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Abstract

We construct a measure of global liquidity using the growth rates of broad money for the G7 economies. Global liquidity produces forecasts of US inflation that are significantly more accurate than the forecasts based on US money growth, Phillips curve, autoregressive and moving average models. The marginal predictive power of global liquidity is strong at three years horizons. Results are robust to alternative measures of inflation.

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1 Introduction

Accurate inflation forecasts are essential for successful monetary policy making. Effective predictors are essential for producing accurate forecasts. In the recent past, characterized by low and stable inflation, researchers in academia and policy institutions have had difficulty to find a reliable predictor for inflation. As Stock and Watson (2006) emphasize, inflation has become so hard to forecast that it is difficult to improve upon the projections of a naive random walk.

A long standing literature in macroeconomics has documented the long-run relationship between money growth and inflation (see for instance Friedman and Schwartz, 1982; Lucas, 1980; McCandless and Weber, 1995; Benati, 2007). It does not come as surprise, then, that central banks monitor monetary aggregates in an effort to predict movements in inflation. The European Central Bank goes as far as regarding the stabilization of the growth of a broad monetary aggregate as the first pillar of its monetary policy strategy.

The information content of monetary indicators for inflation, however, has been recently called into question as a few studies, including Galí et al.(2004) and Gerlach and Svensson (2003), argue that *domestic* money growth has little predictive power for domestic inflation.

A growing empirical literature exemplified by Rogoff (2003) has shown that national inflation rates in several industrialized economies share a significant international common component. To the extent that money growth and inflation are highly correlated in the long-run, significant international comovements in inflation may reflect significant international comovements in liquidity, which can then be used to forecast domestic inflation.

In this work, we investigate whether global liquidity has marginal predictive power for US inflation. We find that global liquidity, measured as either the mean or the first dynamic principal component of the growth rates of broad money across the G7 economies, produces inflation forecasts that are significantly more accurate than the forecasts based on traditional models such as an autoregressive specification, a Phillips curve relationship and a model based on

US money growth. The predictive advantage is particularly pronounced at three years horizon. Results are robust to alternative measures of inflation.

The forecasting models and the measure of global liquidity are presented in Section 2. Section 3 reports the main results. Section 4 provides a robustness analysis and a discussion of some alternative forecasting equations proposed in recent contributions.

2 Forecasting models: old and new

There are several channels through which global liquidity may have an impact on future domestic inflation. Over the last twenty years, inflation dynamics have become more synchronised: different countries have shared similar experiences with inflation becoming low and stable by the beginning of the 1990s.

Rogoff (2003) argues that improved monetary policies across the world has been one of the most significant driver of the great moderation. Along similar lines, Barsky and Kilian (2001) offers a monetary explanation of the great stagflation showing that a measure of world liquidity was highly correlated with US monetary policy and inflation during the 1970s.

Another channel of transmission from global liquidity to domestic inflation operates through the terms of trade. If the exchange rate does not fully outweigh a rise in the import prices of intermediate and final goods, then domestic firms will face higher costs and consumers will demand higher wages as result of the deterioration of their purchasing power. By the same token, an inflow of capital from abroad that is not followed by a sufficient appreciation of the exchange rate can influence the evolution of domestic prices.

The goal of this note is to identify a new stylized fact linking global liquidity to future movements in domestic prices, rather than to quantify the relative contributions of the different transmission mechanisms. To this end, we assess the marginal predictive power of global and domestic money growth for US inflation. We consider three measures of inflation and for each measure, we forecast the h-quarter annualized change of the price index, $\pi^h_{t+h} = [\log(P_{t+h}) - \log(P_t)] \times \frac{400}{h}$ using three different specifications:

1. Univariate autoregressive forecasts (AR), where the forecasts of inflation are based exclusively on lags of the first difference of the price index.

$$\pi^h_{t+h|t} = \alpha_1 + \beta_1(L)\pi_t + \varepsilon_{1,t+h} \tag{2.1}$$

2. Money growth forecasts in which the AR specification is augmented with a measure of US broad money growth.

$$\pi^h_{t+h|t} = \alpha_2 + \beta_2(L)\pi_t + \gamma_2(L)M^{US}_t + \varepsilon_{2,t+h} \tag{2.2}$$

3. Global liquidity forecasts in which the AR specification is augmented with a measure of broad money growth in the G7 economies.

$$\pi^h_{t+h|t} = \alpha_3 + \beta_3(L)\pi_t + \gamma_3(L)M^{Global}_t + \varepsilon_{3,t+h} \tag{2.3}$$

The first two specifications are standard and they have been extensively used in the literature (see for example Nicoletti-Altimari, 2001, for an application to the Euro Area). The third specification, in contrast, is new.[1] In the baseline case, global liquidity is defined as the simple mean of the growth rates of broad money in the G7 economies.

