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Forecasting Inflation (and the Business Cycle?) with Monetary Aggregates*

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November 4, 2010

Abstract

We show how monetary aggregates can be usefully incorporated in forecasts of inflation. This requires fully disregarding the high-frequency fluctuations blurring the money/inflation relation, i.e., the projection of inflation onto monetary aggregates must be restricted to the low frequencies. Using the same tools, we show that money growth has (little) predictive power over output at business cycle frequencies.

JEL Classification: C51, E31, E32, E52, E58

Keywords: Inflation Forecasting, Money growth, Low-frequency Filtering

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1 Introduction

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 and modelling of monetary policy. New-Keynesian monetary analysis lives in cashless economies where money demand is considered redundant given an interest rate policy (see, e.g., Woodford 2008) or, in the same vein, the long-run relation between money growth and inflation is seen as just one among many steady-state relations (see Galí 2002). This does not come without criticism as steady state inflation is taken as exogenous (the central bank target), independent of money supply (Nelson 2003). Even if one understands that this only means money supply should accommodate demand given an interest rate policy (Svensson 2003), it is still an issue of debate how this policy can operate in the long-run in view of monetary neutrality (see Nelson 2008). Still, issues of instability of money demand and the fact that money seems useless in forecasting inflation and output (see Estrella and Mishkin 1997 for an earlier reference) contribute to the de-emphasis of the role of money in monetary policy analysis, despite 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. Phillips curve forecasts are in bad shape, the use of large panels does not help (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. All in all, money has become a card out of the deck in inflation forecasts.

Against this background, this paper shows how monetary aggregates can be usefully incorporated in forecasts of U.S. 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. 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). Using similar tools within a pseudo out-of-sample exercise, we show that money growth adds little to forecasts of output, even if we focus on frequencies of output usually associated with the business cycle (possibly related to the output gap concept in current models).

We thus disagree with Woodford's (2008) 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 U.S. over the past twenty years. We agree that the existence of a long-run relation does not imply a special role for money in inflation forecasts, except if there is 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 paper is organized as follows. In section 2 we review the money/inflation relation, giving special attention to the estimation of the lead of money with respect to inflation at low frequencies. We also make clear how the projections aimed at exploring this fact are constructed. Section 3 presents a pseudo out-of-sample forecasting exercise, comparing money based forecasts with a host of alternatives, whereas section 4 analyses money-based forecasts of business cycle fluctuations of output. Section 5 discusses the results, confronting them with theory, and section 6 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[1]. Frequency domain analyses of the money/inflation relation (e.g., in Thoma 1994, Jaeger 2003, Benati 2009, Brugemann et al. 2005 and 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 (2008): "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 in the U.S.. This is the first step towards investigating if money has predictive power over inflation. Our data covers the period 1959Q1-2009Q3 and we split the sample into 1959Q1-1983Q4 and 1984Q1-2009Q3, following Atkeson and Ohanian (2001) and taking into account estimates of the start of the great moderation, see, e.g., McConnell and Perez-Quiros (2000), Stock and Watson (2003) and Giannone, Lenza and Reichlin (2008). 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 - and MZM (Money Zero Maturity, see Teles and Zhou 2004 for a

[1] An exception is de Grawe and Polan 2001, see criticisms to their analysis in Nelson 2003. Teles and Uhlig (2010) present similar findings in low inflation environments.

discussion of the stability of MZM demand and the advantages of using this aggregate instead of M1 in view of financial innovation). It is also instructive to consider the usual M2.

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).

iii) it is often helpful, but not crucial, to control for changes in velocity by including in the analysis 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). Financial innovation can also justify changes in velocity but we explicitly avoid any such control as it can hardly be implemented in a real-time (i.e., without insight) forecasting context.

We report estimates of coherence (a measure of correlation at each frequency) and phase shift (the time delay between the series at each frequency) between quarterly inflation, π_t^1, and (possibly adjusted) quarterly money growth, mg_t. 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 whereas mg_t is either $\ln(M_t/M_{t-1})$, $\ln(M_t/M_{t-1}) - \ln(y_t/y_{t-1})$ or $\ln(M_t/M_{t-1}) - \ln(y_t/y_{t-1}) - \theta(R_t - R_{t-1})$ where M_t is the monetary aggregate, 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 long-run semi-elasticity of the demand for real balances with respect to R_t. In the back of our minds we have thus a Cagan (1956) demand for real balances with unitary income elasticity[2]. Original monthly data is aggregated quarterly using 3-month averages, further details can be found in the data appendix. Figures 1 and 2 report results using M2 and GDP deflator inflation for the samples 1959Q1-1983Q4 and 1984Q1-2009Q3. Results using M2-, MZM as well as those with consumer price index (CPI) inflation are qualitatively similar and will be omitted for brevity.

[2]We have also considered (results not reported) including $\ln(R_t) - \ln(R_{t-1})$ as the measure of opportunity cost change. This is motivated by the money demand function obtained with Lucas's (2000) *shopping time* model. Results are quantitatively and qualitatively similar to those reported with $R_t - R_{t-1}$.

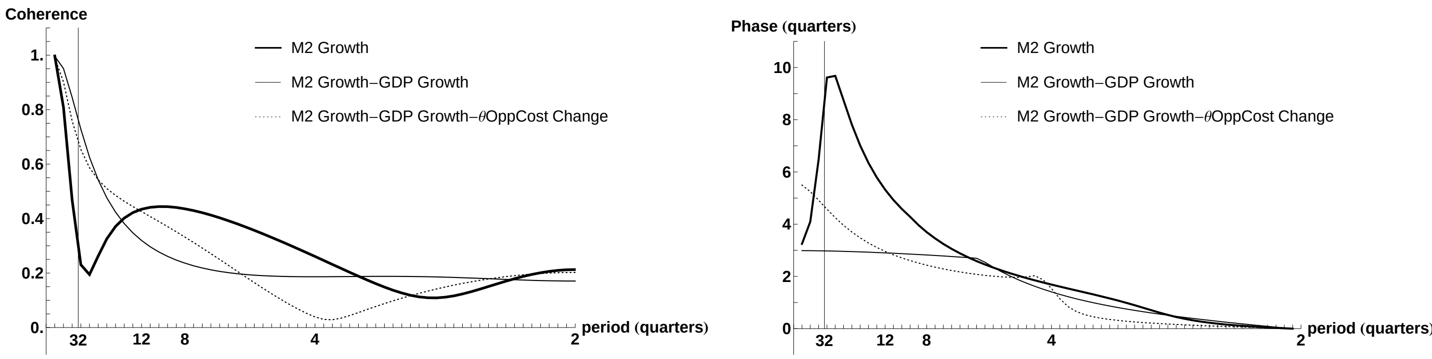


Figure 1

Pre-1984 Estimated coherence and phase shift (in quarters) between U.S. M2 growth and GDP inflation under various adjustments. A **positive** phase indicates that money growth **leads** inflation. Estimation sample: 1959Q1-1983Q4. Following Priestley (1981), we estimate the multivariate spectrum by first pre-whitening vector (π_t^1, mg_t) estimating a VAR(2). We then estimate the spectrum of the residuals non-parametrically using a Parzen window with truncation lag equal to 4. We then recover the spectrum of (π_t^1, mg_t) by inverting the VAR filter. $\theta = 1.08$, in line with Andrés et al. (2009).

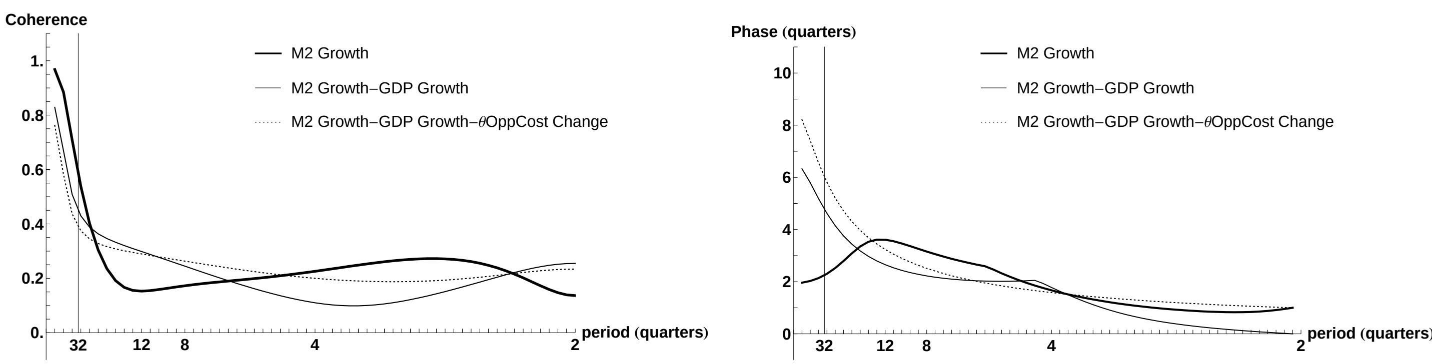


Figure 2

Post - 1984 Estimated coherence and phase shift (in quarters) between U.S. M2 growth and GDP inflation under various adjustments. A **positive** phase indicates that money growth **leads** inflation. Estimation sample: 1984Q1-2009Q3. Estimation details exactly as in figure 1.

As easily concluded, in both sub-samples coherence between money growth and inflation is highest at the very low frequencies while falling below 0.6 before business cycle frequencies (say, frequencies corresponding to periods below 32 quarters). It decreases more rapidly when no adjustment on money growth is made. The phase shift is clearly positive, decreasing in the frequencies when money growth is adjusted for real GDP growth and also when it is further adjusted for the change in the opportunity cost. In the pre-1984 sample and without any adjustment on money growth it shows a peak (10 quarters) around period 32 (notice however that estimated coherence is falling sharply in this region). The fact that it is positive reveals immediately that money leads inflation. Excluding the phase shift in the case of unadjusted money growth, there seems to be a qualitative and even quantitative stability of these frequency domain statistics across sub-samples.

The money/inflation 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), which begs the question: Why isn't this information useful in inflation forecasts? 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 onto money growth. This amounts to targeting a smooth version of inflation. Smooth versions of GDP inflation and M2 growth, disregarding fluctuations with period below 8 years (or 32 quarters), are plotted in figure 3. Despite the well-known 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. Note that the same problem occurs if we are interested in forecasting certain fluctuations of real GDP using money growth (see section 4). We deal with this issue in the next sub-section.

