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The FRBNY Staff Underlying Inflation Gauge: UIG[1]

Marlene Amstad, Simon Potter and Robert Rich

Monetary policymakers and long-term investors would benefit greatly from a measure of underlying inflation that uses all relevant information, is available in real-time, and forecasts inflation better than traditional underlying inflation measures such as core inflation measures. This paper presents the "Federal Reserve Bank of New York (FRBNY) Staff Underlying Inflation Gauge (UIG)" for CPI and PCE. Using a dynamic factor model approach, the UIG is derived from a broad data set that extends beyond price series to include a wide range of nominal, real, and financial variables. It also considers the specific and time-varying persistence of individual subcomponents of an inflation series. An attractive feature of the UIG is that it can be updated on a daily basis, which allows for a close monitoring of changes in underlying inflation. This capability can be very useful when large and sudden economic fluctuations occur, as at the end of 2008. In addition, the UIG displays greater forecast accuracy than traditional measures of core inflation.

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Keywords: Inflation, Dynamic Factor Models, Core Inflation, Monetary Policy, Forecasting

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Contents

1. Introduction

The Consumer Price Index (CPI) and Personal Consumption Expenditure (PCE) deflator released each month are the two most widely followed measures of consumer price inflation in the U.S. From a monetary policy and long-term bond investor perspective, the "headline" measures of both series are too volatile to provide a reliable measure of underlying inflation even after some averaging of the series. As an extreme illustration of this volatility, the headline 12 month change in the CPI was 5.6% in July 2008, fell to zero in December of the same year, and then reached a low of -2.1% in July 2009. Consequently there have been a number of efforts to extract the underlying trend component from the monthly inflation data releases.

The most common technique for measuring underlying inflation is to construct measures of “core” inflation that exclude or down-weight the most volatile prices.[2] One approach excludes the prices of the same specific items. In the U.S., statistical agencies publish core measures of the CPI and PCE that exclude food and energy subcomponents.[3] There is another approach that excludes those goods or services that display the largest price movements (both increases and decreases) in each month, which may differ from month to month. In the U.S., these trimmed mean and median measures are calculated by the Cleveland and Dallas Federal Reserve Banks.[4] There are also strategies that weight inflation subcomponents inversely by their volatility rather than exclude volatile components.

One drawback of these measures is that they do not take into account the time dimension of the different, time-varying persistence of subcomponents of inflation. For example, energy prices are very volatile, but before excluding them from a measure of underlying inflation it is important to examine the persistence of their changes.[5] Modern statistical techniques make it possible to simultaneously combine

2 Going forward, it is instructive to clarify some of the terminology in the analysis. We use the terms ‘traditional underlying inflation measures’, ‘core inflation measures’, and ‘exclusion based measures’ interchangeably (see section 2.2), while the term ‘underlying inflation measure’ denotes an overarching category that also includes ‘data rich-based approaches’ (see section 2.3). In terms of core inflation measures, we focus on the ex-food and energy measure, the trimmed mean, and the median. As noted above, we will refer to all three measures as exclusion-based measures, even though the trimmed mean and median are technically limited-influence estimators. We do this for ease of exposition as well as from the recognition that all three estimators involve the exclusion of inflation subcomponents, although they use different criterion to select the excluded subcomponents.

3 Bryan and Cecchetti (1999) provide an overview of different additional components excluded from the CPI by different central banks. In the 2009 comprehensive revisions of the national income and product accounts, the definition of core PCE was changed to incorporate restaurant prices. Meyer et al. (2013) evaluate different versions of trimmed mean measures and highlight the advantage of the median CPI.

4 See Bryan and Cecchetti (1994) for trimming based on fixed percentages and Bryan, Cecchetti, and Wiggins (1997) for time-varying percentages. Dolmas (2005) describes the construction of the trimmed mean PCE.

