 12$ and less so when $h = 8$;

- The use of the *Multivariate Filter* does not improve significantly (if at all) the performance of the forecasts based on housing starts, real disposable income, employees payrolls and industrial production. On the other hand, it clearly improves the forecasts based on capacity utilization and on the unemployment rate at all horizons. We should notice that these series have little power at high frequencies;

- *Recursive* money based forecasts perform rather poorly at all horizons (notable exception is M2 growth when $h = 12$);

- The use of the *Multivariate Filter* clearly reveals the power of money (MZM) based forecasts. Forecasts based on M2 are only mildly boosted by the *Multivariate filter* when GDP growth is taken into account. In the case of MZM the improvements occur in the case of CPI and much more clearly with the GDP deflator, for all horizons, with or without the corrections for GDP growth and with or without the inclusion of opportunity cost measures. With a few exceptions results are best when one considers MZM adjusted for GDP growth but without inclusion of the opportunity cost. This is actually the general picture, it is helpful to correct the monetary aggregates for GDP growth but unhelpful to include measures of the opportunity cost;

- Money based *Multivariate Filter* forecasts are nonetheless clearly outperformed when $h = 4$ by the SPF forecasts (CPI) and by the capacity utilization rate *Multivariate Filter* forecasts. In relative terms, the significant departures from other methods occur when $h = 6,8,12$.

Putting it simply, in this pseudo out-of-sample forecasting exercise money growth (specially as measured by MZM) is a privileged predictor of inflation. A few caveats must be pointed however: First, we rely on stationarity of inflation and money growth. This is definitely conceivable for a sub-sample starting in the mid 1980's but hard to believe in the full post 1960 sample. Since we use long lags of the predictors and estimate high order autocovariances we need a relatively long estimation sample, hence the consideration of the full-sample. We have however verified that forecasts starting in the mid 1990's using an estimation sample beginning in 1984 are very close to the ones obtained with the full sample. Still, in the first case, forecasts including the period 1984-1988 weaken substantially our results as it becomes more difficult to beat the univariate benchmarks, although the basic distinctions between methods and variables still apply. This is due to a clear failure of the long-run forecasts for the period 1984 -1988. Our sense is that we don't control "enough" for the violent decrease in velocity due to the decrease in the opportunity cost of holding money during the end of a period of disinflation. This kind of correction is typically employed in order to re-establish a stable demand for real balances (see *e.g.*, Reynard 2007), but we explicitly avoid any correction in the monetary aggregates that could not have been done in real-time.

With respect to long-run forecasts of 2009 and the last quarter of 2008, we should refer that all methods proved disastrous in forecasting inflation. In such a degree that the (squared) errors for those few observations are as large as the cumulative squared errors of the last 20 years. However, the basic picture does not change. A table including these forecasts would deliver basically the same information as it is still true that the methods approximating smooth inflation using money growth are superior.

Finally, another concern is the choice of frequencies that are disregarded, which is essentially arbitrary. We have indeed considered different cut-off frequencies but 32 quarters proved a good compromise for all horizons. The optimal degree of smoothing generally increased with the forecast horizon, but the differences were slim. This is consistent with evidence in Reichlin and Lenza (2007) for the euro area, who forecast in-sample moving averages of inflation, concluding that longer moving averages improve the forecast performance when the horizon increases. Our idea is very similar in spirit to theirs, but we are able to perform the projection in real-time.

Regarding the euro area, results for the (short) evaluation period 2007Q1-2010Q1 are presented in table 2. The main conclusions are:

- *Mean* forecasts outperform all competing methods, except at uninteresting short horizons, where forecasts based on monetary aggregates or activity indicators seem better regardless of the forecasting method;

- there is no superior predictive ability of the money based forecasts relative to the activity indicators based forecasts;

- if we disregard (results not shown) from the evaluation period the last 5 observations (2009 and 2010Q1) all forecast methods perform poorly at all horizons, except recursive forecasts based on the unemployment rate.