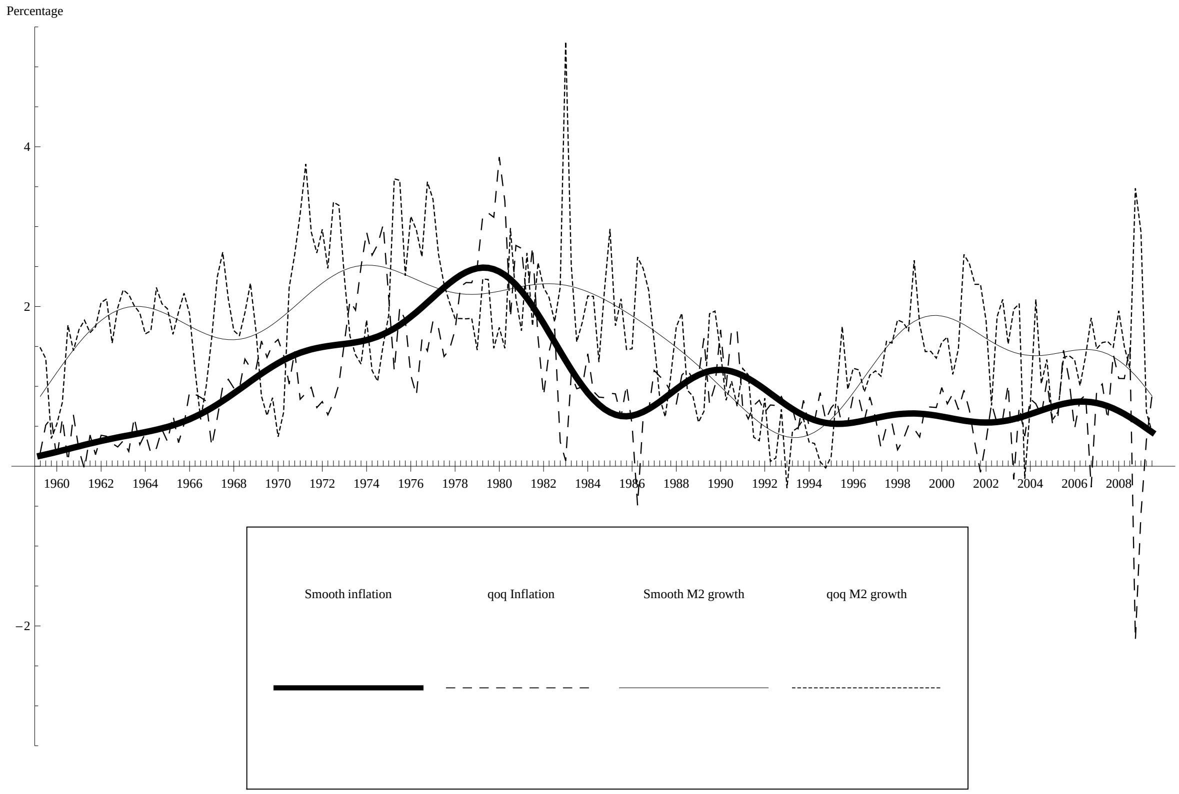


Figure 3

U.S. GDP deflator inflation, M2 growth and filtered versions (cleaned of fluctuations with period below 32 quarters), quarterly series 1959Q1-2009Q3

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

Suppose we are interested in forecasting $y_t = B(L)x_t$ (say, the low frequencies of inflation or business cycle fluctuations of real GDP) where $B(L) = \sum_{j=-\infty}^{\infty} B_j L^j$ is an arbitrary (absolutely summable and stationary) polynomial in the lag operator L defining a signal on x_t (say, inflation or log of real GDP). If y_t denotes the low frequencies of x_t, $B(L)$ is just a band-pass filter eliminating fluctuations with period below a specified cut-off period. The weights of the "ideal" filter performing this task are well-known and given by:

$$B_o = \frac{\omega_h}{\pi}, \qquad B_j = \frac{\sin[\omega_h j]}{\pi j}, |j| \geq 1, \omega_h = \frac{2\pi}{\text{cut-off}}$$

On one hand, if more (high) frequencies are excluded (i.e., the cut-off period or smoothness of the target increase) we will be giving up on more of the variance of x_t. On the other hand, estimation of a projection of a smoother x_t onto covariates may be more accurate if correlation at low frequencies is higher. To be clear, we will see approximations to the low frequencies of inflation at some point in the future (say, y_{T+h}, $h > 0$) as forecasts of inflation itself (x_{T+h}). In theory, if the high-frequency fluctuations of inflation are uncorrelated (or loosely correlated) with the high frequencies of money growth, it is not efficient (in finite samples) to estimate (or use) models that approximate them. Focusing on approximations to the predictable component of inflation may lead to a superior forecast performance if the assumed restriction (unpredictability at high frequencies) in fact holds. Given the results in the previous subsection we believe this restriction is indeed highly reasonable. We need however to fix a cut-off period defining low and high frequencies. Most results presented in the paper result from focusing on fluctuations of inflation with period below the standard cut-off of 32 quarters. Obviously, the optimal degree of smoothness may vary with the forecast horizon, but we should note that results are similar when the cut-off period is between 24 and 36 quarters. We will deal explicitly with this issue in the analysis of the forecast performance of the low-frequency projections (section 3.4).

If y_t denotes business cycle fluctuations of x_t (say, fluctuations with period in the range $[\textit{lower period}, \textit{upper period}] = [6, 32]$ quarters in the pseudo-spectrum of x_t, see Stock and Watson 1998, Baxter and King 1999 and Christiano and Fitzgerald 2003), the weights of the ideal filter are given by:

$$B_o = \frac{\omega_h - \omega_l}{\pi}, \qquad B_j = \frac{\sin[\omega_h j] - \sin[\omega_l j]}{\pi j}, |j| \geq 1 \text{ with}$$
$$\omega_h = \frac{2\pi}{\textit{lower period}\ (=6)} \text{ and } \omega_l = \frac{2\pi}{\textit{upper period}\ (=32)}$$

In practice we want to isolate the signals above given the finite sample $\{x_t\}_{t=1}^{T}$ and c series of covariance-stationary covariates $z_1, ..., z_c$. Let $x = (x_1, x_2, ..., x_T)'$, $z_1 = (z_{1,1}, z_{1,2}, ..., z_{1,T})'$, ..., $z_c = (z_{c,1}, z_{c,2}, ..., z_{c,T})'$. Under such circumstances filter $B(L)$ is not applicable but signal y_t can be approximated by $\widehat{y}_t$, a weighted sum of elements of x and elements of $z_1, ..., z_c$:

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

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 $\widehat{y}_t$ we choose the weights $\{\widehat{B}_j^{p,f}, \widehat{R}_{1,j}^{p,f}, ..., \widehat{R}_{c,j}^{p,f}\}_{j=-f,\dots,p}$ associated with the series of interest and the available covariates that solve the following problem:

$$\underset{\{\widehat{B}_j^{p,f}, \widehat{R}_{1,j}^{p,f}, ..., \widehat{R}_{c,j}^{p,f}\}_{j=-f,\dots,p}}{Min} E[(y_t - \widehat{y}_t)^2] \tag{2}$$

where the information set is implicitly restricted by p and f. In the case of integrated x_t (say, log of real GDP), a restriction must be imposed on $\widehat{B}(L) = \sum_{j=-f}^{p} \widehat{B}_j^{p,f} L^j$ (namely $\widehat{B}(1) = 0$, since $B(1) = 0$). This ensures that the problem is well-defined and stationarity of the extracted signal. We use the solution to problem (2) discussed in Valle e Azevedo (2010) to approximate both the low frequencies of inflation and business cycle fluctuations of real GDP. The weights of the filter are obtained by simply solving a linear system with $(p + f + 1) \times (c + 1)$ equations and unknowns. The solution depends only on the second moments of $(x_t, z_{1,t}, ..., z_{c,t})'$ and on the weights of the "ideal" filter (see appendix A for implementation details). We note that dropping the second term in the right hand side of (1) delivers the univariate approximation of Christiano and Fitzgerald (2003) and Wildi (1998)[3]. Additionally fixing $p = f$ delivers the Baxter and King (1999) approximation.

Remark 1 f is allowed to be negative, which is of particular interest if at time T (say, the current quarter) the series of interest x_t is not available. Thus, it is straightforward to extract the signal $y_{T+h} = B(L)x_{T+h}$ for $h > 0$. One just needs to set $f = -h$ in the solution, so that

[3]We should stress that Geweke (1978) and Pierce (1980) had shown that the best approximation to the signal of interest is obtained by applying the filter $B(L)$ to the series of interest, but with the particularity that this series is extended with optimal backcasts and forecasts (based on the available observations) when data points are not available.

only the available information (that is, up to period T in this case) is taken into consideration.

Remark 2 we should note that it would be feasible to project (with OLS) an accurate measure of y_t, obtained with the Baxter and King (1999) filter ($\widehat{y}_t = \sum_{j=-m}^{m} B_j x_{t-j}$), onto past money growth. That is, one could always extract (approximately) y_t up to $T - m$, project this onto variables dated $T - m - h$ and earlier (h is the forecast horizon) and then use at time T the estimated projection coefficients to forecast y_{T+h}. So long as m is not too large, few observations of the dependent variable are lost in the beginning and end of the sample. However, in our analysis a large m is needed because very low frequencies are to be kept (eliminated) if y_t denotes the low frequencies of inflation (respectively, business cycle fluctuations of output). This requires more observation of x_t being averaged out. We have nonetheless tried this simpler approach but results were not promising. In practical terms the main difference between this approach and a direct solution to problem (2) is that the latter considers (and requires for smaller filtering errors) a potentially large number of lags $(p - f)$ of x_t and of the covariates as part of the forecast[4]. In fact, for all empirical purposes we will set $p = 50$. An OLS type projection resembling this one requires a large number of lags of x_t and of the covariates, which leads to overfitting and poor out-of-sample behavior.

Remark 3 in the case of inflation forecasts, we should add that it would be feasible to construct a forecast combining a projection at low frequencies (with money growth as covariate) with an (orthogonal) projection at high frequencies, with measures of supply shocks as covariates. The improvements (if any) are slight and will not be analyzed in this paper.

3 Forecast results

3.1 Data and Pseudo-out-of-Sample design

We focus on forecasts of CPI and GDP inflation from 1989Q1 through 2008Q3 (reasons for the choice of this evaluation period will be discussed below). As already referred, the monetary

[4]And this requires only estimation of the autocovariance function of all the variables involved (or the spectrum) up to a sufficiently high order.

aggregates used in the forecasts are M2, M2- and MZM. For comparison purposes we will also use the activity variables considered more promising by Stock and Watson (1999, 2007): the unemployment rate (all, 16+, seasonally adjusted), the capacity utilization rate, housing starts, industrial production index, real disposable income, employees payrolls and the Chicago Fed national activity index (CFNAI). All (transformed) data are aggregated quarterly as 3-month averages, check the data appendix for all the details.

Subscript $|t$ on a variable denotes a forecast using information up to time t. We focus throughout the paper 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 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 with 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.

3.2 Competing forecasts

We consider forecasts obtained with the *Multivariate Filter* approximation to smooth inflation (i.e. inflation cleaned of fluctuation with period below the standard cut-off of 32 quarters, see section 3.4 for the analysis of different cut-offs), aimed at exploring the low-frequency relation between inflation and money growth. We consider as covariates (besides inflation itself) money growth, $\ln(M_t/M_{t-1})$, but also money growth adjusted for real GDP growth, $\ln(M_t/M_{t-1}) - \ln(y_t/y_{t-1})$, the change in the opportunity cost of holding the aggregates, $(R_t - R_{t-1})$, or a combination of these. We thus restrict the way money growth and real GDP growth enter the forecasts while not using any estimated long-run semi-elasticity of money demand with respect to R_t (i.e., $R_t - R_{t-1}$ is treated as just an additional covariate[5]). Corrections on money are

[5]Again, we have considered including $\ln(R_t) - \ln(R_{t-1})$ as the measure of opportunity cost change. Results are quantitatively similar to those reported with $R_t - R_{t-1}$.

typically employed in order to re-establish a stable demand for real balances (see e.g., Reynard 2007), but we explicitly avoid any measure that could not have been constructed in real-time (this also means we do not seek any long-run demand for the real money stock, as in Geralch and Svensson 2003 for the euro area). These forecasts will be confronted with those obtained with several alternative methods and models:

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

- Median forecasts from the Philadelphia *Survey of Professional Forecasters* (SPF). Results with the mean are similar and will not be reported.

- 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 (i.e., we model both inflation change and inflation). Again, besides money growth the chosen variables x_t are the unemployment rate (all, 16+, seasonally adjusted), capacity utilization rate, housing starts, industrial production index, real disposable income, employees payrolls and the CFNAI.

- Integrated moving average (*IMA*) forecasts for inflation, i.e., it is assumed that $\pi^1_t - \pi^1_{t-1} = \varepsilon_t - \theta\varepsilon_{t-1}$, where $\theta = 0.65$ as in Stock and Watson (2007) for the post 1984 period. Forecasts are obtained with the Kalman filter. The more general setting is an unobserved components model with time-varying variances, specifically $\pi_t = \tau_t + u_t$, where $\tau_t = \tau_{t-1} + \upsilon_t$ and $\upsilon_t \backsim N(0, \sigma^2_{\upsilon,t})$ and $u_t \backsim N(0, \sigma^2_{u,t})$. θ can be recovered from the ratio of these variances and seems stable for the post 1984 period in the U.S.. Stock and Watson use this model for GDP inflation but we extend the analysis to CPI inflation. It should be noted that these cannot be seen as real-time forecasts. This is useful for our purpose as it makes the method a tough competitor.