5 A temporary increase in oil prices is the classic example of a relative price movement to which monetary policy makers should not react. Because of the nature of their construction, traditional underlying inflation measures all suffer from the same shortcoming: what is temporary only becomes clear in retrospect, and not in advance. On several occasions, James Hamilton and Menzie Chinn have written blog posts on oil prices that illustrate this point. While it may have been

information from both the cross-sectional distribution of prices as well as time-series properties of individual prices in a unified framework. The statistical techniques, known as large data factor models, are widely used to complement existing measures of real activity and underlying inflation.[6] In this paper we use the large data factor approach of Forni *et al.* (2001) to develop underlying measures of CPI inflation and PCE inflation that also take into account the aforementioned issue of persistence of their subcomponents. We refer to the resulting series as the Federal Reserve Bank of New York (FRBNY) staff underlying inflation gauge (UIG).[7]

Unlike many large data set approaches using US data, we include all of the non-seasonally adjusted disaggregate price components for the overall CPI and PCE deflator to construct the relevant UIG measure. Furthermore, the FRBNY UIG allows for a broad range of additional nominal, real and financial variables – such as labour market data and asset prices – to influence the measure of underlying inflation. There is no objective criterion to judge which data should or should not be included in such a broad data set. Consequently, we rely on the experience gained by the FBRNY staff in modelling inflation to determine which data to include. The data set includes the series that FRBNY staff considers to be the most relevant and stable determinants of future inflation. The data set has remained the same since the inception of the UIG in 2005.

Forecasting headline inflation

An extensive literature examining measures of underlying inflation concludes that there is no single gauge that consistently outperforms the others based on a number of criteria.[8] However, the criteria of greatest interest to most policymakers and market participants are the capability of an underlying inflation measure to track and forecast inflation. We find that the UIG clearly outperforms traditional core

reasonable to exclude the oil price increases in the 1970s from core inflation measures back then because they were temporary in nature, it makes much less sense to do so now because oil price increases appear to be more permanent due to limited supplies and growing demand for energy. Furthermore, Cecchetti (2007) points out that the exclusion of energy from this measurement has imparted a bias to medium-term measures of inflation.

6 For Euro Area GDP, the Centre for Economic Policy Research (CEPR) produces EuroCoin, which is publicly available on a monthly basis (see Altissimo *et al.* (2001)). For US GDP, there is the Chicago Fed National Activity Index that is based on the methodology of Stock and Watson (1999). For US inflation, Reis and Watson (2010) use a dynamic factor model to separate absolute from relative price changes. For Euro Area inflation, see Cristadoro *et al.* (2001). Altissimo *et al.* (2009) use a dynamic factor model to investigate the persistence in aggregate Euro Area inflation. For inflation in Switzerland, the Swiss National Bank (SNB) produces a gauge called dynamic factor inflation (DFI) which is evaluated daily (see Amstad and Fischer (2009a and b)). See Giannone and Matheson (2007) for a quarterly inflation measure in New Zealand. See Khan et al (2013) for a monthly inflation measure in Canada.

7 UIG is the outcome of a stay of Marlene Amstad as Resident Scholar in 2004/2005 at the Federal Reserve Bank of New York while then being with Swiss National Bank and regular follow up visits. An earlier version has been published as FRBNY staff report No 402 under the title "Real Time Underlying Inflation Gauges for Monetary Policymakers" (2009). It draws from earlier experience to develop a similar gauge (DFI, dynamic factor inflation) for Switzerland with Andreas Fischer (SNB, CEPR).

8 See for example, Rich and Steindel (2007) and therein given references. More recently, Stock and Watson (2008) gave a comprehensive analysis supporting this assessment including a number of models that use output gaps.

inflation measures in terms of tracking trend inflation as well as in forecasting inflation over different time periods (before and during the recent financial crisis).

There is another extensive literature that examines whether measures of real activity improve inflation forecasts. Stock and Watson (2008) find that a simple random walk specification (i.e., using the most recently observed annual change in inflation to forecast future inflation) is at least as accurate as most forecasting models that include measures of real activity, confirming the earlier result of Atkeson and Ohanion (2001). We find that the UIG outperforms a random walk specification in a pseudo out-of-sample forecast exercise and in a genuine out-of-sample forecast exercise from November 2006 to July 2012.[9]

Analysis of underlying inflation in real-time

For monetary policy makers and long term bond holders, a desirable property of a measure of underlying inflation is that it should remain fairly stable in normal times, but change quickly in times of crisis. We show that in past non-crisis periods, the UIG changed very slowly and did not overly react to incoming news. However, in times of turbulence, such as in 2008, the UIG was very responsive to the worsening of the economy and offered a daily signal of the speed and scale of changes in underlying inflation. This contrasts with the monthly data releases of headline and traditional underlying inflation measures, as well as the lag in the ability of traditional underlying inflation measures to signal changes in inflation trends.