Despite these results, we believe that the predictive power of monetary aggregates in forecasting inflation may be hidden in the euro area data (see Benati 2009 on reasons why this might occur). Further, the short available sample and the low variability of inflation complicate any estimation process while limiting the possibility of drawing strong conclusions. We could consider augmenting the sample with historical data of the participating countries prior to 1996, but aggregation of series with different definitions is undesirable, and even more so in the presence of a clear a regime shift. Second, in recent years the relation between M3 and inflation seems to have weakened (see Alves, Marques and Sousa 2007, Reichlin and Lenza 2007), but we are still unable to conclude if this is a robust feature and/or if it is the result of the undesirable characteristics of M3, namely the fact that it drifts from the concept of money. So, it may be that recovering the predictive ability of money requires

Table 1 (to be continued)

SIMULATED PSEUDO OUT-OF-SAMPLE FORECASTING RESULTS FOR US
Evaluation period 1989Q1-2008Q3

h – horizon	h=1		h=2		h=4		h=6		h=8		h=12	
Inflation measure	**CPI**	**GDP**	**CPI**	**GDP**	**CPI**	**GDP**	**CPI**	**GDP**	**CPI**	**GDP**	**CPI**	**GDP**
NAIVE (AO)	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
RMSFE	0.004973	0.002338	0.007162	0.003526	0.010774	0.005590	0.011327	0.006818	0.012197	0.008121	0.014157	0.009804
Mean	2.20	3.98	1.55	2.68	1.06	1.74	1.02	1.47	0.97	1.26	**0.85**	1.09
IMA θ=0,65	0.70	0.77	0.77	0.84	0.95	0.99	0.98	0.98	0.95	0.97	0.97	0.97
Survey Professional Forecasters Median	1.31		1.06		0.83							
Forecasts with multivariate filter												
MZM growth	0.70	0.76	0.77	0.82	0.94	0.92	0.97	0.84	0.93	0.82	0.96	0.91
MZM growth-GDP growth	0.68	**0.73**	0.73	**0.76**	0.86	**0.83**	0.89	**0.79**	0.86	0.83	0.93	0.96
MZM growth & opp cost	0.70	0.76	0.77	0.81	0.93	0.92	0.97	0.89	0.93	0.90	0.98	1.02
MZM growth-GDP growth & opp cost	0.70	0.78	0.77	0.85	0.95	1.03	1.01	1.04	0.99	1.08	1.05	1.20
M2 growth	0.78	0.89	0.92	1.04	1.19	1.32	1.27	1.28	1.29	1.23	1.30	1.22
M2 growth-GDP growth	0.72	0.78	0.81	0.84	1.00	0.96	1.04	0.87	1.02	0.83	1.06	0.90
M2 growth & opp cost	0.79	0.87	0.92	1.01	1.19	1.26	1.26	1.24	1.28	1.21	1.30	1.25
M2 growth-GDP growth & opp cost	0.74	0.78	0.83	0.84	1.02	0.97	1.05	0.89	1.01	0.87	1.07	0.97
Industrial production	0.68	0.79	0.73	0.87	0.87	1.03	0.90	1.01	0.87	1.03	0.96	1.14
Capacity utilization	**0.66**	0.79	**0.69**	0.86	**0.81**	1.04	**0.86**	1.08	0.86	1.14	0.97	1.33
Unemployment	0.67	0.76	0.73	0.82	0.86	0.92	0.88	0.88	0.84	0.90	0.96	1.04
Housing starts	0.74	0.88	0.85	1.01	1.04	1.27	1.09	1.26	1.06	1.22	1.13	1.29
Real disposable income	0.71	0.86	0.81	1.01	1.01	1.28	1.09	1.28	1.11	1.30	1.19	1.34
Employees payrolls	0.68	0.79	0.73	0.87	0.89	1.06	0.95	1.06	0.95	1.09	1.06	1.21

Table 1 (continued)

SIMULATED PSEUDO OUT-OF-SAMPLE FORECASTING RESULTS FOR US
Evaluation period 1989Q1-2008Q3

