Global Inflation – The Ghost in the Machine?[1]

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[1] This paper is a short version of a previous work published in July 2007 as "Global Inflation: the Ghost in the Machine?" – Economic Analysis, UniCredit Global Research

1. Introduction

Despite the recent turmoil spurred by US subprime concerns, market attention has started focusing again on inflation risks: in the past months, the public debate has been dominated by the idea that we might be facing a structural and sustained rise in energy and food prices. The warning signs are clear: oil prices are already at historical highs, and risks appear skewed to the upside, reflecting not just strong demand but also gradual depletion of proven reserves, low investment, and geopolitics. Food inflation recently rose to an average 7% in emerging market economies, where food typically accounts for more than 30% of the consumption basket, compared to about 15% in advanced industrial countries. Spillover effects to food inflation in industrialized countries have so far remained contained, though the food component of the CPI in OECD countries accelerated sharply of late.

The first question should be whether it makes sense to talk of a global inflation risk rather than focussing on inflation risks in individual countries. Evidence of a global co-movement is particularly strong in the case of inflation: most industrialized countries experienced a "Great Inflation" beginning in 1969-70, followed by a "Great Disinflation" beginning in 1983-86

Starting from the idea that inflation can be treated as a global phenomenon, we have based our analysis of inflation drivers on the "globe-centric" approach developed in an ECB working paper by Ciccarelli and Mojon (2005)[2]. By focusing on global determinants of consumer prices, this approach differs from more traditional ways of modelling inflation based mostly on country-specific factors. In this sense, we can say that the "globe centric approach" explains inflation in a top-down fashion.

2. Inflation: looking for a common factor

The idea that fluctuations in a large number of economic variables can be modeled by a smaller number of factors is at the core of the so-called Principal Component Analysis (PCA), which aims at extracting a common factor explaining the largest part of the variance in a given set of data. In particular, the idea behind the common factor model is that each series of the given set can be expressed as the sum of two orthogonal components:

- The first one is a common component, which should explain the main part of the variance of the panel and can be constructed as a linear combination of common, unobservable, factors;

- The second one is an idiosyncratic component, containing the remaining specific information and capturing shocks that have only local effects, i.e. are only weakly correlated across the panel.

Both the common and the idiosyncratic components cannot be observed directly, so that they must be estimated. We will focus on the analysis of the common component of national CPI, which has the objective to find a new set of variables that are a linear combination of the different national inflation rates. The first component accounts for the largest amount of total variation in the data, the second for the second largest amount not already accounted by the first component and so on.

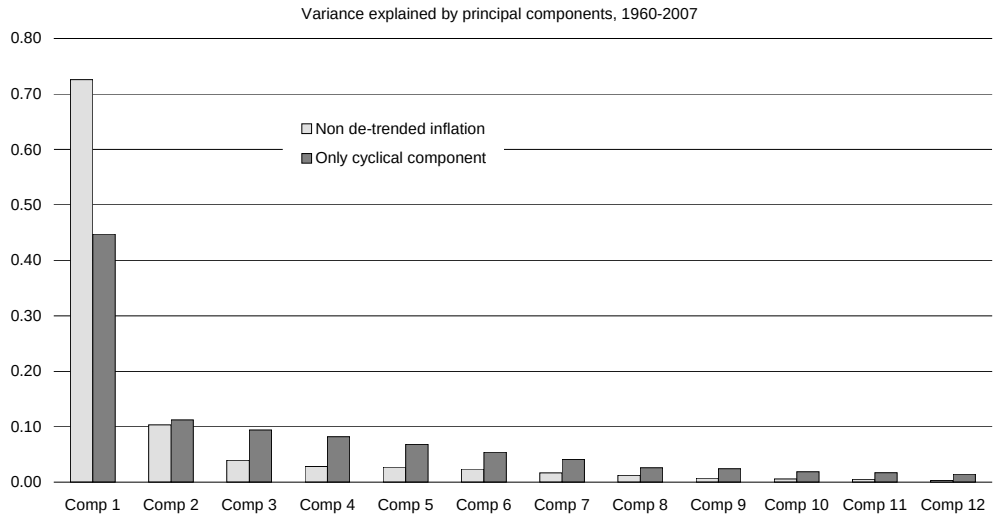
The raw data are CPI indices available quarterly from the OECD database starting from Q1 1960 up to Q1 2007. We will focus our analysis on 12 OECD countries, which we label as G12 (Australia, Belgium, Canada, France, Germany, Italy, Japan, The Netherlands, Spain, Sweden, UK, US). As the principal components analysis is not scale invariant, we standardized the original series in order