Aside from forecasting inflation, daily UIG updates can also be used to identify the sources of a change in inflation forecasts by determining the impact of a particular economic or financial news release (e.g., unemployment rate or ISM number) on underlying inflation. Amstad and Fischer (2009a and b) provide an example of this type of analysis using an event study approach for Swiss inflation.

The remainder of the paper is organized as follows. Section 2 discusses a suite of measures of underlying inflation and relates them to the data rich approach of the UIGs introduced in this paper. Section 3 describes the data environment used to construct the real-time UIGs and provides a non-technical description of the estimation procedure and a rationale for our chosen parameterization. In section 4, the UIG is compared to traditional underlying inflation measures using descriptive statistics as well as a forecasting exercise.

The UIG was first constructed during 2005 and has been updated since then usually at a daily frequency. Throughout the paper, we add some discussion of the real-time modelling experience with the UIG. Based on this real-time experience, we conclude that the UIG adds value relative to traditional core inflation measures for monetary policymakers and long-term bond holders.

9 This is a genuine forecast comparison exercise because the UIG forecasts were produced in real-time as part of the forecasting process at the FRBNY.

2. Underlying inflation: concepts and methodology

In this section we review the concept of underlying inflation. We emphasize the difference between exclusion-based measures and data rich-based approaches. The discussion motivates our definition of underlying inflation, choice of methodology, data set, and parameterization of the selected factor model.

2.1 Defining underlying inflation

The term "core inflation" is widely used by practitioners as well as in academia to represent a measure of underlying inflation that is less volatile than a headline measure. However, there is no exact and widely accepted definition of underlying inflation. For any observed headline inflation rate π_t, we can always decompose it as:

$$\pi_t = \pi_t^* + c_t \tag{1}$$

where π_t^* denotes the underlying rate of inflation and c_t denotes deviations of inflation from the underlying rate.

Some examples of measures of underlying inflation for the U.S. are:

- *Core ex food and energy*: for both the CPI and PCE, the measure excludes food as well as energy goods and energy services. For the US this measure also excludes "food away from home" in the CPI, whereas other countries often only exclude fresh food because "food away from home" is not very volatile. We will denote these measures by the extension XFE.
- *Core ex energy*: for both the CPI and PCE, this measure excludes all energy goods and energy services.
- *Core PCE market based*: this measure excludes all food, energy goods, energy services, and a number of imputed prices for financial and medical services.
- *Trimmed mean CPI/PCE*: these measures exclude goods and services with the largest price movements (increases and decreases). For example, the 8% trimmed mean would exclude good and services whose price movements were located in the bottom 8% and top 8% of the price change distribution based on expenditure weights. We will denote these measures by the extension TM.
- *Median CPI*: this measure is a special case of the trimmed mean CPI/PCE. It is constructed as the good or service associated with median price change based on expenditure weights. We will denote this measure by the extension MED.
- *Model-based approaches*: These measures are derived from economic theory, with the principal example being forecasts from Gordon (1982) "triangle" type models. The triangle model is a common approach to modeling inflation in the Federal Reserve System (see Rudd and Whelan 2007).
- *Unobserved component models:* These measures are based on time series methods that attempt to extract a persistent component of inflation. Simple univariate examples are the exponential smoothed model of Cogley (2002) and the stochastic volatility model of Stock and Watson (2007). More complex multivariate examples are the Chicago Fed National Activity Index for GDP and the model for inflation used in this paper.

- *Market or survey based approaches:* These measures are derived from financial markets (e.g. treasury implied securities or TIPS) or surveys of inflation expectations (e.g. University of Michigan Consumer Inflation Expectations).