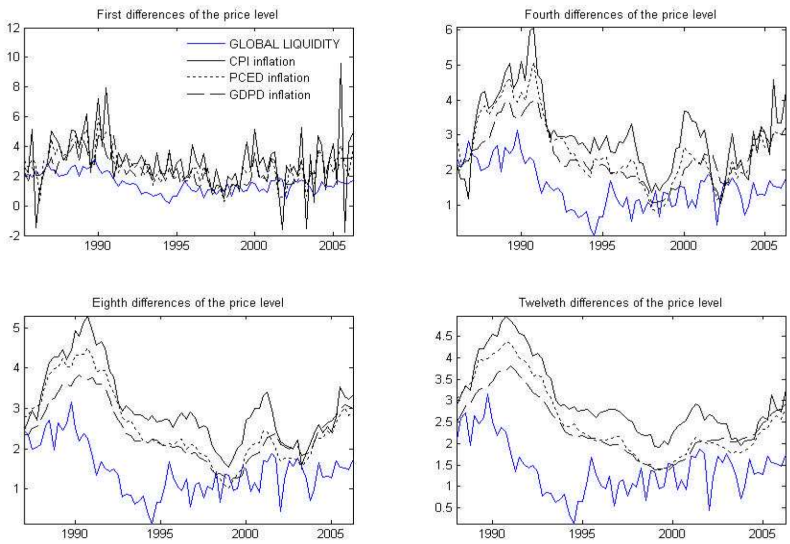
As definitions vary across countries, we select the monetary aggregates that are most similar in terms of composition: M4 for the U.K., M3 for Italy and France, and M2 for all other countries. Inflation is measured as the log difference of the Consumer Price Index (*CPI*), Personal Consumption Expenditure Deflator (*PCED*) and GDP deflator *(GDPD)*.

In each countries, the figures on monetary aggregates are typically released between the first and the third week of the following month. The latest observation on US prices is rarely available by the first half of the following month.

The series of global liquidity is shown in Figure 1 as blue, bold line together with the three series of US inflation. The top left and right, and the bottom left and right panels correspond to the 1^{st}, 4^{th}, 8^{th} and 12^{th} log differences of the price level and thus they refer to one quarter, and one, two and three years inflation.

[1]We refer to the second and third specifications as 'unrestricted' or 'augmented AR'.

Figure 1: *Global liquidity and inflation at different frequencies*



Interestingly, the peaks and troughs in global liquidity always precede the peaks and troughs in US inflation. This pattern is more pronounced for the 8^{th} and 12^{th} differences in the bottom panels, suggesting that the correlation between global liquidity and US inflation may be stronger at low frequencies.

The correlations in Figure 1 are, of course, only suggestive, and a formal analysis requires defining a metric for forecasting comparison. We perform a pseudo out-of-sample forecasting exercise for each variable and model over the horizons $h = 1, 4, 6, 8, 10$, and 12 quarters. The estimation sample begins in the first quarter of 1980 and it ends in the fourth quarter of 1989. The pseudo out-of-sample forecasting period begins in the first quarter of 1990 and it ends in the second quarter of 2006.

Forecasts constructed at date $t + h$ are based on models that are estimated using observations dated t and earlier. We focus on recursive samples, though results are robust to using rolling samples. The Mean Square Forecast Error

(MSFE) is the metric for evaluating the forecast accuracy:

$$MSFE_{t_0}^{t_1}(i,h,m) = \frac{1}{t_1 - t_0 + 1} \sum_{t=t_0}^{t_1} \left(\hat{\pi}_{i,t+h|t}^h(m) - \pi_{t+h}^h \right)^2$$

where $1990:1 \leq t_0 \leq t_1 < 2006:2-h$. This is the average squared error between time t_0 and t_1, for variable i, at horizon h, using model m.

3 Results

In this section, we assess the predictive accuracy of the three models (2.1)-(2.3). Results are reported for three alternative measure of inflation based on *CPI*, *PCED* and *GDPD*.