[2] M. Ciccarelli & B. Mojon, "*Global Inflation*", ECB Working paper N°537, ECB, October 2005

to get comparable data. After that, we have extracted the principal components of the G12 group. The results plotted in the chart next page show that the first principal component accounts for 73% of the total variance among the twelve national inflation rates, meaning that they have a strong common factor. Since the second principal component explains just 10% of the total variance and the third less than 4%, it is clear that a common global factor can be considered an important source of variability for national inflation rates. From now on, we will refer to this common factor as Global Inflation.

To assess the extent to which national inflation rates are driven by Global Inflation, we have run basic regressions with national inflation as the independent variable, and Global Inflation as the explanatory variable. The results are striking: in many cases global inflation explains more than 80% of the single-country inflation variance, while only in two cases (Australia and France) the R-Squared of the regression is less than 50%.

INFLATION AS A GLOBAL PHENOMENON, 1960-2007



Source: UniCredit Global Research

However, the approach adopted so far leaves one problem still unsolved. In fact, inflation series are I(1), while the PCA analysis approach was originally developed only for stationary variables[3]. Hence, the common factor might catch the common trends in the inflation series, while failing to capture cyclical fluctuations.

In order to solve this problem, we de-trended the single-country inflation rates using a simple Hodrick-Prescott filter, so that each inflation time series is decomposed into two parts: a trend and a cycle component. We then used the twelve national cyclical components of inflation to extract the common factor at business cycle frequencies. The percentage of variance that is explained by the first principal component is of course lower (45%) than the one obtained with non-detrended series, but still remains significant[4]. For a simple comparison, keep in mind that in the case of industrial production – one variable that is often modeled at the global level - the first principal component explains about 55% of the variance of yearly growth rates at the individual-country level[5]. Returning to inflation, in the case of non-detrended series, the first four principal components explain 90% of the variance, while for the cyclical part, it takes the first seven factors to explain the same amount of variance.

[3] Indeed, Stock and Watson (1988) estimated a principal component vector for non-stationary variables, while Harris (1997) showed that this approach can be used to estimate cointegrating vectors.

[4] Note that the average R-Squared from the two sets of 12 regressions amounts respectively to 72% and 45%, which correspond to the amount of variance explained by the first principal component.

[5] As the national IP yearly growth rates are stationary, there is no need to de-trend the series.

We then re-run our original twelve regressions, using the first common cyclical factor as the explanatory variable to estimate the cyclical component of the G12 inflation rates. Clearly, the R-Squared of the various regressions is now lower than what was estimated when considering non-detrended series. Notice that the common factor of de-trended inflation does not have any explanatory power for inflation developments in Spain, whereas the non-detrended measure helps explain 70% of the country's inflation variance. This is not surprising: Spain in the 1960s and 1970s was a country characterized by low inflation discipline, so that national developments were driving inflation much more than global common factors. On the other hand, we see also that two historically low-inflation countries (Germany and The Netherlands) display a relatively high R-Squared even when the inflation trend is subtracted: although they tend to be less influenced than other countries by global developments, the common factor still has a good explanatory power.

GLOBAL EXPLAINS LOCAL, 1960-2007

	AU	BE	CA	FR	GE	IT	JP	NE	SP	SW	UK	US	Average
Trend+Cycle	0.70	0.85	0.82	0.88	0.65	0.83	0.60	0.64	0.70	0.48	0.83	0.71	**0.72**
Cycle	0.29	0.63	0.46	0.70	0.37	0.59	0.55	0.34	0.01	0.51	0.38	0.52	**0.45**