The FRBNY staff UIG defines underlying inflation as:

$$E_t\left[\pi_{t+h}\right] \rightarrow E_t\left[\pi^*_{t+h}\right] \quad as\ h\ increases. \tag{2}$$

where π_{t+h} denotes inflation in period $t+h$ and π^*_{t+h} denotes the underlying rate of inflation in period $t+h$. That is, a policymaker following underlying inflation would only react to changes in inflation until the forecasted level of inflation converges to desirable levels at medium horizons. Note that if the expectation of underlying inflation $E_t\left[\pi^*_{t+h}\right]$ satisfies the above property, then it implies that the transitory component converges to zero in expectation as the horizon extends into the future, i.e. $E_t\left[c_{t+h}\right] \rightarrow 0$. Thus, a desirable property of a measure of underlying inflation is that it should capture the persistent component in inflation at the horizon of interest to policymakers. This can be very different from simply constructing a less volatile measure of inflation.[10]

2.2 Traditional underlying inflation measures

The focus on measures of core inflation gained attention in the 1970s as headline inflation was influenced by large oil price movements. This experience triggered the construction of a variety of different "CPI ex some subcomponent" gauges, either in the form of measures that always exclude the same subcomponents (as in the ex food and energy measure) or allow the excluded subcomponents to vary over time (as in the trimmed mean or median measures). However, the practice of excluding volatile components to derive a measure of underlying inflation suffers from several disadvantages.

In the case of the ex food and energy measure, the specific subcomponents to be removed are determined in a strictly backward looking manner based on the historical behavior of the "noise" that has appeared in the inflation release. In their comprehensive comparison of core inflation measures, Rich and Steindel's (2007) conclusion that no single core measure outperforms the others over different sample periods is due to the fact that there is considerable variability in the nature and sources of transitory price movements.

Additionally, in the case of the trimmed mean measure, the excluded subcomponents are determined by a technical criterion. Usually the cut-off percentage (whether symmetric or not) is fixed to the value that minimizes the errors in forecasting underlying inflation (with the latter often defined as a centered 36-month moving average of CPI inflation). However, by excluding components that display large price changes (of either sign) and only including components that display more moderate price changes, the reduced volatility may also remove any early signals of changes in the inflation process that tend to show up in the tails of

10 An advantage of our concept compared to traditional underlying inflation measures is that it allows us to focus on a particular horizon of interest. As discussed in section 3.2, we will define the horizon of interest of policy makers to be 12 months or longer due to the limited ability of policymakers to affect fluctuations in inflation over shorter horizons.

the price change distribution. Therefore, even though the average forecast error might be low using an exclusion-based approach, the core inflation measure might be a lagging indicator at turning points.

Core inflation measures that exclude large price changes are subject to another criticism. In particular, critics argue that excluding the largest price changes limits movements in inflation by definition, and thereby narrows the range of possibly reported outcomes. For example, many analysts argue that the sustained oil price increase through mid-2008 should have been interpreted as a signal about the trend in price changes and not as a series of temporary outliers. Their argument was based on the view that oil price increases since 2000 were driven mostly by long-term supply and demand considerations rather than short-term supply disruptions – the traditionally cited reason to exclude oil prices. In this case, excluding the direct effects of oil would be misleading or at least produce a lagged inflation signal. This example demonstrates the need for underlying inflation measures to be able to smooth short-term volatility in inflation without neglecting potentially informative price changes.

2.3 Data rich models of underlying inflation

Given the limitations of measures of underlying inflation that exclude volatile variables, we look into measures based on data rich models.[11]

Characteristics of data rich models

One of the most prominent differences between exclusion-based measures of underlying inflation and data rich models of underlying inflation is that the focus of the latter is not limited to an inflation measure or its subcomponents. Simplicity is the main advantage of the exclusion-based measure, and its performance, as shown by Atkeson and Ohanion (2001), can be very similar or even better than more complicated approaches. From a policy perspective as well as from a forecasting perspective, however, there are several reasons why it is beneficial to add, rather than exclude, information to measure underlying inflation. As argued in Bernanke and Boivin (2003), monetary policymaking operates in a "data rich environment". Furthermore, Stock and Watson (1999, 2008) show that a broad information set can improve forecast accuracy in certain time periods. Therefore, several authors (including Gali (2002)) argue that a policymaker would benefit from a comprehensive measure that extracts and summarizes the relevant information for inflation from a broader data set.