The restricted *AR* model is used as benchmark and therefore its MSFEs, in italics, are expressed in absolute terms. The findings for the other specifications are presented as the MSFE of that specification *relative* to the MSFE of the *AR* model. The number of lags is selected using the Schwartz information criterion.[2] Asterisks denote rejection of the null hypothesis that the MSFE of the *AR* model is equal to the MSFE of the unrestricted models.[3]

A number of interesting results emerge from Table 1. US money growth has no information content for future US inflation as the relative MSFEs in the second row of each panel are above one, with the only (insignificant) exception of *CPI* at 4 quarter horizon. Global liquidity, in contrast, has strong marginal predictive power for inflation, producing forecasts that are significantly more accurate than the forecasts of the autoregressive model for all horizons beyond one year. The improvements in forecast ability over 10 and 12 quarter horizons are, on average, in the order of 54%.

The last row of the panels in Table 1 shows the findings for an alternative measure of global liquidity based on the first dynamic principal component (pc).[4]

[2]Candidate predictors enter benchmark and augmented specifications with the first lag. Three lags are used for CPI, and four lags for PCE and GDPD inflation. Results are robust to using the Akaike information criterion.

[3]The test is based on the MSFE-F statistics proposed by Clark and McCracken (2005). As in nested models the statistics has a non-standard asymptotic distribution, we compute empirical critical values using 5000 bootstrap repetitions as suggested by Clark and McCracken (2005).

[4]In an exact factor model, the estimates of the common factor based on maximum likelihood

Table 1: Relative MSFEs - 1990Q1:2006Q2

Horizon	***1***	***4***	***6***	***8***	***10***	***12***
	Consumer price index					
Autoregressive	*2.38*	*0.95*	*0.85*	*0.87*	*0.85*	*0.84*
US money growth	1.04	0.97	1.07	1.12	1.15	1.29
Global liquidity	1.13	0.95*	0.69***	0.55***	0.44***	0.33***
Global liquidity pc	1.00	1.06	0.84**	0.71**	0.64**	0.58**
	Personal consumption expenditure					
Autoregressive	*0.91*	*0.64*	*0.65*	*0.74*	*0.84*	*0.98*
US money growth	1.01	1.02	1.11	1.13	1.12	1.18
Global liquidity	0.94*	0.69***	0.60***	0.56***	0.47***	0.47***
Global liquidity pc	0.95**	0.77***	0.62***	0.55***	0.48***	0.42***
	GDP Deflator					
Autoregressive	*0.53*	*0.30*	*0.37*	*0.43*	*0.49*	*0.54*
US money growth	1.16	1.47	1.38	1.44	1.41	1.47
Global liquidity	0.93***	0.82***	0.66***	0.55***	0.50**	0.52***
Global liquidity pc	0.85***	0.81**	0.74***	0.66***	0.56**	0.48***

Notes: The autoregressive model is the benchmark and its MSFEs, in italics, are reported in absolute terms. The other entries refer to the MSFEs of that specification relative to the MSFEs of the benchmark. Asterisks denote that the MSFEs of the unrestricted model are statistically different and (more accurate) than the MSFEs of the the benchmark (restricted) model at 1% ($***$), 5% ($**$) and 10% ($*$) significance levels.

The marginal predictive power of the alternative measure is less pronounced than the predictive power of the simple mean. The principal component, however, produces improvements in forecast ability beyond two years which are still, on average, in the order of 47%. Results hold true for all measures of inflation, and are robust to using the estimation sample 1985:1-1994:4.

are more accurate than the estimates based on principal components. To the extent that a small group of countries within the G7 may share a regional common factor, due for instance to business cycle synchronization or a regional monetary system, the idiosyncratic components are likely correlated. In an approximate factor structure with one common factor, Doz, Giannone and Reichlin (2006) show that maximum likelihood and the two-step procedure used in this paper perform similarly, even for cross-section dimensions as small as five. In our panel, the correlation between the common factors extracted with the two methods is 0.96.

4 Robustness analysis and discussion

In this section, we discuss the robustness of our findings to the international composition of our measure of global liquidity, the inclusion of global inflation and the nominal exchange rate as additional predictors, a different transformation of the price indexes, alternative forecasting models and sample selection. We also discuss the evidence for the other G7 countries.