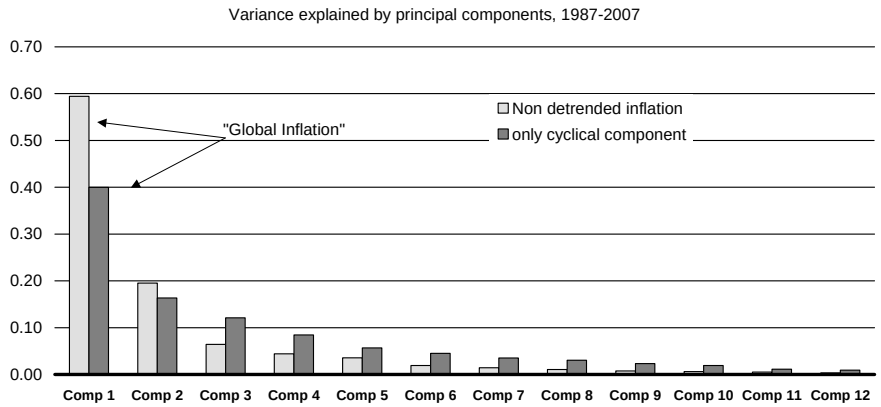
Source: Unicredit Global Research

A visual inspection of the twelve national inflation series shows clearly that a structural break might have occurred in the mid-eighties. We thus restricted our original sample to the last 20 years, ranging from 1987 to 2007, mainly for two reasons:

- The co-movement of inflation might be due to the trend component associated with the 1970s "Great Inflation" that brought many countries to experience high rates of inflation up to the 1980s, and the gradual disinflation that followed.

- In August 1987, Alan Greenspan became Chairman at the Federal Reserve and his term has been characterized by important innovations, namely pre-emption and adaptation to structural changes that have contributed to a better management of inflation and inflation expectations.

After having restricted our sample, we now follow the same steps as before, i.e. we first estimate the principal components both for the standardized inflation data including the trend and for the de-trended series. The results are shown in the chart next page. As inflation in the 1987-2007 sub-sample is less volatile and less driven by global developments as oil shocks, it is not surprising that when considering non-detrended inflation the amount of variance explained by the common factor drops from 73% to 59% (18%). The important and encouraging result, however, is that the loss of explanatory power of the detrended common factor is much more contained (from 45% to 40%, i.e. 11%). Indeed, for the detrended case, the first common factor still explains 40% of the variance of the 12 inflation rates.



Finally we re-estimate our twelve regressions with national CPI as the independent variable and Global Inflation as the explanatory variable, and see that the R-Squared is extremely low (close to zero) only in those countries characterized by persistently low inflation rates (Germany and the Netherlands again) and in Japan, which experienced a decade of deflation.

GLOBAL EXPLAINS LOCAL, 1987-2007

	AU	BE	CA	FR	GE	IT	JP	NE	SP	SW	UK	US	Average
Trend+Cycle	0.35	0.47	0.60	0.78	0.30	0.81	0.54	0.00	0.85	0.82	0.83	0.74	**0.59**
Cycle	0.43	0.44	0.61	0.61	0.01	0.58	0.05	0.05	0.52	0.57	0.37	0.56	**0.40**

Source: Global Research

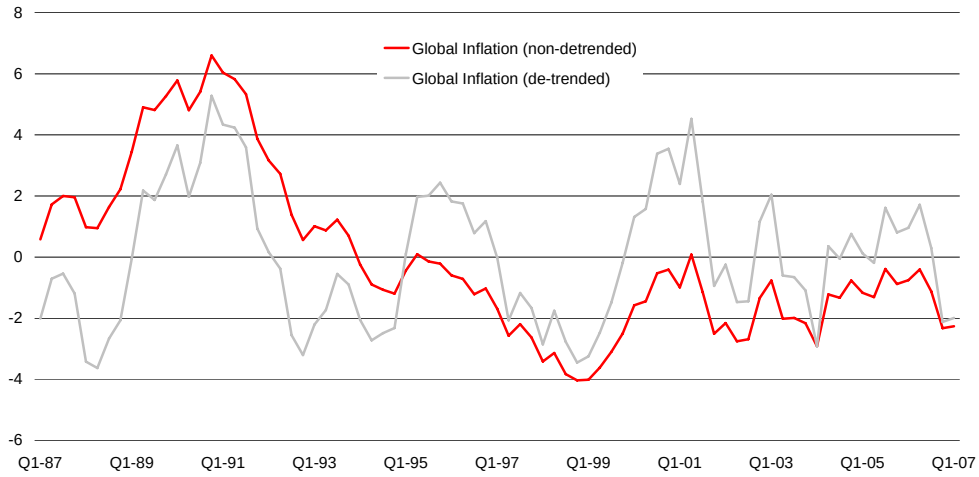
To summarize, the analysis in this section shows that most of the variability of national inflation in the G12 countries can be explained by a single common factor, our "Global Inflation". This holds both for overall inflation and for its detrended measures—albeit obviously to a lesser extent. Moreover, the importance of the comovement in inflation is not endangered by the structural break in inflation experienced by most countries. In fact, the power of our common factor in explaining the cyclical fluctuations of national inflation is nearly as strong in the post-1987 sub-sample as in the full sample.