One popular approach that includes other variables than just inflation data is based on Gordon (1982) and the estimation of a backward looking Phillips curve type model. This approach considers labour market information along with price data and additional covariates to capture exogenous pricing pressures such as those from energy. Underlying inflation measures can then be derived by specifying the

[11] We refer to a 'data rich model' as a model that uses a broad data set that is larger than what a regression could accommodate without introducing multicollinearity and degrees of freedom issues.

future path of exogenous covariates and generating forecasts from the model.[12] A criticism of this particular approach is that it is very sensitive to the particular model specification (see Stock and Watson 2008).

Factor models

Another class of data rich models are factor models, which aim to summarize the information contained in many variables into a small number of variables – referred to as factors. We investigate the use of factor models, which has three main advantages: a broad data approach, flexibility, and smoothness.

(a) broad representation of economic developments

First, factor models can be applied to a particularly broad information set and used to summarize price pressures in a formal and systematic way. In the various exclusion-based measures, some individual goods and service prices are omitted. Factor techniques allow us to use all the information in the monthly US CPI inflation report. Furthermore, there are many other time series that may be useful to measure underlying inflation. Specifically, information about future price pressures is incorporated in real and financial variables. For example, slack or tightness in product and labour market are often cited as possible determinants of inflation. However, none of this information is used to construct traditional underlying inflation measures.

(b) flexible weighting scheme

Second, standard Phillips curve models rely on one measure of slack and are vulnerable to specification errors in this regard. The factor model approach allows information to be extracted in a flexible manner from a very large data set. When estimating the factors, the correlations between the variables are considered without imposing any restriction on sign or magnitude. This differs from the strong assumptions often made, for example, in structural VAR-models.

(c) smoothness

Third, the type of factor model used to construct the UIG – the dynamic factor model – allows for an evaluation of whether a large movement in a particular price is likely to persist over a specified period of time (e.g., 12 months or longer). If the price movement is likely to persist, then it will influence the estimate of underlying inflation. In contrast, traditional exclusion-based measures will initially ignore a large price movement (e.g. in energy prices) and only incorporate it at a later date if and when the price movement has passed-through to the prices of other items included in the exclusion-based measure.

3. FRBNY Staff Underlying inflation gauge (UIG)

The Federal Reserve Bank of New York (FRBNY) Staff UIG examines a broad data set and uses up-to-date statistical techniques in its derivation. In this section we

[12] For example, one could specify a path for energy prices based on futures market information.

describe the data set, the estimation procedure as well as the parameterization of the model.