- In order to check wether results are driven by the method employed we also apply the *Multivariate Filter* approximation considering the activity indicators (with exactly the same filtering design used with money) as well as the *Univariate Filter* (i.e., using inflation only) approximation.

- Gordon's (1982) triangle model with a constant natural rate of unemployment $\pi_t^1 = \beta(L)\pi_{t-1} + \lambda(L)(u_t - u^*) + \gamma(L)z_t + \varepsilon_{t+h}$, 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_t^1. To produce forecasts using this model the right hand side variables are forecasted with an autoregression (AIC for lag length selection) while projection coefficients are estimated by OLS

3.3 Results

Table 1 summarizes the results for horizons $h = 1, 2, 4, 6, 8, 12$. It contains the ratio of the root mean square forecast error (RMSFE) of the forecasts from each method/model to the RMSFE of the AO forecasts. Below each relative RMSFE is the OLS estimate of the parameter λ from the following forecast combination regression:

$$\pi_t^4 = \alpha + \lambda f_t^{comp} + (1 - \lambda)\, f_t^{\mathrm{AO}} + e_t$$

where f_t^{comp} and f_t^{AO} denote the forecasts of π_t^4 from the competing model and AO, respectively. α controls for biases in the forecasts and e_t is a (most likely serially correlated) error term. The main conclusions regarding money-based forecasts follow:

- *Recursive* money based forecasts perform rather poorly at all horizons. The notable exception occurs with M2 growth when $h = 12$ in the case of GDP inflation. On the other hand, the use of the *Multivariate Filter* clearly boosts the performance of M2- and MZM based forecasts. This occurs in the case of CPI and GDP deflator inflation, for all horizons, with or without the corrections for GDP growth and with or without the inclusion of opportunity cost change. With a few exceptions, results are best when one considers MZM, adjusted for GDP growth but without inclusion of opportunity cost change. In general, once money is corrected for GDP growth it is no longer helpful to control for velocity changes using measures of opportunity cost change. In the case of M2 improvements occur mostly in the case of GDP inflation and are not as striking

- Survey forecasts (only available for $h \leq 4$ and CPI inflation) have a poor performance when $h = 1, 2$ but outperform marginally the best performing money based *Multivariate Filter* forecast when $h = 4$. In the case of CPI inflation we cannot conclude that money based forecasts are superior to those obtained with the *Univariate Filter* (only with MZM adjusted for real GDP growth do we find marginal improvements at $h = 2, 4$). In fact, the *Univariate Filter* is rather successful for both measures of inflation and all horizons, weakening the main result of the paper. Now, results for GDP deflator inflation (arguably the quantity theoretic relevant inflation measure), specially using MZM adjusted for real GDP growth should dissipate any doubts, cf. the relative RMSFE using money at $h = 1$ (**0.73**), $h = 2$ (**0.76**), $h = 4$ (**0.83**) , $h = 6$ (**0.79**) and $h = 8$ (**0.83**) with those obtained with the *Univariate Filter*, respectively **0.77**, **0.84**, **0.95**, **0.88** and **0.85**

Further results from Table 1 can be summarized as follows:

- *Recursive* activity based forecasts are hardly useful (even when beating the AO forecast, which occurs at $h = 1, 2$, they are beaten by the univariate autoregression). The exception occurs with housing starts when $h = 12$ and less so when $h = 8$. Gordon's triangle model and *IMA* forecasts also add little (if anything) to the benchmark when $h \geqslant 4$

- The use of the *Multivariate Filter* improves (vis-a-vis the *Recursive* method) the performance of forecasts based on employees payrolls, CFNAI and industrial production. On the other hand, it clearly improves forecasts based on capacity utilization (overall, the best predictor of CPI inflation, although far from competitive for GDP inflation) and on unemployment (at all horizons and for both measures of inflation, deserving further analysis below). We should notice that these series have little power at high frequencies, suggesting that our approximations can significantly reduce forecast errors in various contexts

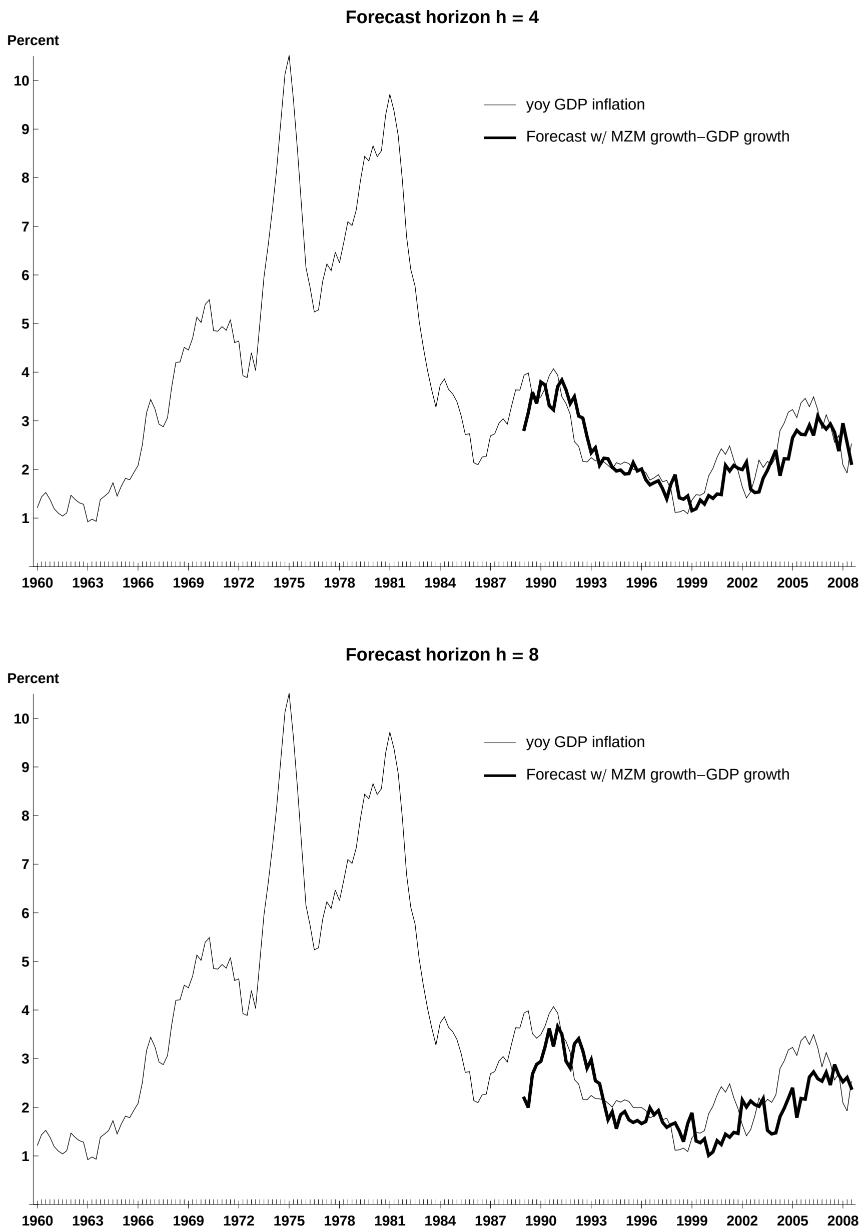
- Survey forecasts (for CPI inflation) prove hard to beat when $h = 4$, confirming results in Ang, Bekaert and Wei (2007)

- Most estimated λ's are large and statistically significant when using the *Multivariate Filter* (with money as well as with activity indicators as covariates). In the case of *Recursive* forecasts the estimated λ's are lower and more frequently significant when money is used. In general, they convey basically the same information as the relative RMSFE (being large when the ratio is well below 1)

Figure 4 presents the forecasts of GDP inflation using the *Multivariate Filter* with MZM growth - GDP growth as covariate when $h = 4$ and $h = 8$. The forecasts depict to a great extent the major movements in GDP inflation across the evaluation period, although for $h = 8$ the upward swings in 2001 and 2006/2007 (especially 2001) are missed. Additionally, figure 5 compares the differences between the accumulated squared forecast errors using AO (from 1989Q1 trough the date in the x-axis) and the accumulated squared forecast errors obtained with the *Multivariate Filter* approximations using MZM growth - GDP growth as well as unemployment as covariates (the target is again GDP inflation and $h = 4, 8$). A positive value indicates that the approximations outperform the AO benchmark in the period 1989Q1-date in the x-axis. Obviously, if this difference increases the forecast error for the period in the x-axis is lower than the corresponding AO forecast error. In all cases the difference becomes positive in the early 1990's , associated with significant forecast gains in the period 1991-1993, remaining so until the end of the sample. More importantly, only when adjusted (for output) money growth is used can we observe a clear positive trend, associated with relatively lower forecast errors in the period 1998-2008 for $h = 4$ (the exception occurs in 2005-2006) and in the period 2004-2008 for $h = 8$. In the case of unemployment the figures reveal an overall stagnation of the forecast gains after 1992.

Figure 4

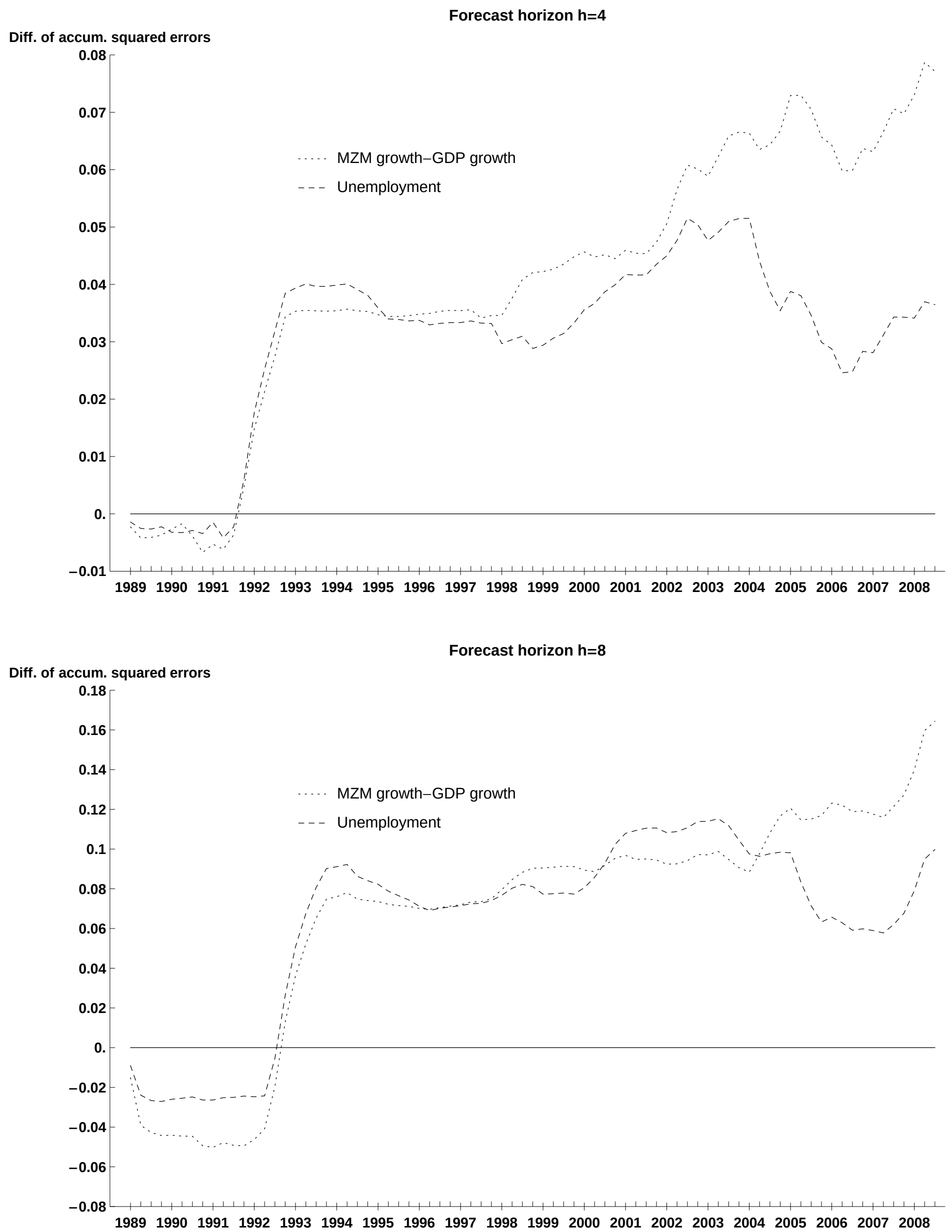
yoy GDP inflation forecasts using the *Multivariate Filter* approximation with MZM growth - GDP growth as covariate. Evaluation period: 1989Q1-2008Q3. Estimation sample starts in 1959Q1.