In our view these results provide overwhelmingly convincing evidence that inflation should in fact be analysed as a global phenomenon. We now turn to the next task, namely to identify the drivers of global inflation.

4. Modelling global inflation

Having found strong and convincing evidence that inflation is a global phenomenon indicates that the causes of inflation have to be searched at the global rather than national level. Is the current concern about a widespread rise in the prices of energy, metals and food then justified? In this section we try to identify the main drivers of cyclical fluctuations in global inflation and to assess their relative importance and possible interactions. The analysis is again restricted to the sub sample 1987-2007, which we deem as more significant for policy implications.

Global Inflation cycles (common factor)



Source: UniCredit Global Research

For each of the G12 countries, we have selected a broad set of possible determinants ranging from real economy variables to financial indicators: IP growth (y-o-y), the output gap as computed by the OECD, the unemployment rate, the yearly growth rate in hourly earnings, import prices, unit labour

costs, the level of nominal short and long term interest rates (3-month and 10y, respectively), real M3 growth (y-o-y), and the real M3-to-GDP ratio. Due to data availability problems for M3, we used the euro area aggregate series instead of the six series of the EMU countries considered. To assess the role of fluctuations in commodity prices, we have included in our analysis oil (both WTI and Brent), food, metals, and several other commodity indices, all expressed as yearly growth rates. All series are standardized so that they have zero mean and unit variance.

At a visual inspection, most real economy and financial variables seem to display a stochastic trend, which we want to neutralize before extracting the common factor. A unit-root test confirms that the only stationary series are IP, the output gap, import prices and commodity prices. We therefore filter the remaining series using the Hodrick-Prescott algorithm to separate the trend from the cyclical component, and focus only on the latter. Once all real economy and financial variables are made stationary, we can extract a common factor, in order to get a world-wide measure of all the possible determinants of inflation: the world IP cycles, the world output gap, the world interest rate cycles, and so on.

We start the variable selection process by running a Granger-causality test on inflation cycles and all the above-mentioned real economy and financial indicators. This is done not only to check whether the candidate explanatory variables are useful to forecast inflation, but also to detect cases (if any) in which Granger causality doesn't run only in one direction (i.e. it runs both from the explanatory variable to inflation, and vice versa). We summarize the results, keeping in mind that the Granger test is very sensitive to the lag specification, and as such the results should be interpreted with a pinch of salt.

- In general, the output gap, the unemployment rate, M3 and M3/GDP are the variables that have statistically significant forecasting power, and satisfy the right directionality of Granger causation.

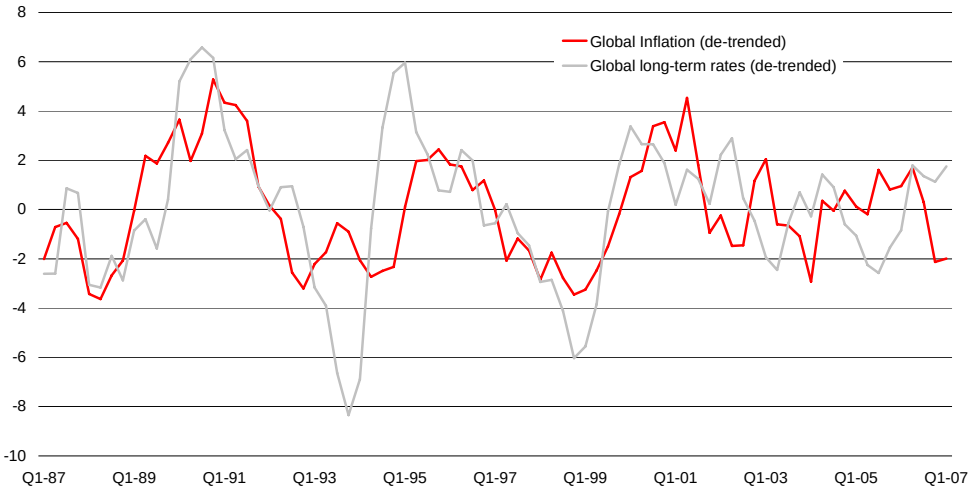
- In the case of long-term rates, the result isn't unequivocal given that the test points to a two-way Granger causation. From a theoretical point of view, the latter finding could be justified by the tendency of inflation risk premium to increase when current inflation is high, which would weaken the (more intuitive) inverse relationship between market rates and consumer price growth.