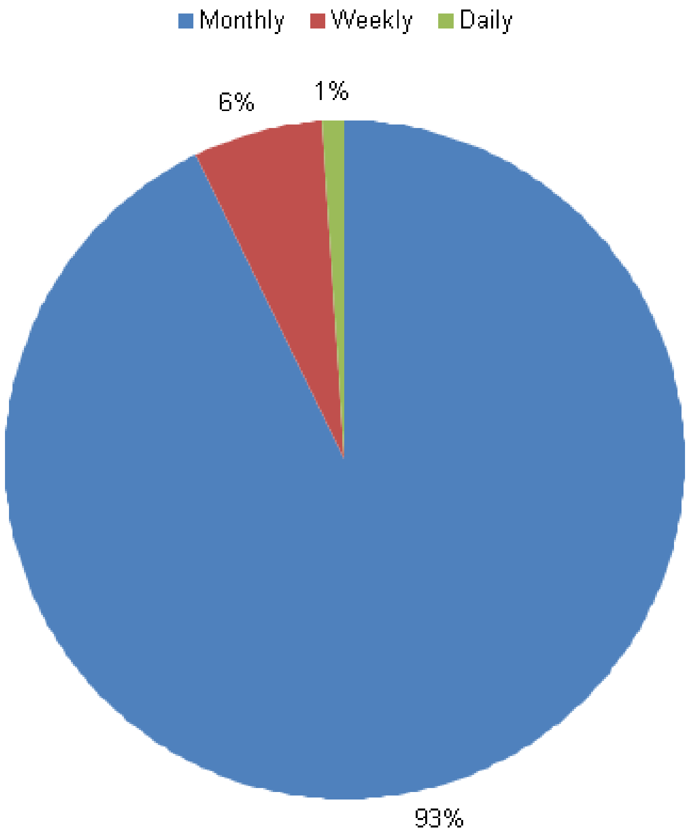
3.1 Data

Sample range

Based on substantial evidence of structural breaks in the US inflation process (see Clark (2004) and Stock and Watson (2008) for a comprehensive evaluation), we limit our analysis to the period starting in January 1993. For similar reasons, the OECD (2005) divides the sample for a multi-country study of inflation into the sub periods 1984-1995 and 1996-2004. In addition, there is a tension between our data rich environment approach and the statistical methodology that requires a balanced data set to start the estimation, requiring us to strike a balance between the length of the time period of the study and the range/broadness of time series we can use. These considerations reinforced the choice of January 1993 as the start date, as an earlier time period would have limited significantly the number of times series that could be considered for the analysis.

Breakdown of UIG Series by Frequency

Figure 1a

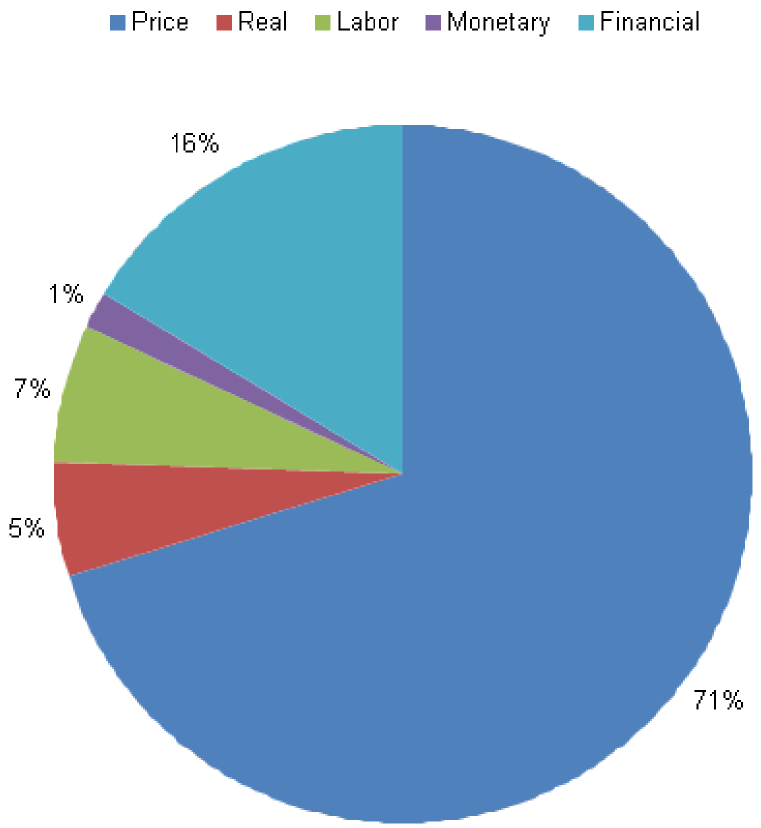


We use two data sets from the following broad categories: (i) goods and services prices (CPI, PPI); (ii) labor market, money, producer surveys, and financial variables (short and long term government interest rates, corporate and high yield bonds, consumer credit volumes and real estate loans, stocks, commodity prices).

We refrain from including every available indicator that could have a possible impact on inflation because research on factor models (see Boivin and Ng (2006)) shows this does not come without risks.[13] Our approach is to include the variables that were regularly followed by the FRBNY staff in their assessment over several economic cycles. This procedure has the benefit of drawing upon their long-term experience and maintains some continuity in the set of variables on which the UIG is based. Ideally, the variables considered to construct the UIG remain the same over several cycles, so as to assure that a change in the UIG is not caused by changes in the data composition through the addition or removal of series. The weighting of each series in the UIG changes over time and is determined by the factor model. Figures 1a and 1b provide more information on the current data set used, while the Data Appendix provides a detailed listing of the variables.