Putting it simply, in this pseudo out-of-sample forecasting exercise money growth is a privileged predictor of inflation. A few caveats must be pointed however: First, we rely on station-

Figure 5

Difference between the accumulated squared forecast errors using *AO* (from 1989Q1 trough the date in the $\mathcal{X}$-axis) and the accumulated squared forecast errors using the *Multivariate Filter* approximations with MZM growth - GDP growth as well as unemployment as covariates



arity of inflation and money growth. This is definitely conceivable for a sub-sample starting in the mid 1980's but unrealistic for the full post -1959 sample. Since the *Multivariate Filter* requires long lags of the predictors and estimation of 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. Second, we chose as evaluation period 1989Q1-2008Q3 since including forecasts for the period 1984-1988 would weaken substantially our results, although the basic distinctions between methods and variables would still apply. This is due to a clear failure of the long-run forecasts for the period 1984 -1988. Our sense is that we do not control "enough" for the violent decrease in velocity due to the decrease in the opportunity cost of holding money in the aftermath of Volcker's disinflation (see Goodfriend and King 2005 for a thorough analysis of this period). 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 sum of the squared forecast errors for those 4 observations is as large as the sum of the squared forecast errors of the last 20 years. However, it turned out that the smallest forecast errors (although reflecting a qualitatively useless forecast) were associated with *Multivariate Filter* approximations using money growth, which would magnify the results in table 1 and in figures 5 and 8 (in section 3.4 below).

As referred, results concerning *Multivariate Filter* forecasts using the unemployment rate deserve some attention as they seem to revive Phillips curve forecasts. We thus analyse estimates of coherence/phase between unemployment and inflation (GDP inflation here, results for CPI are similar). Now, figures 6 and 7 clearly reveal that the lead of unemployment with respect to inflation (a necessary condition for usefulness in forecasting, which was established in our pseudo out-of-sample exercise) is not a stable feature of the full 1959Q1-2009Q3 sample. The lag in the earlier part of the sample, evident in figure 7, translates into an estimated negative phase shift (compare with the clear lead in the post-1984 sample). In any case it is worth noticing the high coherence between inflation and unemployment at very low frequencies (admissible on theoretical grounds according to Friedman 1976 and, more recently, Berentsen et al. 2008).

It is time to refer that the analysis in this paper was repeated with euro area data, using the harmonized index of consumer prices (HICP) inflation and the "monetary" aggregate M3, which contains a much wider array of instruments (some with a loose connection with transactions motives) compared to MZM, M2- or even M2 in the U.S.. M3 did not prove a useful predictor of inflation in the evaluation period considered (2007Q1-2010Q1, definitely short in view of data and methodological constraints). We believe that the predictive power of monetary aggregates with respect to inflation may be hidden in euro area data (see Benati 2009 on reasons why this might occur in stable and low inflation environments) but crucially, the short available sample (post 1996) 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 for the period prior to 1996, but aggregation of series with different definitions is undesirable, and even more so in the presence of a clear regime shift. Still, 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 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 et al. 2006), seems a non-starter as it is contaminated by staff judgement. Comparing the results obtained for the U.S. with M2 (which includes several illiquid instruments) with those using MZM or M2- (which include 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.

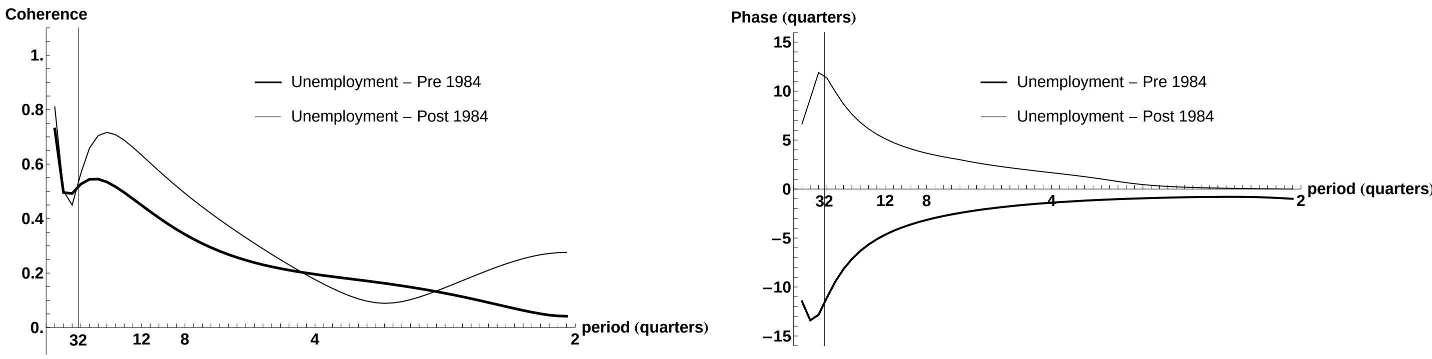


Figure 6

Estimated coherence and phase shift (in quarters) between U.S. unemployment and GDP inflation. A **positive** phase indicates that unemployment **leads** inflation. Estimation Sample: 1959Q1-1983Q4 (Pre 84) and 1984Q1-2009Q3 (Post 84). Estimation details are exactly as in figure 1.

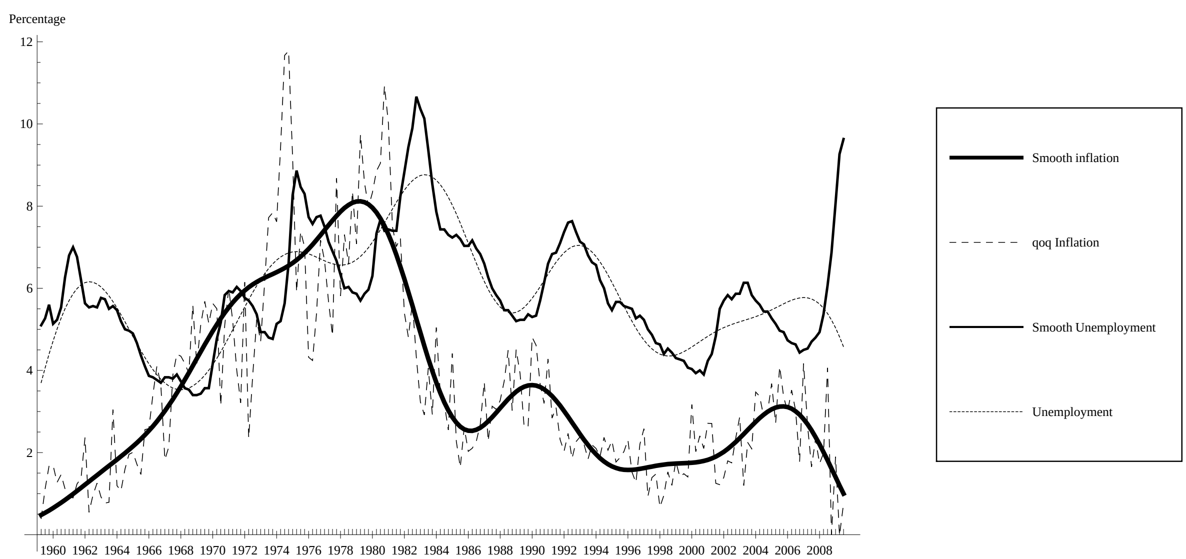


Figure 7

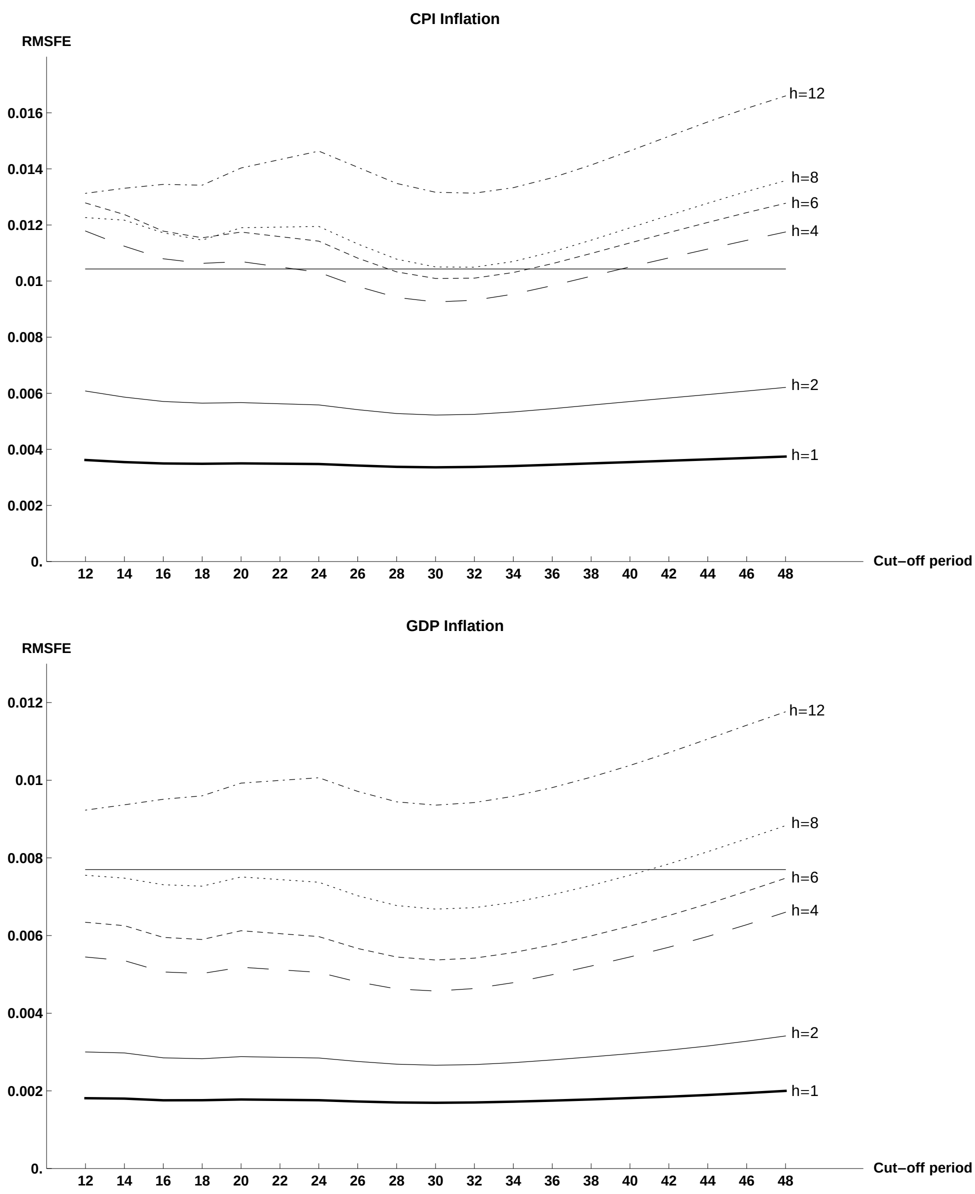
U.S. GDP deflator inflation, unemployment and filtered versions (cleaned of fluctuations with period below 32 quarters), quarterly series 1959Q1-2009Q3

3.4 Optimal Smoothing

So far we have approximated inflation short of fluctuations with period below the standard business cycle cut-off of 32 quarters. Here we check whether a different degree of smoothness would alter the results while confirming that restricting the fluctuations of inflation that are approximated has a relevant effect on the accuracy of the forecasts. Figure 8, containing for each h considered the RMSFE of *Multivariate Filter* forecasts (of CPI and GDP inflation) using MZM growth - GDP growth, shows that the standard cut-off of 32 quarters is close to optimal although in some instances the consideration of a cut-off of 28 or 30 quarters would boost somehow the performance of these money based inflation forecasts (although not much relative to other filter forecasts, since we have verified that forecasts obtained with the *Univariate filter* and with the *Multivariate filter* using unemployment and activity indicators have a very similar behavior). In contrast to evidence in Reichlin and Lenza (2007) for the euro area (who forecast in-sample moving averages of inflation), forecasting inflation by targeting longer moving averages of inflation as the horizon increases (increasing smoothness in our case) does not improve the forecast performance. Underway extensions of this exercise seem to indicate that the interesting patterns found here apply to macroeconomic forecasting more generally. We plan to explore the theoretical underpinnings of these results in future research.