h – horizon	h=1		h=2		h=4		h=6		h=8		h=12	
Inflation measure	**CPI**	**GDP**	**CPI**	**GDP**	**CPI**	**GDP**	**CPI**	**GDP**	**CPI**	**GDP**	**CPI**	**GDP**
Recursive forecasts												
MZM growth	0.72	0.81	0.82	0.92	1.10	1.14	1.19	1.25	1.19	1.33	1.23	1.45
MZM growth-GDP growth	0.71	0.81	0.81	0.91	1.08	1.11	1.16	1.23	1.18	1.33	1.25	1.47
MZM growth & opp cost	0.70	0.83	0.79	0.97	1.07	1.26	1.19	1.36	1.19	1.37	1.26	1.46
MZM growth-GDP growth & opp cost	0.70	0.83	0.82	0.98	1.10	1.26	1.20	1.37	1.20	1.39	1.18	1.47
M2 growth	0.73	0.81	0.85	0.91	1.18	1.02	1.33	1.04	1.36	1.04	1.06	**0.88**
M2 growth-GDP growth	0.70	0.82	0.80	0.93	1.06	1.18	1.15	1.29	1.10	1.32	1.08	1.39
M2 growth & opp cost	0.74	0.85	0.87	0.94	1.14	1.13	1.19	1.17	1.25	1.04	1.08	0.88
M2 growth-GDP growth & opp cost	0.72	0.85	0.85	1.00	1.08	1.24	1.10	1.27	1.03	1.25	1.06	1.38
Industrial Production	0.74	0.82	0.83	0.91	1.08	1.13	1.13	1.23	1.14	1.30	1.15	1.40
Capacity Utilization	0.76	1.00	0.93	1.26	1.33	1.74	1.53	1.95	1.60	1.97	1.78	1.81
Unemployment	0.70	0.83	0.81	0.95	1.06	1.23	1.16	1.35	1.17	1.40	1.23	1.46
Housing Starts	0.73	0.80	0.85	0.90	1.11	1.03	1.13	1.04	0.93	0.96	**0.78**	1.01
Real Disposable Income	0.72	0.83	0.81	0.91	1.06	1.09	1.10	1.16	1.08	1.13	1.19	1.26
Employees Payrolls	0.72	0.84	0.80	0.94	1.02	1.18	1.08	1.30	1.06	1.38	1.13	1.37
Inflation Change, Industrial Production	0.73	0.82	0.83	0.93	1.08	1.13	1.17	1.22	1.13	1.29	1.12	1.39
Inflation Change,Capacity Utilization	0.75	0.99	0.89	1.25	1.24	1.74	1.44	1.83	1.43	1.66	1.26	1.49
Inflation Change, Unemployment	0.70	0.83	0.79	0.96	1.07	1.27	1.24	1.39	1.24	1.42	1.31	1.50
Inflation Change, Housing Starts	0.73	0.80	0.86	0.91	1.15	1.06	1.24	1.08	1.05	1.06	1.02	1.36
Inflation Change, Real Disposable Income	0.72	0.84	0.81	0.97	1.09	1.16	1.17	1.24	1.11	1.32	1.16	1.38
Inflation Change, Employees Payrolls	0.72	0.83	0.82	0.95	1.06	1.14	1.12	1.21	1.08	1.29	1.08	1.37
Gordon's Triangle Model												
Inflation	0,72	0,88	0,79	1,07	1,03	1,41	1,09	1,43	0,98	1,36	1,39	1,56
Inflation Change	0,72	0,89	0,78	1,08	1,02	1,41	1,07	1,43	0,97	1,34	1,23	1,50

Source: Authors' calculations.
Notes: Ratio of the Root Mean Squared Forecast Error (RMSFE) with each method to the RMSFE of Atkeson Ohanian (AO) forecasts. Evaluation period: 1989Q1-2008Q3. Bottom 20% values of each column are highlited, lowest value of each column is in bold.

Table 2

SIMULATED PSEUDO OUT-OF-SAMPLE FORECASTING RESULTS FOR THE EURO AREA
Evaluation period 2007Q1-2010Q1

h – horizon	h=1	h=2	h=4	h=6	h=8	h=12
Inflation measure	HICP	HICP	HICP	HICP	HICP	HICP
NAIVE (AO)	1.00	1.00	1.00	1.00	1.00	1.00
RMSFE	0.007808	0.013500	0.020048	0.019911	0.014506	0.013657
Mean	1.77	1.07	0.74	**0.71**	0.93	1.02
Forecasts with Multivariate Filter						
M3 growth	0.93	0.75	0.80	0.78	0.94	0.99
M3 growth-GDP growth	0.92	0.74	0.79	0.77	0.94	**0.99**
Unemployment	0.89	**0.70**	**0.72**	0.74	1.01	1.05
Employment expectation	0.90	0.71	0.75	0.74	**0.93**	0.99
Recursive Forecasts						
Univariate	0.97	0.86	0.91	0.82	0.93	1.01
M3 growth	**0.89**	0.84	0.87	0.80	0.95	1.04
M3 growth-GDP growth	1.01	0.93	0.95	0.81	0.97	1.02
Unemployment	0.97	0.87	0.86	0.79	1.12	1.01
Employment expectation	0.91	0.81	0.91	0.88	1.02	1.02

Source: Authors' calculations.