Global comovements

To the extent that global liquidity captures an authentic international comovement, our results should not hinge upon the forecasting performance of broad money growth in a specific country. We investigate this hypothesis by computing the relative MSFEs of seven alternative specifications in which the AR model is augmented with a measure of international liquidity that excludes, in turn, the money growth of one of the G7 economies.

The measures of global liquidity based on the seven panels of six countries retain the forecasting advantage of the baseline measure, and therefore they reveal that the marginal predictive power of global liquidity for US inflation comes from a genuine global component.

The forecasts based on global liquidity are significantly more accurate than the forecasts based on a measure of global inflation. Global inflation is constructed as the simple mean of inflation rates across countries. Augmenting the model of global liquidity with the log difference of the trade-weighted nominal exchange does not overturn our conclusions and, in a few occasions, it improves the predictive accuracy of the unrestricted model.

An alternative transformation of the price index

In his Nobel lecture, Lucas (1995) emphasizes that a central prediction of the quantitative theory of money is that the relationship between inflation and money growth holds in the long-run. Recent international evidence by Benati (2007) shows that the slow-moving component of money growth leads the slow-moving component of inflation. Theory and evidence thus suggest that money growth is useful to forecast the *change in the price level*, and the change in the price level has been indeed the focus of our analysis.

When the focus is on short-run movements, however, the econometrician may find it more convenient to forecast the *change in inflation*, $\pi^h_{t+h} - \pi_t$, with h representing the forecast horizon (see for instance Stock and Watson, 2006). Together with the results of the previous section, Figure 1 suggests that global liquidity and US inflation are significantly correlated only at low frequencies.

Relative MSFEs, not reported but available upon request, reveal that neither domestic nor global liquidity have marginal predictive power for the *change in inflation*. The latter finding, however, is not surprising as the transformation $\pi^h_{t+h} - \pi_t$ removes the low frequency component of inflation, and therefore the predictive ability of money growth.[5]

Two popular models of inflation

The Phillips curve is one of the corner stone of modern macroeconomic theory. The in-sample evidence on the existence of a robust correlation between inflation and real activity has led several authors to conjecture the existence of a Phillips curve relationship also out-of-sample. Inflation can be then forecasted as:

$$\pi^h_{t+h|t} = \alpha_4 + \beta_4(L)\pi_t + \gamma_4(L)u_t + \varepsilon_{4,t+h} \tag{4.4}$$

where u_t represents the growth rate of unemployment.

A more agnostic view on the inflation process has been discussed by Stock and Watson (2006), who shows that the IMA(1,1) provides a reasonable description of US inflation. According to the IMA(1,1), inflation evolves as:

$$\pi_t - \pi_{t-1} = (1 - \theta L)\, a_t \tag{4.5}$$

where θ is positive and a_t is serially uncorrelated with zero mean. We employ the letter θ to emphasize that the IMA(1,1) does not nest the benchmark model

[5] Along similar lines, Watson (2004) argues that the change in inflation cannot be used to establish the existence of a Phillips curve relationship out of sample, because the transformation $\pi^h_{t+h} - \pi_t$ removes, by construction, the business cycle frequency component of inflation that the Phillips curve is meant to capture.

(2.1). For the IMA(1,1), and only for the IMA(1,1), we will perform the test of equal predictive accuracy proposed by Diebold and Mariano (1995).

Table 2: Relative MSFEs - 1990Q1:2006Q2 - alternative models

Horizon	***1***	***4***	***6***	***8***	***10***	***12***
	Consumer price index					
Autoregressive	*2.38*	*0.95*	*0.85*	*0.87*	*0.85*	*0.84*
Phillips curve	1.13	1.04	1.01	1.03	1.04	1.02
IMA(1,1)	1.06	1.19^{oo}	1.26^{ooo}	1.26^{ooo}	1.29^{ooo}	1.31^{ooo}
	Personal consumption expenditure					
Autoregressive	*0.91*	*0.64*	*0.65*	*0.74*	*0.84*	*0.98*
Phillips curve	1.01	0.96^{*}	1.03	1.06	1.10	1.09
IMA(1,1)	0.91	0.93^{oo}	0.92^{oo}	0.88^{oo}	0.84^{oo}	0.76^{oo}
	GDP Deflator					
Autoregressive	*0.53*	*0.30*	*0.37*	*0.43*	*0.49*	*0.54*
Phillips curve	1.12	0.98	1.06	1.12	1.15	1.13
IMA(1,1)	1.19	1.09^{o}	1.06^{o}	1.02^{o}	1.00	0.92

Notes: see Table1. Circles denote rejection of the hypothesis of equal predictive accuracy relative to the autoregressive model at 1% (*ooo*), 5% (*oo*) and 10% (*o*) significance levels.