Figure 8

RMSFE by cut-off period of *Multivariate Filter* inflation forecasts (of CPI and GDP inflation) with MZM growth -GDP growth as covariate. Straight lines are the standard deviation of inflation. Evaluation period 1989Q1-2008Q3



4 Forecasting Business cycle fluctuations using money

Obviously, as Brunner (1969) puts it "it is not money as such which drives up prices". Here we pursue the identification of the traditional output (spending) channel using monetary aggregates to forecast **real** GDP, but focusing on business cycle fluctuations of real GDP (specifically, fluctuations with period between 6 and 32 quarters in the log of real GDP). We could call these the output gap but we avoid that terminology because we find no clear mapping between these measures and the output gap in conventional models. It may be difficult to show that money has marginal predictive power over output, as the relation is blurred by uncorrelated fluctuations (crucially, the low frequencies in light of long-run monetary neutrality), but easier if we focus on business cycle fluctuations. It would be true that if (in theory) money forecasts any range of frequencies of GDP, then it forecasts GDP. Since business cycle fluctuations are not observed (but can be extracted with high precision in the middle of a given sample) our evaluation period covers the period 1989Q1-2008Q3 (this is enough to ensure that only negligible revisions occur in the "final"[6] estimates once additional data becomes available, see Valle e Azevedo 2010. Including the period 1984-1988 would not change the general picture). Results are summarized in table 2, containing the ratio of the RMSFE for the approximations to business cycle fluctuations at various horizons using money growth (with the variations considered in forecasts of inflation) to that of the *Univariate Filter* approximation. We also consider the activity variables analyzed before. Additionally, we compute the sign concordance for each approximation (i.e., the percentage of times the approximations and target share the same sign). This gives an indication on whether the approximations correctly indicate if GDP is below or above the long-run trend. The main conclusions follow:

- In terms of relative RMSFE (upper panel) neither monetary aggregates nor activity variables provide additional information regarding cyclical developments when compared to GDP itself

[6]These "final" estimates are obtained by approximating the signals using the whole sample (here using data through 2010Q1 and setting $f = T - t$ and $p = t - 1$ in the *Univariate filter* with moments derived from an autoregression, AIC for lag length) and then disregarding the last observations.

- As for sign concordance (bottom panel) results indicate that only when $h = 4, 6, 8$ do some approximations outperform the univariate approximation in indicating correctly wether GDP will be below or above the long-term trend. Interestingly, this occurs more clearly when using MZM growth adjusted for real GDP growth and/or including opportunity cost change

Clearly, this pseudo out-of-sample exercise shows that in this evaluation period the case for predictive ability of money with respect to business cycle fluctuations is weak. We have shown elsewhere (Valle e Azevedo and Pereira 2008) that in the post -1984 period it has become very difficult to outperform the univariate approximation, even resorting to large panels of time series reduced by estimation of common factors. Nonetheless, in-sample evidence reveals a moderate correlation between business cycle fluctuations of money (M_t^{BC}) and those of output (y_t^{BC}) with a clear lead of money. Figure 9 plots these series (with MZM measuring money)[7] and figure 10 the corresponding cross-correlogram ($Correlation[y_t^{BC}, M_{t-lag}^{BC}]$). The lead of money is evident in figure 9 and seems to increase after the early 1980's, in such a degree that movements seem countercyclical[8]. This translates into figure 10, where the Post-1984 chart looks a shift to the right of the Pre-1984 chart (with lower correlations as well). Estimates of coherence and phase shift between money growth and output growth at business cycle frequencies for the Pre-1984 and Post-1984 samples (unreported) convey a similar message.

[7] These series are obtained with the univariate filter isolating the $[6, 32]$ periods band using the full sample (1959Q1-2009Q3) and moments derived from an autoregression. The last observations will suffer revisions once more data becomes available. Except for these observations, the filter does not induce phase shift as it becomes symmetric towards the middle of the sample.

[8] A lead equal to half cycle can be confounded with a negative correlation and lag of half cycle. The nature of causation must obviously be dealt with theoretically (Friedman 1961 deals with earlier quibbles on this issue. Here we avoid stretching unreasonably those arguments).

Figure 9

Extracted business cycle fluctuations of output and MZM growth (Percentage deviation from trend). 1959Q1-2009Q3

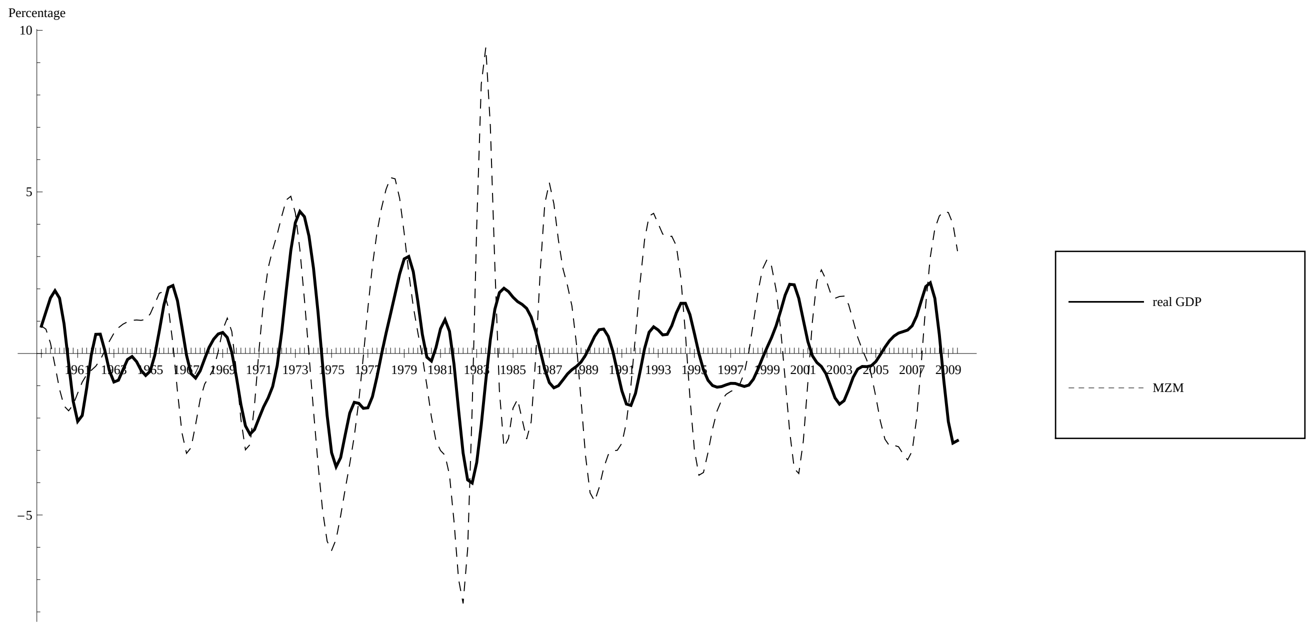
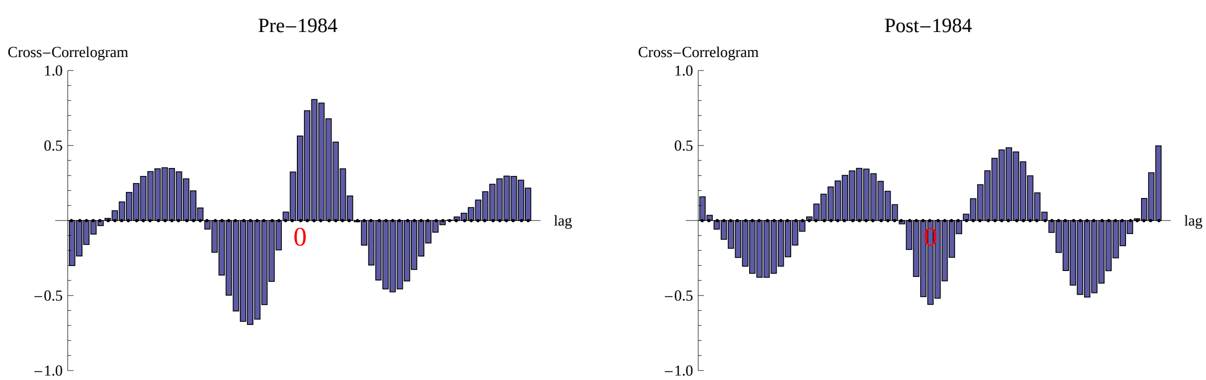


Figure 10

Pre and Post-1984 Cross-correlogram between business cycle fluctuations of output and MZM, $Correlation[y_t^{BC}, M_{t-lag}^{BC}]$



5 Discussion

Here we contrast the results above with the implications of representative models, to highlight how theory seems at odds with forecastability of inflation given money growth. We start with New-Keynesian models, where money is regularly absent (for a seminal example see Rotemberg and Woodford 1997) or it is considered 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:

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

π^* is the inflation target, $\varphi_\pi > 1$ (Taylor principle) and $\varphi_y \geq 0$. Append to these equations the following money demand function, rationalized by considering a utility function with time-separability as well as separability across consumption and (necessarily included) real money balances:

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

$m_t - p_t$ 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:

$$E[\pi_t - \pi^*] = 0 \tag{3}$$
$$E[\ln(Y_t/Y_t^*)] = 0$$
$$R^* = E[R_t] = E[r_t^*] + \pi^*$$

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 stated in Woodford (2007, 2008) 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 means that in the long-run, when prices are flexible, the central bank is able to control the nominal interest rate with open market operations. Regardless of the reasonableness of the arguments, the matter of fact is that once the output gap ($\ln(Y_t/Y_t^*)$) and current inflation are taken into account, money growth receives zero weight in forecasts of inflation. Now, relaxing separability between consumption and real money balances does open a direct channel from money to aggregate demand, implying that money helps forecasting inflation through it's relation with the output gap. However, reasonable calibrations and econometric estimates imply a very modest role to this channel (see, e.g., McCallum 2000, Ireland 2004 or Andrés et al 2006 using euro area data). The informational role of money within models that consider only one interest rate can be restored by allowing for portfolio (of real money balances) adjustment costs, see Andrés et al. (2009). In this environment, money demand responds not only to the current nominal interest rate but also to expected future interest rates (and output), thus conveying information on the determinants of future aggregate demand. In any case, the role for money may be understated if the demand for real money balances responds to a much wider spectrum of interest rates or, similarly, if monetary policy affects the prices of a wider range of assets. If this is the case the effects of monetary policy actions can perhaps be summarized by information in monetary aggregates (see Nelson 2003 for an example where money serves this purpose and Meltzer 2001 for a review of the role for money stressed by the monetarist literature).