Breakdown of UIG Series by Type

Figure 1b



[13] Their results suggest that factors estimated using more data do not necessarily lead to better forecasting results. The quality of the data must be taken into account, with the use of more data increasing the risk of 'leakage of noise' into the estimated factors.

Stability of UIG when data are revised

In order to derive a signal of underlying inflation for monetary policymakers, stability of the most current estimates becomes an important issue. Therefore, nearly all of the data selected is not subject to revision. This implies that we must rely heavily on survey data for measures of real activity and not use more traditional measures based on the National Income and Product Accounts. Another advantage of survey data is that it is usually released more quickly than expenditure and production data. Additionally, we only use non-seasonally adjusted data and, following Amstad and Fischer (2009a and b), apply filters within the estimation procedure to generate a seasonally adjusted estimate of underlying inflation. The main reason for adopting this approach is that it prevents revisions in our measure of underlying inflation from being driven by concurrent seasonal adjustment procedures.

As is standard in the factor model literature, prior to estimation the data is transformed to induce stationarity and each series is standardized so that it has zero mean and unit variance. The standardization process requires us to assign an average value for the measures of underlying inflation derived from the analysis. We use 2.25% for the CPI and 1.75% for the PCE. When we began the project at the end of 2004, these numbers were very close to the respective average inflation rates starting from 1993.[14]

Real-time updates

The UIG is designed as a model of monthly inflation that is updated daily as suggested by Amstad and Fischer (2004, 2009) in their work using Swiss data. The monthly dating of the UIG is motivated by the monthly frequency of inflation reports in the U.S. The daily updates allow for a close monitoring of the inflation process and also provide a basis for monetary policymakers to assess movements in underlying inflation due to daily changes in financial markets between monthly inflation reports.

3.2 Estimation procedure

We follow the dynamic factor model approach of Forni, Hallin Lippi and Reichlin (2000), which draws upon the work of Brillinger (1981) and extends it for use with large data sets. An econometric summary of the procedure is given in the Technical Appendix of Amstad and Potter (2009). In this section, we motivate the choice of

[14] A growing number of countries establish their monetary policy more or less explicitly according to an inflation target. In these countries the information on the inflation targeting regime is useful for constructing the measure of underlying inflation. In particular, if the country has a point target, then the average of the underlying measure should be at this point target. A feature of the dynamic factor model technique we use is that it does not directly provide an estimate of the average of the underlying measure. Thus, in countries with inflation targets the target can be used as the average. When we started this analysis, the Federal Reserve had not stated a numerical inflation goal. In January 2012, the FOMC agreed to a longer-run goal of a 2 percent PCE inflation rate. This is higher than the value we have assumed for PCE inflation but, according to some estimates, is close to our assumption for CPI inflation.

important parameters of the model.[15] In particular, we discuss the time horizon of interest for the UIG, as well as the number of factors used to summarize the information content of the whole data set.

Horizons of interest

We want the UIG to be useful for monetary policymakers and long-term investors. Lags in the monetary transmission mechanism suggest that inflation at a horizon of one year or less is relatively insensitive to changes in current monetary policy, and therefore there is little that policymakers can do to affect these fluctuations in inflation. Consequently, if monetary policy has been achieving its objective of price stability with well anchored inflation expectations, then the effects of current movements in monetary policy on expected inflation will be at horizons greater than 12 months. Thus, we focus on horizons of 12 months and longer to extract the factors.[16]

Number of factors

Different papers find that much of the variance in U.S. macroeconomic variables is explained by two factors. Giannone, Reichlin and Sala (2005) show this result using hundreds of variables for the period 1970-2003, as well as Sims and Sargent (1977) who examine a relatively small set of variables and use frequency domain factor analysis for the period 1950-1970. Watson (2004) notes that the two-factor model provides a good fit to U.S. data during the post-war period, and that this finding is quite robust. Hence, in most large data factor model applications the number of factors is set to two.

The factors in a data set can be interpreted as 'drivers' of the data set. It is often claimed that one factor is associated with real variables (such as GDP or aggregate demand), while the second factor is associated with nominal prices (such as the CPI). Our choice of the number of factors is not based on this consideration. Rather, our aim is to include the lowest number of factors needed to represent our data environment properly, without any attempt to label the factors (as either real or nominal) or to interpret them.