- Hourly earnings and unit labour costs do not satisfy the right directionality of Granger causation. Apparently, over the last twenty years, earnings have reacted mainly ex post to inflation developments and the Granger test shows little or no evidence of a wage-inflation spiral, as the one-way causation effect from CPI to earnings is particularly clear-cut for any chosen lag.

- IP and import prices have no statistically significant forecasting power and show no evidence of Granger causation, in either direction.

Tacking stock of the test results, we decide to limit our variable selection process to the output gap, the unemployment rate, M3 and M3/GDP, and try to investigate further the link between inflation and long-term rates. In this respect, a graphical inspection gives helpful insights as it suggests that the rate cycles have generally anticipated inflation cycles, with the inverse relationship becoming visible with a fairly long lag. Had the main causality run the other way around (i.e from inflation to inflation risk premium), we would have expected to detect a positive relationship between inflation and long-term rates, the former affecting the latter with a relatively short lag. Based on these considerations, it seems reasonable to consider long-term rates as a candidate to enter our model.

Global inflation and long-term rates (common factor)



With a simple OLS regression analysis, we find that a good and parsimonious model specification is one including both real and financial determinants. When selected with the appropriate lags, the unemployment rate, long-term rates, and the M3-to-GDP ratio are all significant at the 1% confidence level and explain about 60% of the variance of global inflation cycles.

*INF(t) = 0.05 – 0.61*UNEMP(t-3) – 0.24*LTR (t-8) + 0.40*M3_GDP(t-12)*

(0.27) (-7.22) (-3.96) (2.94)

R2: 0.61

Adj-R2: 0.59

DW: 0.86

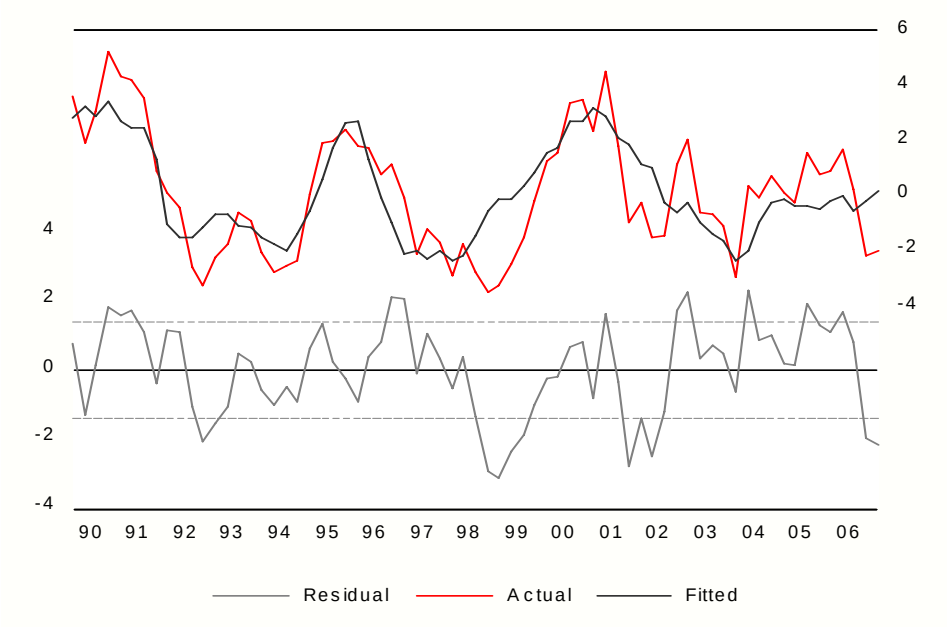
t-statistic in parenthesis

Interestingly, unemployment does a better job than the output gap in capturing the effect of the strength of economic growth on price pressures, shows extremely high significance and works best when lagged by three quarters. This validates the existence of a Phillips curve at the global level. The 10-y rate enters with a negative sign and shows the highest significance when lagged by eight quarters. In other words, it takes about two years for long-term rates to sort the largest effect on CPI. Last, but certainly not least, the M3-to-GDP ratio shows good explanatory power when entering the equation with a considerable lag (12 quarters). This finding seems to vindicate the view that in the long run inflation is (largely) a monetary phenomenon.