If within New-Keynesian modelling money struggles to enter the stage (in the sense of being a useful indicator of monetary policy stance or of **medium to long-run** price developments), considering flexible prices will likely complicate matters[9]. Consider the following simple model with flexible prices, taken from Marcet and Nicolini (2009). It can be seen as an extreme interpretation of the quantity theory, although no monetarist would endorse it (as it lacks the slightest break of monetary neutrality). Households maximize utility given by $E_0 \sum_{t=0}^{\infty} \beta^t U(C_t^1, C_t^2)$, with $U = min\{(1 - v_t^{-1})C_t^1, v_t^{-1}C_t^2\}$, where C_t^1 is a cash good and C_t^2 a credit good. v_t is a white-noise 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 white-noise 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 $\pi_{t+1} = \ln(P_{t+1}/P_t)$. Even without specifying how μ_t is set, one can conclude that $E_t[\pi_{t+1}] = E[\pi_{t+1}|\pi_t, \pi_{t-1,...,}\xi_t, \xi_{t-1}, ...]$,

[9] In Lucas's (1972) islands model and variants the forecast of the change in the aggregate price level, $E_t[P_{t+1} - P_t]$, equals $a\varsigma_t$ $(a < 1)$, where ς_t is the unanticipated (and thus serially uncorrelated) change in money supply, M_t, where $M_t = M_{t-1} + \mu + \varsigma_t$. Hence, the change in money supply leads the change in the price level, but only by one period (the "memory" of the unanticipated shock ς_t). The argument generalizes with serial correlation in $\{M_t - M_{t-1}\}$.

i.e., knowledge of the history of (π_t, ξ_t) suffices to forecast π_{t+1} without loss of information (observations on past money growth are redundant given the history of (π_t, ξ_t)). Consider the special case where 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 because to stabilize inflation the central bank offsets the effects of velocity and productivity shocks. The arguments go through in more general environments (crucially, with interest elastic money demand). The bottom line is that while long averages of π_t and μ_t will move one-to-one, μ_t does not forecast inflation.

6 Conclusions

We have shown how to usefully integrate money in forecasts of U.S. inflation. This amounts to projecting only the low frequencies of inflation onto 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 U.S.. Additionally though, we have found that money growth adds little (if anything) to forecasts of business cycle fluctuations of real GDP, meaning that it is not clear a short-run break of monetary neutrality over the past 20 years. These results were contrasted with a common feature of most theoretical models: money growth is surely correlated with inflation (at least in the long-run), but it adds nothing to inflation forecasts.

Appendix A: Estimation of filter weights

The solution to (2) depends only on the second moments of $(\Delta x_t, z_{1,t}, ..., z_{c,t})'$ (that need to be estimated, see below) and on the weights of the ideal filter. Define $\widehat{B} = (\widehat{B}_p^{p,f}, \widehat{B}_{p-1}^{p,f}, ..., \widehat{B}_0^{p,f}, ..., \widehat{B}_{-f+1}^{p,f}, \widehat{B}_{-f}^{p,f})'$ and $\widehat{R}_s = (\widehat{R}_{s,p}^{p,f}, \widehat{R}_{s,p-1}^{p,f}, ..., \widehat{R}_{s,0}^{p,f}, ..., \widehat{R}_{s,-f+1}^{p,f}, \widehat{R}_{s,-f}^{p,f})'$, where $s = 1, ..., c$. Stack these vectors in the vector of weights $\widehat{W} = (\widehat{B}', \widehat{R}_1', ..., \widehat{R}_c')'$. The linear system solved to recover the solution $\widehat{W}$ is the following:

$$V = Q\widehat{W} \tag{4}$$

where Q is a $(p+f+1) \times (p+f+1)$ matrix that depends only on the second moments of the vector $(\Delta x_t, z_{1,t}, ..., z_{c,t})$ and V is a vector of dimension $p+f+1$ that depends also on the second moments of the vector $(\Delta x_t, z_{1,t}, ..., z_{c,t})$ as well as on the weights of the infinite sample filter $(B(L))$. Specific adaptations need to be made in V and Q when we approximate business cycle fluctuation of real GDP. This occurs because we impose the restriction $\widehat{B}(1) = \sum_{j=-f}^{p} \widehat{B}_j^{p,f} = 0$ that guarantees the removal of one unit-root in (log of) real GDP. The exact expressions for V and Q can be found in Valle e Azevedo (2010).

In this paper we will always set $p = 50$ (larger values of p lead to negligible differences in the approximations) and $f = -h$ (h is the forecast horizon). We estimate the needed autocovariance function (or spectrum) of vector $(\Delta x_t, z_{1,t}, ..., z_{c,t})$ based on a standard non-parametric estimator of the spectrum, given by:

$$\widehat{S}_{\Delta x, z_1, ..., z_n}(\omega) = \frac{1}{2\pi}(\widehat{\Gamma}(0) + \sum_{k=1}^{M(T)} \kappa(k)(\widehat{\Gamma}(k)e^{i\omega k} + \widehat{\Gamma}(k)'e^{-i\omega k}))$$

where $\kappa(k,T) = (1 - \dfrac{k}{M(T)+1})$ denotes the Bartlett lag window, $\widehat{\Gamma}(k)$, $k = 0, 1, ..., M(T)$ is the sample autocovariance of vector $(\Delta x_t, z_{1,t}, ..., z_{c,t})$ at lag k and the truncation point $M(T) < T$ is a function of the sample size T. $M(T)$ is typically required to grow slower than T to guarantee consistency of $\widehat{S}_{\Delta x, z_1, ..., z_n}(\omega)$. For all empirical purposes we set in this estimator $M = 30$ in all the exercises (in the range $20 < M < 40$ results are very similar). The univariate filter obtains by not considering covariates $(z_{1,t}, ..., z_{c,t})$. In some instances (referred in the text) we use second moments obtained from an autoregression (lag length chosen by AIC).

Appendix B: Data

All series were downloaded from the FRED database (Federal Reserve Bank of St. Louis) except the Chicago Fed National Activity Index (CFNAI), which was downloaded from the Federal Reserve Bank of Chicago. Since focus is on quarterly inflation, monthly data is converted to quarterly (as 3-months averages) before any transformation ensuring stationarity.

The following table shows the definition of all series, FRED's id code (except for CFNAI), applied transformation and observation range.

Definition	**Transf.**	**FRED code**	**Obs. range**
Consumer Price Index: All Items	(1-L)ln	CPIAUCSL	1959:01-2009:09
Gross Domestic Product Deflator	(1-L)ln	GDPDEF	1959:Q1-2009:Q3
M2 Minus	(1-L)ln	M2MSL	1959:01-2009:09
M2 Minus Own Rate	level	M2MOWN	1959:01-2009:09
MZM Money Stock	(1-L)ln	MZMSL	1959:01-2009:09
MZM Own Rate	level	MZMOWN	1974:01-2009:09
M2 Money Stock	(1-L)ln	M2SL	1959:01-2009:09
M2 Own Rate	level	M2OWN	1959:04-2009:09
Industrial Production Index	(1-L)ln	INDPRO	1959:01-2009:09
Capacity Utilization: Manufacturing (NAICS)	level	CUMFN	1972:Q1-2009:Q3
Civilian Unemployment Rate	level	UNRATE	1959:01-2009:09
Housing Starts	ln	HOUST2F	1963:08-2009:09
Real Disposable Personal Income	(1-L)ln	DPIC96	1959:Q1-2009:Q3
Total Nonfarm Payrolls: All Employees	(1-L)ln	PAYEMS	1959:01-2009:09
Chicago Fed National Activity Index (CFNAI)	$(1\text{-L})^{-1}$		1967:03-2009:09
Real Gross Domestic Product	(1-L)ln	GDPC1	1959:Q1-2010:Q1
Spot Oil Price: West Texas Intermediate	(1-L)ln	OILPRICE	1959:01-2009:09
3-Month Treasury Bill: Secondary Market Rate	level	TB3MS	1959:01-2009:09

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Table 1 - Simulated Pseudo Out-of-Sample Forecasting Results

Forecast 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)	Rel. RMSFE	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	Rel. RMSFE	2.20	3.98	1.55	2.68	1.06	1.74	1.02	1.47	0.97	1.26	0.85	1.09
		(0.09)	*(0.04)*	*(0.21*)*	*(0.09)*	*(0.55*)*	*(0.23*)*	*(0.6*)*	*(0.35*)*	*(0.69*)*	*(0.51*)*	*(0.95*)*	*(0.83*)*
IMA θ=0,65	Rel. RMSFE	0.70	0.77	0.77	0.84	0.95	0.99	0.98	0.98	0.95	0.97	0.97	0.97
		(1.29)*	*(0.99*)*	*(1.17*)*	*(0.89*)*	*(1.47*)*	*(0.68*)*	*(0.93*)*	*(0.89)*	*(1.48*)*	*(1.4*)*	*(1.31*)*	*(1.97*)*
SPF Median	Rel. RMSFE	1.31		1.06		0.83							
		(0.39)*		*(0.45*)*		*(0.85*)*							
Forecasts with Filter													
Univariate	Rel. RMSFE	0.68	0.77	0.74	0.84	0.88	0.95	0.89	0.88	**0.84**	0.85	0.91	0.92
		(1.23)*	*(0.96*)*	*(1.15*)*	*(0.82*)*	*(1.19*)*	*(0.75*)*	*(1.24*)*	*(1.31*)*	*(1.42*)*	*(1.69*)*	*(1.36*)*	*(1.72*)*
M2(-) growth	Rel. RMSFE	0.70	0.76	0.77	0.81	0.93	0.90	0.96	0.83	0.91	**0.81**	0.95	0.91
		(1.16)*	*(0.94*)*	*(1.03*)*	*(0.84*)*	*(0.84*)*	*(0.85*)*	*(0.8*)*	*(1.2*)*	*(0.96*)*	*(1.37*)*	*(1.04*)*	*(1.34*)*
M2(-) growth-GDP growth	Rel. RMSFE	0.68	0.73	0.73	0.77	0.87	0.84	0.89	0.80	0.85	0.83	0.92	0.95
		(1.22)*	*(1.03*)*	*(1.14*)*	*(0.97*)*	*(1.23*)*	*(1.39*)*	*(1.13*)*	*(1.73*)*	*(1.26*)*	*(1.69*)*	*(1.17*)*	*(1.41*)*
M2(-) growth & opp cost	Rel. RMSFE	0.71	0.75	0.77	0.79	0.94	0.89	0.97	0.85	0.92	0.86	0.96	0.98
		(1.17)*	*(0.95*)*	*(1.04*)*	*(0.87*)*	*(0.92*)*	*(1.01*)*	*(0.86*)*	*(1.35*)*	*(1.08*)*	*(1.54*)*	*(1.21*)*	*(1.48*)*
M2(-) growth-GDP growth & opp cost	Rel. RMSFE	0.70	0.77	0.77	0.83	0.95	0.99	1.00	0.99	0.97	1.02	1.01	1.12
		(1.22)*	*(1*)*	*(1.11*)*	*(0.9*)*	*(1.11*)*	*(0.97*)*	*(0.98*)*	*(1.26*)*	*(1.26*)*	*(1.39*)*	*(1.42*)*	*(1.5*)*
MZM growth	Rel. RMSFE	0.70	0.76	0.77	0.82	0.94	0.92	0.97	0.84	0.93	0.82	0.96	0.91
		(1.16)*	*(0.93*)*	*(1.03*)*	*(0.82*)*	*(0.83*)*	*(0.79*)*	*(0.78*)*	*(1.12*)*	*(0.93*)*	*(1.3*)*	*(1.01*)*	*(1.3*)*
MZM growth-GDP growth	Rel. RMSFE	0.68	**0.73**	0.73	**0.76**	0.86	**0.83**	0.89	**0.79**	0.86	0.83	0.93	0.96
		(1.22)*	*(1.02*)*	*(1.15*)*	*(0.96*)*	*(1.28*)*	*(1.39*)*	*(1.17*)*	*(1.69*)*	*(1.26*)*	*(1.64*)*	*(1.17*)*	*(1.36*)*
MZM growth & opp cost	Rel. RMSFE	0.70	0.76	0.77	0.81	0.93	0.92	0.97	0.89	0.93	0.90	0.98	1.02
		(1.19)*	*(0.98*)*	*(1.1*)*	*(0.9*)*	*(1.06*)*	*(1.06*)*	*(1*)*	*(1.47*)*	*(1.24*)*	*(1.68*)*	*(1.33*)*	*(1.54*)*
MZM growth-GDP growth & opp cost	Rel. RMSFE	0.70	0.78	0.77	0.85	0.95	1.03	1.01	1.04	0.99	1.08	1.05	1.20
		(1.24)*	*(1*)*	*(1.16*)*	*(0.91*)*	*(1.3*)*	*(0.95*)*	*(1.15*)*	*(1.14*)*	*(1.41*)*	*(1.17*)*	*(1.49*)*	*(1.16*)*
M2 growth	Rel. RMSFE	0.78	0.89	0.92	1.04	1.19	1.32	1.27	1.28	1.29	1.23	1.30	1.22
		(0.99)*	*(0.73*)*	*(0.78*)*	*(0.56*)*	*(0.48*)*	*(0.38*)*	*(0.46*)*	*(0.48*)*	*(0.51*)*	*(0.57*)*	*(0.61*)*	*(0.69*)*
M2 growth-GDP growth	Rel. RMSFE	0.72	0.78	0.81	0.84	1.00	0.96	1.04	0.87	1.02	0.83	1.06	0.90
		(1.1)*	*(0.89*)*	*(0.92*)*	*(0.76*)*	*(0.66*)*	*(0.67*)*	*(0.64*)*	*(0.88*)*	*(0.7*)*	*(1*)*	*(0.76*)*	*(1.05*)*
M2 growth & opp cost	Rel. RMSFE	0.79	0.87	0.92	1.01	1.19	1.26	1.26	1.24	1.28	1.21	1.30	1.25
		(1.01)*	*(0.78*)*	*(0.81*)*	*(0.63*)*	*(0.51*)*	*(0.46*)*	*(0.5*)*	*(0.55*)*	*(0.55*)*	*(0.62*)*	*(0.65*)*	*(0.7*)*
M2 growth-GDP growth & opp cost	Rel. RMSFE	0.74	0.78	0.83	0.84	1.02	0.97	1.05	0.89	1.01	0.87	1.07	0.97
		(1.12)*	*(0.91*)*	*(0.94*)*	*(0.8*)*	*(0.7*)*	*(0.73*)*	*(0.69*)*	*(0.96*)*	*(0.78*)*	*(1.1*)*	*(0.81*)*	*(1.1*)*
Industrial Production	Rel. RMSFE	0.68	0.79	0.73	0.87	0.87	1.03	0.90	1.01	0.87	1.03	0.96	1.14
		(1.25)*	*(0.94*)*	*(1.19*)*	*(0.8*)*	*(1.29*)*	*(0.58*)*	*(1.23*)*	*(0.74)*	*(1.35*)*	*(0.82*)*	*(1.29*)*	*(0.77)*
Capacity Utilization	Rel. RMSFE	**0.66**	0.79	**0.69**	0.86	**0.81**	1.04	**0.86**	1.08	0.86	1.14	0.97	1.33
		(1.26)*	*(0.96*)*	*(1.26*)*	*(0.85*)*	*(1.59*)*	*(0.77*)*	*(1.52*)*	*(0.93*)*	*(1.57*)*	*(0.97*)*	*(1.37*)*	*(0.93*)*