In Table 2, we present the results from the models (4.4) and (4.5), together with those from the autoregressive specification. The relative MSFEs based on the Phillips curve are above one with the exception of the 4 quarter horizon for *PCED* and *GDPD*. As for the IMA(1,1), the relative MSFEs are uniformly above one for *CPI* and *GDPD*, but below one for *PCED*. In the latter case, however, the performance of the forecasts based on the IMA(1,1) seems far from the performance of the forecasts in Table 1 based on global liquidity.

Sample selection

Does the marginal predictive content of global liquidity for US inflation extend to the 1970s? In their accounting of the great inflation, Barsky and Kilian (2001) argue that "despite its origins in the U.S., the monetary expansion in the early 1970s was amplified by the workings of the international monetary system", and note that the increases in world liquidity were followed by increases in both world and US inflation.

The pre- and post-1984 periods have been associated with different degrees of macroeconomic stability as well as different degrees of integration in goods and capital markets. To the extent that terms of trade and capital flows are important channels in the transmission of international shocks, global liquidity should have a more limited impact on domestic inflation over the pre-1984 period.

Table 3: Relative MSFEs - 1970Q1:1984Q4

Horizon	***1***	***4***	***6***	***8***	***10***	***12***
	Consumer price index					
Autoregressive	*6.73*	*7.40*	*8.73*	*9.49*	*9.27*	*8.63*
US money growth	1.02	1.07	1.04	0.95	0.89*	0.85**
Global liquidity	1.02	0.98	0.92*	0.86**	0.84**	0.87*
Global liquidity pc	1.03	1.02	0.96	0.87*	0.82**	0.85*
	Personal consumption expenditure					
Autoregressive	*2.38*	*4.10*	*4.80*	*5.09*	*5.01*	*4.75*
US money growth	1.04	1.07	1.03	0.98	0.90*	0.89*
Global liquidity	1.04	0.99	0.97	0.91*	0.85**	0.88*
Global liquidity pc	1.05	1.04	1.00	0.93*	0.84*	0.87*
	GDP Deflator					
Autoregressive	*2.92*	*3.90*	*4.23*	*4.13*	*4.02*	*3.52*
US money growth	1.11	1.21	1.09	1.00	0.98	1.03
Global liquidity	1.05	1.09	0.92	0.70**	0.62***	0.74**
Global liquidity pc	1.05	1.21	1.04	0.86*	0.74**	0.81*

Notes: see Table 1

Tables 3 reports results for the estimation sample beginning in 1963Q2, when data on broad money growth become available for at least five of the G7 countries.[6] Liquidity helps to forecast inflation at horizons beyond two years, consistently with the notion of a *long-run* relationship between money growth and inflation. The panel for GDP deflator reveals that global liquidity has strong marginal predictive power over and above US money growth. As for the other measures of inflation, the forecasts based on domestic and global liquidity seem equally accurate at 10 and 12 quarter horizons, whereas at 8 quarter horizon the forecasts based on global liquidity are significantly more accurate.

[6]For Italy and France, data on broad money growth are available since 1980Q1 only.

International Evidence

While an international comparison is beyond the scope of this work, we wish to assess whether the results for the U.S. are the rule or the exception within the G7 economies. For the other countries, we find that global liquidity has predictive power for domestic inflation only when also domestic liquidity has predictive power.

To the extent that favourable terms of trade, capital inflows and exchange rate dynamics may account for some of the forecasting performance of global liquidity, the US transmission mechanism of international shocks appears different from those of the other G7 economies.

5 Conclusions

We have proposed a new predictor for US inflation: global liquidity. The forecasts based on global liquidity are significantly more accurate than those based on US money growth, Phillips curve, autoregressive and moving average models. Results are particularly strong at horizons beyond two years.

The implication of our finding is that money growth still contains useful information to predict future movements in domestic inflation rates. The information content of money, however, is no longer reflected in domestic aggregates; rather it is embodied in measures of global liquidity.

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