From a purely statistical point of view, the specification of our model is satisfactory, though certainly not perfect. In fact, while the coefficients show very good stability, the residuals tend to be autocorrelated – which is unsurprising, given the high degree of persistence of the dependent variable - and the null hypothesis of no heteroskedasticity of the error terms is rejected at standard confidence levels. In theory, we are able to overcome all these problems by simply adding lagged inflation to the list of regressors: this increases the regression fit to about 75%, leaves unaltered the significance and lags of the other three independent variables – though all coefficient estimates are sensibly lower than before - and delivers residuals with sound statistical properties. However, this improvement comes at a cost. In order to have the clearest possible picture and avoid blurring in any way the determinants of global inflation cycles, it would be optimal to stick to a specification– from now on the “benchmark model” – that doesn’t include lagged inflation among the regressors, therefore accepting to deal with a certain degree of residual autocorrelation and heteroskedasticity. To see if this doesn’t undermine the robustness of our findings, we check whether the significance

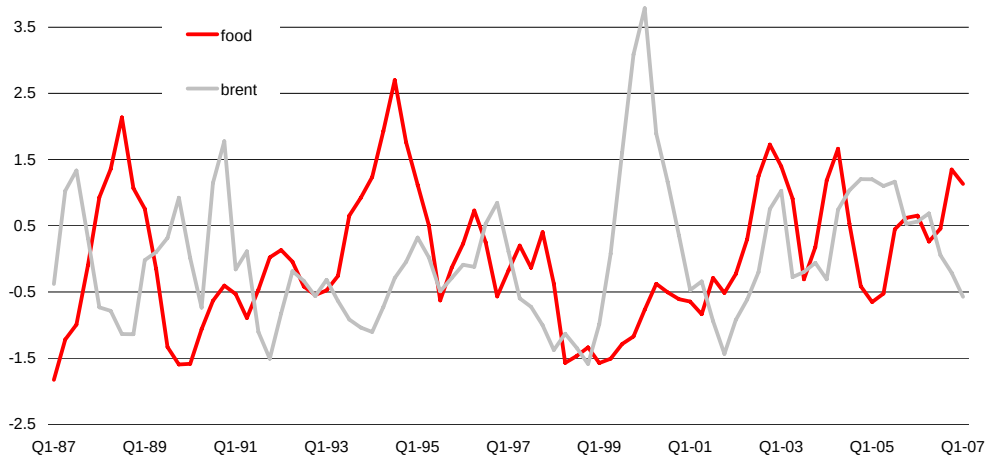
of our determinants remains acceptable even when carrying out the estimate adopting a correlation and heteroskedasticity-consistent standard error. The result is encouraging, in the sense that all the three independent variables remain significant at the 1% confidence level. From now on, we are therefore happy to rely on our benchmark model to continue our analysis of global inflation.

MODEL I: FUNDAMENTALS ONLY



The next step consists in evaluating the impact of commodity prices on our proxy of global inflation cycles. The basic idea is to add one or more commodities to the previously estimated model – that relies only on economic fundamentals – and check whether the fit of the regression improves significantly. We have considered the following: oil (Brent and WTI), food, foodstuff, cereals, agricultural raw, industrial raw, metals, industrials, livestock, soft commodities.

INCLUDING COMMODITIES IN OUR ANALYSIS (y-o-y % change, standardized)



The specification that delivers the best fit in terms of adjusted R-squared (which penalizes the addition of regressors that do not contribute to the explanatory power of the model) is the one that combines the three fundamental variables with the yearly change in the price of four commodities: Brent (lagged one quarter), the CRB food index (lagged two quarters), the CRB livestock index (lagged three quarters), and the CRB agricultural raw materials index (lagged four quarters).