Table 1 - Simulated Pseudo Out-of-Sample Forecasting Results (cont.)

Forecast 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
Unemployment	Rel. RMSFE	0.67	0.76	0.73	0.82	0.86	0.92	0.88	0.88	0.84	0.90	0.96	1.04
		(1.25)*	*(0.98*)*	*(1.19*)*	*(0.86*)*	*(1.39*)*	*(0.86*)*	*(1.36*)*	*(1.11*)*	*(1.51*)*	*(1.15*)*	*(1.27*)*	*(0.93*)*
Housing Starts	Rel. RMSFE	0.74	0.88	0.85	1.01	1.04	1.27	1.09	1.26	1.06	1.22	1.13	1.29
		(1.18)*	*(0.88*)*	*(1.04*)*	*(0.74*)*	*(0.88*)*	*(0.52*)*	*(0.87*)*	*(0.64*)*	*(0.98*)*	*(0.82*)*	*(1.05*)*	*(0.91*)*
Real Disposable Income	Rel. RMSFE	0.71	0.86	0.81	1.01	1.01	1.28	1.09	1.28	1.11	1.30	1.19	1.34
		(1.18)*	*(0.83*)*	*(1.04*)*	*(0.61*)*	*(0.76*)*	*(0.26)*	*(0.64*)*	*(0.36)*	*(0.69*)*	*(0.44)*	*(0.76*)*	*(0.6*)*
Employees Payrolls	Rel. RMSFE	0.68	0.79	0.73	0.87	0.89	1.06	0.95	1.06	0.95	1.09	1.06	1.21
		(1.27)*	*(0.98*)*	*(1.23*)*	*(0.83*)*	*(1.42*)*	*(0.62)*	*(1.2*)*	*(0.68)*	*(1.21*)*	*(0.67)*	*(1.06*)*	*(0.6)*
Chicago Fed National Activity Index	Rel. RMSFE	0.68	0.78	0.75	0.85	0.91	1.03	0.97	1.07	0.99	1.13	1.16	1.36
		(1.26)*	*(0.97*)*	*(1.22*)*	*(0.87*)*	*(1.21*)*	*(0.73*)*	*(1.14*)*	*(0.9)*	*(1.23*)*	*(1)*	*(1.17*)*	*(0.88)*
Recursive Forecasts													
Univariate	Rel. RMSFE	0.70	0.81	0.80	0.92	1.07	1.14	1.16	1.23	1.18	1.32	1.24	1.44
		(0.9)*	*(0.9*)*	*(0.89*)*	*(0.73*)*	*(0.42)*	*(0.53*)*	*(0.44*)*	*(0.7*)*	*(0.89*)*	*(0.84*)*	*(1.32*)*	*(1.09*)*
M2(minus) growth	Rel. RMSFE	0.72	0.82	0.82	0.94	1.09	1.16	1.18	1.26	1.18	1.32	1.21	1.44
		(0.87)*	*(0.89*)*	*(0.82*)*	*(0.71*)*	*(0.33)*	*(0.5*)*	*(0.3)*	*(0.67*)*	*(0.67*)*	*(0.88*)*	*(1.11*)*	*(1.04*)*
M2(minus) growth-GDP growth	Rel. RMSFE	0.71	0.81	0.81	0.92	1.08	1.14	1.16	1.26	1.18	1.35	1.24	1.47
		(0.9)*	*(0.9*)*	*(0.88*)*	*(0.72*)*	*(0.39)*	*(0.53*)*	*(0.45*)*	*(0.63*)*	*(0.89*)*	*(0.71*)*	*(1.3*)*	*(0.82)*
M2(minus) growth & opp cost	Rel. RMSFE	0.70	0.84	0.79	0.96	1.04	1.22	1.16	1.33	1.16	1.35	1.25	1.45
		(1.01)*	*(0.82*)*	*(0.86*)*	*(0.66*)*	*(0.57*)*	*(0.52*)*	*(0.49*)*	*(0.62*)*	*(0.79*)*	*(0.82*)*	*(0.93*)*	*(0.98*)*
M2(minus) growth-GDP growth & opp cost	Rel. RMSFE	0.70	0.84	0.82	0.99	1.09	1.26	1.20	1.38	1.19	1.40	1.22	1.47
		(1.03)*	*(0.8*)*	*(0.86*)*	*(0.63*)*	*(0.49*)*	*(0.43)*	*(0.47*)*	*(0.52*)*	*(0.86*)*	*(0.67*)*	*(0.93*)*	*(0.66)*
MZM growth	Rel. RMSFE	0.72	0.81	0.82	0.92	1.10	1.14	1.19	1.25	1.19	1.33	1.23	1.45
		(0.87)*	*(0.89*)*	*(0.83*)*	*(0.72*)*	*(0.29)*	*(0.55*)*	*(0.3)*	*(0.69*)*	*(0.71*)*	*(0.84*)*	*(1.15*)*	*(1.03*)*
MZM growth-GDP growth	Rel. RMSFE	0.71	0.81	0.81	0.91	1.08	1.11	1.16	1.23	1.18	1.33	1.25	1.47
		(0.9)*	*(0.89*)*	*(0.89*)*	*(0.72*)*	*(0.39)*	*(0.59*)*	*(0.46*)*	*(0.67*)*	*(0.91*)*	*(0.72*)*	*(1.3*)*	*(0.73)*
MZM growth & opp cost	Rel. RMSFE	0.70	0.83	0.79	0.97	1.07	1.26	1.19	1.36	1.19	1.37	1.26	1.46
		(1.04)*	*(0.83*)*	*(0.91*)*	*(0.68*)*	*(0.52*)*	*(0.49)*	*(0.44)*	*(0.59*)*	*(0.78*)*	*(0.79*)*	*(1.01*)*	*(1.01*)*
MZM growth-GDP growth & opp cost	Rel. RMSFE	0.70	0.83	0.82	0.98	1.10	1.26	1.20	1.37	1.20	1.39	1.18	1.47
		(1.05)*	*(0.84*)*	*(0.88*)*	*(0.66*)*	*(0.48*)*	*(0.46)*	*(0.48*)*	*(0.54*)*	*(0.88*)*	*(0.69*)*	*(0.97*)*	*(0.53)*
M2 growth	Rel. RMSFE	0.73	0.81	0.85	0.91	1.18	1.02	1.33	1.04	1.36	1.04	1.06	**0.88**
		(0.82)*	*(0.87*)*	*(0.7*)*	*(0.71*)*	*(0.26)*	*(0.51*)*	*(0.24*)*	*(0.47*)*	*(0.31*)*	*(0.47*)*	*(0.46*)*	*(0.58*)*
M2 growth-GDP growth	Rel. RMSFE	0.70	0.82	0.80	0.93	1.06	1.18	1.15	1.29	1.10	1.32	1.08	1.39
		(0.91)*	*(0.89*)*	*(0.89*)*	*(0.71*)*	*(0.44*)*	*(0.46*)*	*(0.39*)*	*(0.62*)*	*(0.59*)*	*(0.95*)*	*(0.82*)*	*(1.21*)*
M2 growth & opp cost	Rel. RMSFE	0.74	0.85	0.87	0.94	1.14	1.13	1.19	1.17	1.25	1.04	1.08	0.88
		(0.88)*	*(0.75*)*	*(0.67*)*	*(0.59*)*	*(0.3*)*	*(0.4*)*	*(0.33*)*	*(0.38*)*	*(0.36*)*	*(0.47*)*	*(0.45*)*	*(0.58*)*
M2 growth-GDP growth & opp cost	Rel. RMSFE	0.72	0.85	0.85	1.00	1.08	1.24	1.10	1.27	1.03	1.25	1.06	1.38
		(0.97)*	*(0.76*)*	*(0.77*)*	*(0.58*)*	*(0.41*)*	*(0.44*)*	*(0.47*)*	*(0.56*)*	*(0.66*)*	*(0.99*)*	*(0.82*)*	*(1.22*)*
Industrial Production	Rel. RMSFE	0.74	0.82	0.83	0.91	1.08	1.13	1.13	1.23	1.14	1.30	1.15	1.40
		(0.93)*	*(0.82*)*	*(0.78*)*	*(0.63*)*	*(0.33)*	*(0.31)*	*(0.34)*	*(0.26)*	*(0.62*)*	*(0.2)*	*(0.9*)*	*(0.15)*
Capacity Utilization	Rel. RMSFE	0.76	1.00	0.93	1.26	1.33	1.74	1.53	1.95	1.60	1.97	1.78	1.81
		(0.84)*	*(0.51*)*	*(0.62*)*	*(0.27*)*	*(0.2)*	*(0.04)*	*(0.14)*	*(0.02)*	*(0.27*)*	*(-0.07)*	*(0.39*)*	*(-0.02)*

Table 1 - Simulated Pseudo Out-of-Sample Forecasting Results (cont.)