Notes: Ratio of the Root Mean Squared Forecast Error (RMSFE) with each method to the RMSFE of Atkeson Ohanian (AO) forecasts. Evaluation period: 2007Q1 - 2010Q1. Bottom 20% values of each column are highlited, lowest value of each column is in bold.

a more thorough treatment (or pruning...) of the available M3. The use of M3 for monetary analysis is far from consensual but the current practice of using a corrected (for portfolio shifts) M3 series (see Hofmann 2008 and Fisher; Lenza, Pill and Reichlin 2006), seems a non-starter as it is contaminated by judgment.

4. DISCUSSION

Here we contrast the results above with the implications of two simple theoretical models, to show how current theory is at odds with forecastability of inflation given money growth. Money is absent in most so-called New-Keynesian models or it is often seen as redundant. The point is easily seen in the simplest prototypical model (taken from Nelson 2008) composed of a Phillips curve, an IS equation and a monetary policy rule:

$$\pi_t - \pi^* = \kappa \ln(Y_t / Y_t^*) + \beta E_t[\pi_{t+1} - \pi^*] + u_t$$

u_t is a white-noise shock, $\kappa > 0$ and $0 < \beta < 1$ whereas π_t denotes inflation, π^* the central bank target for inflation, Y_t output and Y_t^* potential output.

$$\ln(Y_t / Y_t^*) = E_t[\ln(Y_{t+1} / Y_{t+1}^*)] - \sigma(R_t - E_t[\pi_{t+1}] - r_t^*)$$

where $\sigma > 0$, r_t^* is the short-term natural real interest rate, and R_t is the short-term nominal interest rate. Assume the policy rule is a Taylor type rule:

$$R_t = R^* + \phi_\pi(\pi_t - \pi^*) + \phi_y \ln(Y_t / Y_t^*)$$

π^* is the inflation target, $\phi_\pi > 1$ (Taylor principle) and $\phi_y \geq 0$. Append to these equations the following money demand function:

$$m_t - p_t = c_0 + c_1 \ln(Y_t) + c_2 R_t + \eta_t$$

$m_t - p_t$ is log of real balances, η_t is a white-noise money-demand shock, $c_1 > 0$ and $c_2 < 0$. Forgetting the last equation one could state that in steady-state the following three conditions hold:

$$\begin{aligned} E[\pi_t - \pi^*] &= 0 \\ E[\ln(Y_t / Y_t^*)] &= 0 \\ R^* = E[R_t] &= E[r_t^*] + \pi^* \end{aligned} \qquad (2)$$

The argument goes, in steady state inflation equals target inflation and, given money demand (accommodated by supply), it is true that inflation and money growth move one to one in the long-run if Y_t is growing at a constant rate (just another steady state relation, as Galí 2002 puts it). Money demand (and supply) is nonetheless seen as redundant in the determination of inflation or, in other way, it is possible to explain inflation dynamics without reference to money. This position is clearly summarized in Woodford (2007a, 2007b) although the argument goes back to McCallum (2001). This does not come without counter-arguments. For instance, Nelson (2008) argues that the last steady state relation would imply that in the long-run, when prices are flexible, the central bank can control the nominal interest rate with open market operations. Now, regardless of the reasonableness of the arguments, the matter of fact is that observations on money growth would be useless in forecasting inflation. It is easy to show that once the output gap $\left(\ln\left(Y_t / Y_t^*\right)\right)$ and current inflation are taken into account, money growth would be irrelevant in forecasts of inflation. In models with a real balances effect (*e.g.*, when money enters the utility function, opening a direct channel from money to aggregate demand), money helps forecasting inflation through it's relation with the output gap. However, most studies (*e.g.*, Ireland 2004) argue that the real balances effect is negligible.