*INF(t) = 0.10 – 0.71*UNEMP(t-3) – 0.15*LTR(t-8) + 0.32*M3_GDP(t-12) + 0.53*BRENT(-1)*

(0.71) (-7.35) (-2.92) (2.78) (3.40)

*+ 0.55*FOOD(t-2) + 0.41*LV_STK(t-3) + 0.39*AGR_RAW(t-4)*

(3.70) (4.00) (2.48)

R2: 0.80

Adj-R2: 0.78

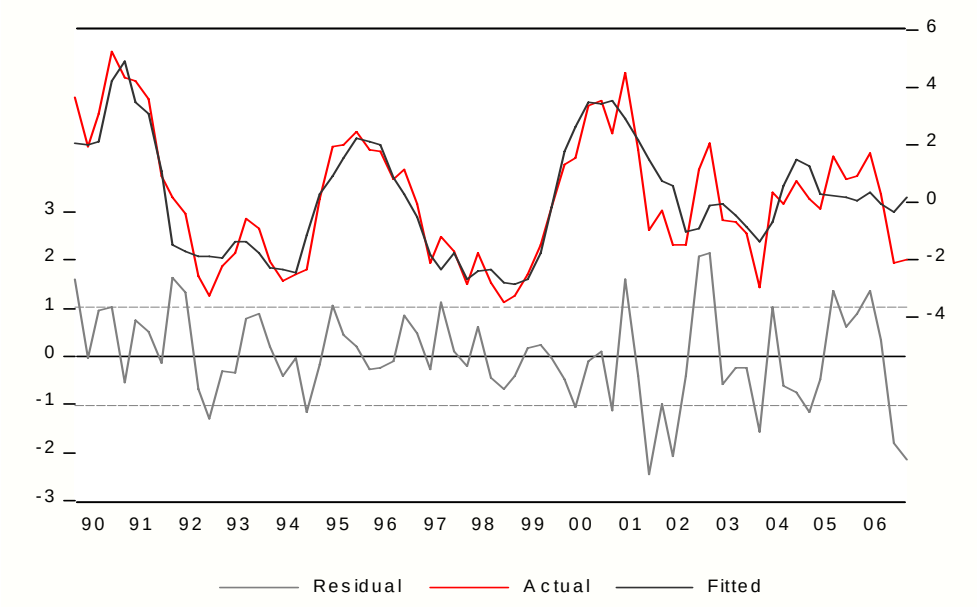
DW: 1.40

Newey-West HAC Standard Errors & Covariance

t-statistic in parenthesis

All variables entering the regression are significant at the 1% confidence level, but notice that the adjusted R-squared of this specification is 78%, 20% higher than the one found with the first version of the model.

MODEL II: FUNDAMENTALS AND COMMODITIES



Bottom line: our econometric analysis shows that the largest part of inflation cycles' volatility is driven by fundamentals, unemployment in particular. Fluctuations in commodity prices – though significant from a statistical point of view – play a smaller role, and their effect tends to be felt only in the short-term.

5.Conclusions: policy and market implications

The first key implication of our analysis is that inflation is definitely a global phenomenon. It is driven by common factors that explain the largest portion of what we observe at the individual country level. Monitoring and forecasting the inflation trend for individual countries of course still helps to forecast the next Fed/ECB/BoE action and the near term market reaction, but national inflation in turn is guided by global inflation as we have defined it in this paper: global inflation is an "attractor" for national inflation.

Our analysis shows clearly that while fluctuations in commodity prices do have a measurable effect on global inflation, their impact is second-order compared to that of fundamentals, and tends to be relatively short-lived: of the total explanatory power of our full model, three quarters is given by fundamentals (in particular by unemployment) and only one quarter by commodities. Therefore, whether or not we should worry about the pressures currently emanating from energy and food depends on what we think is happening to the fundamental drivers of inflation, i.e. a proxy for demand strength (the unemployment rate), market interest rates and liquidity (the M3/GDP ratio).

The extremely high significance of the unemployment term in both our equations confirms that the short-run Philips curve is alive and well: in the short term the cycle matters. Note that the charts above show that the (global) unemployment rate is now close to what has historically been its lowest level - indeed, most economies are now approaching or are already below an appropriate national measure of NAIRU. Once the unemployment cycle turns, its impact will be strong. However, this will not happen soon. Remember that the unemployment rate affects inflation with a three quarters lag; assuming unemployment remains low for another 3-4 quarters before beginning to rise, it will take almost two years before we see a disinflationary impact from that channel.