Forecast 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**
Unemployment	Rel. RMSFE	0.70	0.83	0.81	0.95	1.06	1.23	1.16	1.35	1.17	1.40	1.23	1.46
		(0.98)*	*(0.8*)*	*(0.77*)*	*(0.63*)*	*(0.46*)*	*(0.36)*	*(0.44)*	*(0.36)*	*(0.76*)*	*(0.4)*	*(1.09*)*	*(0.39)*
Housing Starts	Rel. RMSFE	0.73	0.80	0.85	0.90	1.11	1.03	1.13	1.04	0.93	0.96	**0.78**	1.01
		(0.83)*	*(0.88*)*	*(0.79*)*	*(0.67*)*	*(0.44*)*	*(0.52*)*	*(0.45*)*	*(0.53*)*	*(0.62*)*	*(0.58*)*	*(0.82*)*	*(0.56*)*
Real Disposable Income	Rel. RMSFE	0.72	0.83	0.81	0.91	1.06	1.09	1.10	1.16	1.08	1.13	1.19	1.26
		(0.88)*	*(0.82*)*	*(0.81*)*	*(0.69*)*	*(0.37*)*	*(0.38)*	*(0.38*)*	*(0.31)*	*(0.61*)*	*(0.4*)*	*(1.01*)*	*(0.53)*
Employees Payrolls	Rel. RMSFE	0.72	0.84	0.80	0.94	1.02	1.18	1.08	1.30	1.06	1.38	1.13	1.37
		(0.94)*	*(0.78*)*	*(0.8*)*	*(0.57*)*	*(0.46*)*	*(0.28)*	*(0.39)*	*(0.21)*	*(0.52*)*	*(0.11)*	*(0.56)*	*(0.12)*
Chicago Fed National Activity Index	Rel. RMSFE	0.75	0.84	0.84	0.94	1.13	1.19	1.23	1.27	1.19	1.29	1.10	1.40
		(0.86)*	*(0.72*)*	*(0.68*)*	*(0.56*)*	*(0.33*)*	*(0.32)*	*(0.3*)*	*(0.29)*	*(0.43*)*	*(0.25)*	*(0.49*)*	*(0.06)*
Inflation Change, Industrial Production	Rel. RMSFE	0.73	0.82	0.83	0.93	1.08	1.13	1.17	1.22	1.13	1.29	1.12	1.39
		(0.91)*	*(0.81*)*	*(0.77*)*	*(0.61*)*	*(0.34)*	*(0.34)*	*(0.28)*	*(0.35)*	*(0.53*)*	*(0.34)*	*(0.77*)*	*(0.3)*
Inflation Change,Capacity Utilization	Rel. RMSFE	0.75	0.99	0.89	1.25	1.24	1.74	1.44	1.83	1.43	1.66	1.26	1.49
		(0.86)*	*(0.51*)*	*(0.66*)*	*(0.27*)*	*(0.24)*	*(0.04)*	*(0.15)*	*(0.05)*	*(0.29*)*	*(0.04)*	*(0.42*)*	*(-0.08)*
Inflation Change, Unemployment	Rel. RMSFE	0.70	0.83	0.79	0.96	1.07	1.27	1.24	1.39	1.24	1.42	1.31	1.50
		(0.99)*	*(0.79*)*	*(0.78*)*	*(0.61*)*	*(0.46*)*	*(0.32)*	*(0.32)*	*(0.32)*	*(0.52*)*	*(0.33)*	*(0.54*)*	*(0.21)*
Inflation Change, Housing Starts	Rel. RMSFE	0.73	0.80	0.86	0.91	1.15	1.06	1.24	1.08	1.05	1.06	1.02	1.36
		(0.83)*	*(0.88*)*	*(0.72*)*	*(0.66*)*	*(0.35*)*	*(0.44*)*	*(0.3*)*	*(0.43*)*	*(0.46*)*	*(0.43*)*	*(0.57*)*	*(0.27)*
Inflation Change, Real Disposable Income	Rel. RMSFE	0.72	0.84	0.81	0.97	1.09	1.16	1.17	1.24	1.11	1.32	1.16	1.38
		(0.88)*	*(0.81*)*	*(0.79*)*	*(0.59*)*	*(0.34*)*	*(0.34*)*	*(0.32*)*	*(0.38*)*	*(0.51*)*	*(0.29)*	*(0.63*)*	*(0.55*)*
Inflation Change, Employees Payrolls	Rel. RMSFE	0.72	0.83	0.82	0.95	1.06	1.14	1.12	1.21	1.08	1.29	1.08	1.37
		(0.94)*	*(0.78*)*	*(0.77*)*	*(0.56*)*	*(0.4*)*	*(0.32)*	*(0.35*)*	*(0.32)*	*(0.46*)*	*(0.27)*	*(0.61*)*	*(0.21)*
Inflation Change, Chicago Fed National Activity Index	Rel. RMSFE	0.75	0.84	0.85	0.98	1.13	1.25	1.27	1.30	1.26	1.31	1.31	1.26
		(0.86)*	*(0.73*)*	*(0.68*)*	*(0.51*)*	*(0.33*)*	*(0.28)*	*(0.28*)*	*(0.29)*	*(0.36*)*	*(0.28)*	*(0.25)*	*(0.21)*
Gordon's Triangle Model													
Inflation	Rel. RMSFE	0.72	0.88	0.79	1.07	1.03	1.41	1.09	1.43	0.98	1.36	1.39	1.56
		(0.86)*	*(0.71*)*	*(0.8*)*	*(0.51*)*	*(0.45*)*	*(0.23)*	*(0.32)*	*(0.14)*	*(0.58*)*	*(0.05)*	*(-0.3)*	*(-0.31)*
Inflation Change	Rel. RMSFE	0.72	0.89	0.78	1.08	1.02	1.41	1.07	1.43	0.97	1.34	1.23	1.50
		(0.85)*	*(0.7*)*	*(0.81*)*	*(0.53*)*	*(0.5*)*	*(0.27*)*	*(0.39)*	*(0.21)*	*(0.68*)*	*(0.17)*	*(-0.09)*	*(-0.21)*

Table 1 - The entries Rel. RMSFEs are the RMSFEs of the forecasts of each method relative to the RMSFE of Atkeson-Ohanian (AO) inflation forecasts. Below the Rel. RMSFEs (in parentheses) is the OLS estimate of λ from the following forecast combination regression $\pi^{4}_{t+h} = \alpha + \lambda f^{cand}_{t} + (1-\lambda) f^{naive(AO)}_{t} + \varepsilon_{t+h}$, where f^{cand}_{t} is the forecast of π^{4}_{t+h} from the competing model at t, $f^{naive(AO)}_{t}$ is the forecast of π^{4}_{t+h} from the benchmark model at t. The * next to the OLS estimate indicates significance at the 5% level. HAC robust standard errors (estimated using a Bartlett kernel with bandwidth equal to the integer part of $\sqrt{T}$) were used to compute the test statistic. In each column the highlighted values represent the 20% lowest relative RMSFE and the value in bold represents the **smallest** relative RMSFE. The evaluation period is 1989Q1-2008Q3. For all variables the sample period is 1959Q2-2009Q3 except for capacity utilization (1972Q1-2009Q3), housing starts (1963Q4-2009Q3) and Chigado FED national activity index (1967Q2-2009Q3). All multivariate (and univariate) approximations to smooth inflation are obtained setting the cut-off period equal to 32 quarters.

Table 2 - Simulated Pseudo Out-of-Sample Forecasting Results

Forecast horizon	h=1	h=2	h=4	h=6	h=8	h=12
Univariate						
Rel. RMSFE	1.00	1.00	1.00	1.00	1.00	1.00
RMSFE	0.009737	0.009590	0.009770	0.010030	0.010143	0.010189
			Rel. RMSFE			
M2(minus) growth	1.05	1.03	1.00	0.99	0.99	1.01
M2(minus) growth-GDP growth	1.05	1.03	1.00	0.99	0.99	1.01
M2(minus) growth & opp cost	1.08	1.04	1.03	1.04	1.01	1.01
M2(minus) growth-GDP growth & opp cost	1.08	1.05	1.03	1.03	1.01	1.01
MZM growth	1.07	1.04	1.00	0.99	0.98	1.01
MZM growth-GDP growth	1.09	1.05	**0.99**	**0.98**	**0.98**	1.01
MZM growth & opp cost	1.07	1.04	1.02	1.02	1.00	1.01
MZM growth-GDP growth & opp cost	1.07	1.04	1.02	1.02	1.00	1.01
M2 growth	1.00	1.00	1.01	1.01	1.01	1.01
M2 growth-GDP growth	0.99	1.00	1.02	1.03	1.03	1.02
M2 growth & opp cost	1.08	1.05	1.05	1.07	1.05	1.03
M2 growth-GDP growth & opp cost	1.08	1.05	1.05	1.07	1.05	1.03
Industrial Production	1.01	1.01	1.03	1.03	1.03	1.04
Capacity Utilization	0.98	**0.98**	1.01	1.02	1.03	1.02
Unemployment	1.01	1.00	1.00	1.00	1.00	1.00
Housing Starts	**0.97**	0.98	1.01	1.02	1.02	1.02
Real Disposable Income	1.01	1.01	1.00	1.00	1.00	**1.00**
Employees Payrolls	1.00	1.01	1.03	1.03	1.03	1.03
Chicago Fed National Activity Index	0.99	0.99	1.01	1.03	1.05	1.02

Table 2 - Simulated Pseudo Out-of-Sample Forecasting Results (cont.)

Forecast horizon	h=1	h=2	h=4	h=6	h=8	h=12
Univariate						
Sign concordance	0.53	0.53	0.61	0.58	0.56	0.54
			Sign Concordance			
M2(minus) growth	0.49	0.53	0.61	0.62	0.57	0.53
M2(minus) growth-GDP growth	0.48	0.52	0.62	0.62	0.57	0.53
M2(minus) growth & opp cost	**0.58**	0.57	**0.66**	0.61	0.56	0.48
M2(minus) growth-GDP growth & opp cost	0.56	0.56	**0.66**	0.62	0.56	0.47
MZM growth	0.52	0.57	0.63	0.62	**0.61**	0.53
MZM growth-GDP growth	0.51	0.54	0.62	0.63	0.56	0.51
MZM growth & opp cost	**0.58**	0.57	0.65	0.65	0.58	0.49
MZM growth-GDP growth & opp cost	0.56	0.56	**0.66**	**0.66**	0.58	0.46
M2 growth	0.53	0.56	0.58	0.57	0.54	0.52
M2 growth-GDP growth	0.54	0.57	0.59	0.57	0.56	0.52
M2 growth & opp cost	**0.58**	0.57	0.62	0.59	0.54	0.58
M2 growth-GDP growth & opp cost	0.56	0.56	0.62	0.59	0.56	0.57
Industrial Production	0.54	0.54	0.57	0.59	0.56	0.53
Capacity Utilization	**0.58**	**0.61**	0.63	0.58	0.59	**0.61**
Unemployment	0.52	0.52	0.59	0.58	0.54	0.56
Housing Starts	0.56	0.56	0.62	0.61	0.58	0.59
Real Disposable Income	0.53	0.56	0.54	0.54	0.53	0.56
Employees Payrolls	0.57	0.56	0.59	0.56	0.54	0.54
Chicago Fed National Activity Index	0.56	0.59	0.61	0.59	0.59	**0.61**

Table 2 - Top panel: Rel. RMSFEs are the RMSFEs of each approximation relative to the RMSFE of the univariate approximation to business cycle fluctuations of real GDP.
The highlighted values represent the 20% lowest relative RMSFE and the value in bold represents the **smallest** relative RMSFE.
Bottom panel: Sign concordance is the percentage of times the approximations and target share the same sign. The highlighted values represent the 20% highest values of sign concordance and the value in bold represents the **highest** sign concordance. In both panels the evaluation period is 1989Q1-2008Q3.

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