Consider now the following simple model with flexible prices, taken from Marcet and Nicolini (2009). The argument goes through in more general environments. It can be seen as an extreme interpretation of the quantity theory, although no monetarist would endorse it. Households maximize utility given $E_0 \sum_{t=0}^{\infty} \beta^t U\left(\left(1 - v_t\right) C_t^1, v_t C_t^2\right)$, with $U = \min\left\{\left(1 - v_t\right) C_t^1, v_t C_t^2\right\}$, where C_t^1 is a cash good and C_t^2 a credit good. v_t is a preference shock (or velocity shock, see below) and output is exogenously given by $Y_t = Y_0(1+g)^t \varepsilon_t$, where ε_t is a productivity shock. A cash-in-advance constraint $M_t \geq P_t C_t^1$ is imposed and the budget constraint is given by $P_t C_t^1 + P_t C_t^2 + M_t + B_{t+1} \leq M_{t-1} + (1+R_t) B_t + P_t Y_t$ where P_t is the price level, M_t is money holdings, B_t bond holdings and R_t the nominal interest rate. The resource constraint is given by $Y_t = C_t^1 + C_t^2$. Optimization and market clearing leads to $M_t v_t = P_t Y_t$. Take logs and subtract from period $t+1$ to get:

$$\ln(M_{t+1} / M_t) + \ln(v_{t+1} / v_t) = \ln(1+g) + \ln(\varepsilon_{t+1} / \varepsilon_t) + \ln(P_{t+1} / P_t)$$

or

$$\pi_{t+1} = -\ln(1+g) + \mu_{t+1} - \xi_{t+1}$$

where $\xi_{t+1} = \ln(v_{t+1} / v_t) - \ln(\varepsilon_{t+1} / \varepsilon_t)$, $\mu_{t+1} = \ln(M_{t+1} / M_t)$ and $\pi_{t+1} = \ln(P_{t+1} / P_t)$. Now, if the central bank sets μ_t so as to minimize $E_{t-1}(\pi_t - \pi^*)^2$, where π^* is the central bank target, subject to $\pi_t = -\ln(1+g) + \mu_t + \xi_t$, the solution is $\mu_t = \pi^* + \ln(1+g) - E_{t-1}[\xi_t]$. Hence, $\pi_t = \pi^* + \xi_t - E_{t-1}[\xi_t] = \pi^* + \xi_t^*$, say. Therefore π_t is a white noise process contemporaneously uncorrelated with μ_t. The bottom line is that while long averages of π_t and μ_t will move one-to-one, μ_t is useless in forecasting inflation.

These simple examples illustrate how current models don't lend any special role for money in forecasting inflation. It's reasonable to argue that the focus on a narrow range of financial liabilities and interest rates (or only one as has been usual) neglects the channels through which monetary policy affects the prices of a wide range of assets, whose behavior or effects are summarized by information in monetary aggregates (see Nelson 2003 for an example where money serves this purpose).

5. CONCLUSIONS

We have shown how to usefully integrate money in inflation forecasts in the US case. This amounts to projecting only the low frequencies of inflation on money growth, thus giving up from the onset on a sizeable fraction of the variance of inflation. Whereas it has long been recognized that low frequencies of money growth and inflation are highly correlated (and less often that money leads inflation), current practice does not lend money growth any special role in inflation forecasts or in the assessment of monetary policy stance, specially in the US. In the euro area case results were not promising but raise important issues. Comparing the results obtained for the US with M2 (which includes several illiquid instruments) with those using MZM (which includes only very liquid instruments), we are lead to suggest that the euro area aggregate M3 may be far from providing an important and stable source of information for monetary analysis within the Eurosystem. It is reasonable to speculate that an aggregate more closely related to the concept of money could perform this task.

The results were contrasted with the implications of two standard models where money growth is surely correlated with inflation, but it does not help forecast inflation. We finish with Lucas (2006):

"New Keynesian models define monetary policy in terms of a choice of a money market rate, and so make direct contact with central banking practice. Money supply measures play no role in the estimation, testing, or policy simulation of these models. A role for money in the long run is sometimes verbally acknowledged, but the models themselves are formulated in terms of deviations from trends that are themselves determined somewhere off stage. It seems likely that these models could be reformulated to give a unified account of trends, including trends in monetary aggregates, and deviations about trend but so far they have not been. This remains an unresolved issue on the frontier of macroeconomic theory."

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