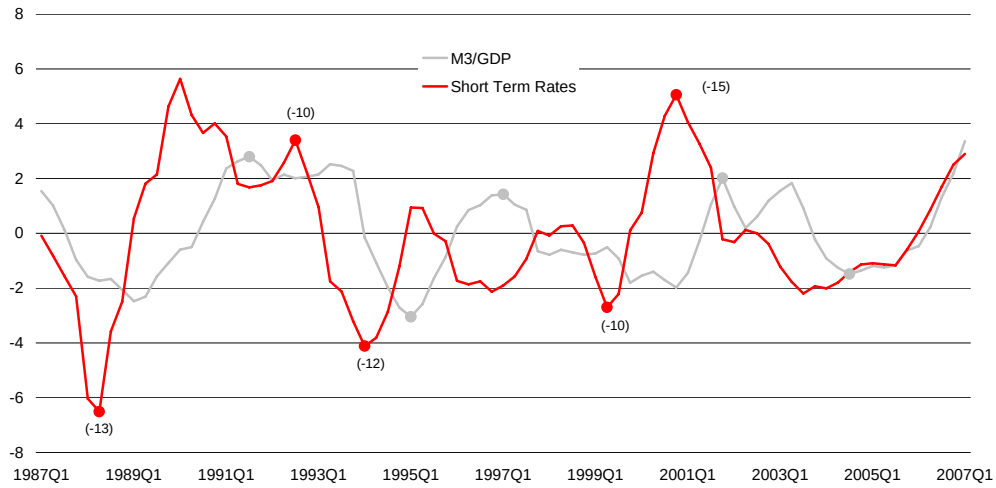
While the unemployment rate is an important driver of inflation, wages and earnings are not. This seems counter-intuitive, as we are all used to central banks' warnings that lower unemployment could trigger higher wage settlements and spark a wage-price spiral. Two considerations are in order here. First, our result suggests that unemployment matters as a proxy for demand conditions rather than supply constraints. As the unemployment rate does a better job at explaining inflation than the output gap, and does not seem to operate through the wage channel, we conjecture that what matters is the cyclical strength of domestic demand, as lower unemployment translates into stronger aggregate purchasing power in the economy. Second, it seems to us that wage price spirals are dormant, not dead. Our analysis shows that prices Granger-cause wages, but not vice versa. In other words, higher inflation does translate into higher wages, but not to the extent that higher wages can feed back into inflation. We believe this is because, over the last twenty years, higher central bank credibility has anchored inflation expectations, stabilizing the wage setting process. If that is true, however, keeping inflation expectations anchored will be essential—we'll come back to this idea below.

With long-term rates already on the rise for two years and the unemployment rate hovering very close to its lowest, it is crucial to detect a possible turning point for our liquidity measure. To this extent, a few observations are in order: over the last years, while central banks have been tightening monetary policy, no meaningful sign of a slowdown in global money growth actually appeared. On the contrary, financial markets were (and are) still awash with liquidity. Our analysis suggests that it might be simply too early to tell whether central banks have lost control over liquidity. The fact that we have not seen a significant impact so far is still consistent with the very long lags between interest rate movements and their impact on liquidity, which emerge from historical evidence.

A simple visual inspection of the relationship between M3/GDP (our variable of interest) and the short-term rate for the 1987-2007 sub-sample period is quite telling. The chart below shows that over the last twenty years, the most notable turning points in short term interest rates tended to

anticipate the M3/GDP ratio by 10 to 15 quarters. The econometric analysis supports this finding and actually suggests a slightly longer lag (15-18 quarters). The implications are quite straightforward. We observe that short-term rates reached their lowest point in Q3 2003: a 15-quarter lag would imply that the turning point for money growth is in sight around the end of the year-beginning of 2008.

LONG LAGS BETWEEN SHORT-TERM RATES AND LIQUIDITY



Beware that our analysis is not suggesting that by that time we will see Global Inflation coming down, as the effects of money will be fully felt only after 12 quarters. Moreover, if financial innovation and accumulation of FX reserves have recently played a role in weakening the relationship between G12 interest rates and liquidity, this effect might not be fully captured by our econometric analysis, and we might therefore be underestimating the transmission lags. In that case, it might take more than another couple of quarters to see the turning point in liquidity, and the corresponding cooling impact on inflation might come no earlier than end-2010.