We start our examination of the UIG measure by presenting estimates based only on price data from the CPI and PCE, respectively.[17] One would expect these series to be driven by one single factor. Figures 2a and 2b show, respectively, the estimates for the UIG for CPI inflation and PCE inflation assuming 1 and 2 factors along with the 12 month change in the relevant price index. As shown, there is little difference between the two estimates. Further, the movements in the estimates are

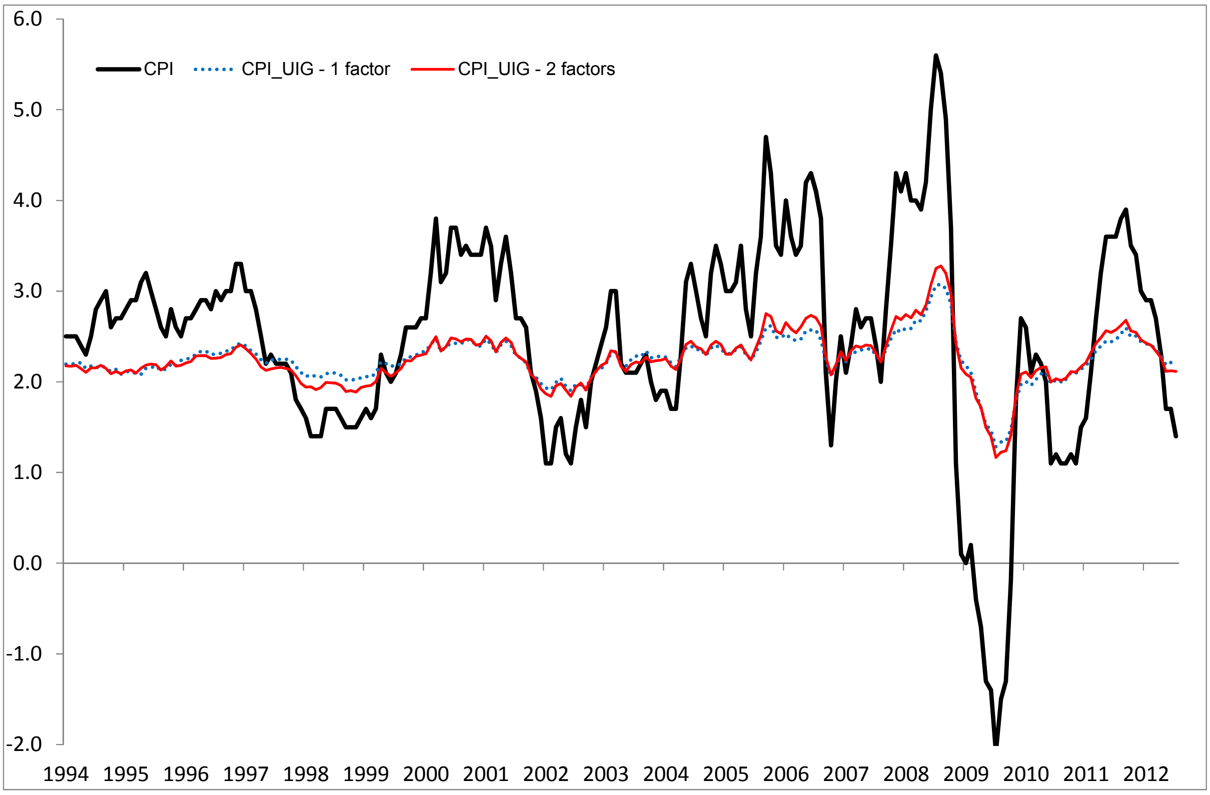
15 Please note that the approach in this paper allows us to set these parameters exogenously. For FRBNY internal analysis different parameter settings are evaluated on a regular basis (e.g., different time horizons).

16 In practice, the estimation is done directly in the frequency domain, as described in the Technical Appendix of Amstad and Potter (2009)

17 We refer to these as CPI_UIG_Prices Only and PCE_UIG_Prices Only, while CPI_UIG and PCE_UIG will refer to the UIG measures derived from using all the variables shown in Data Appendix.

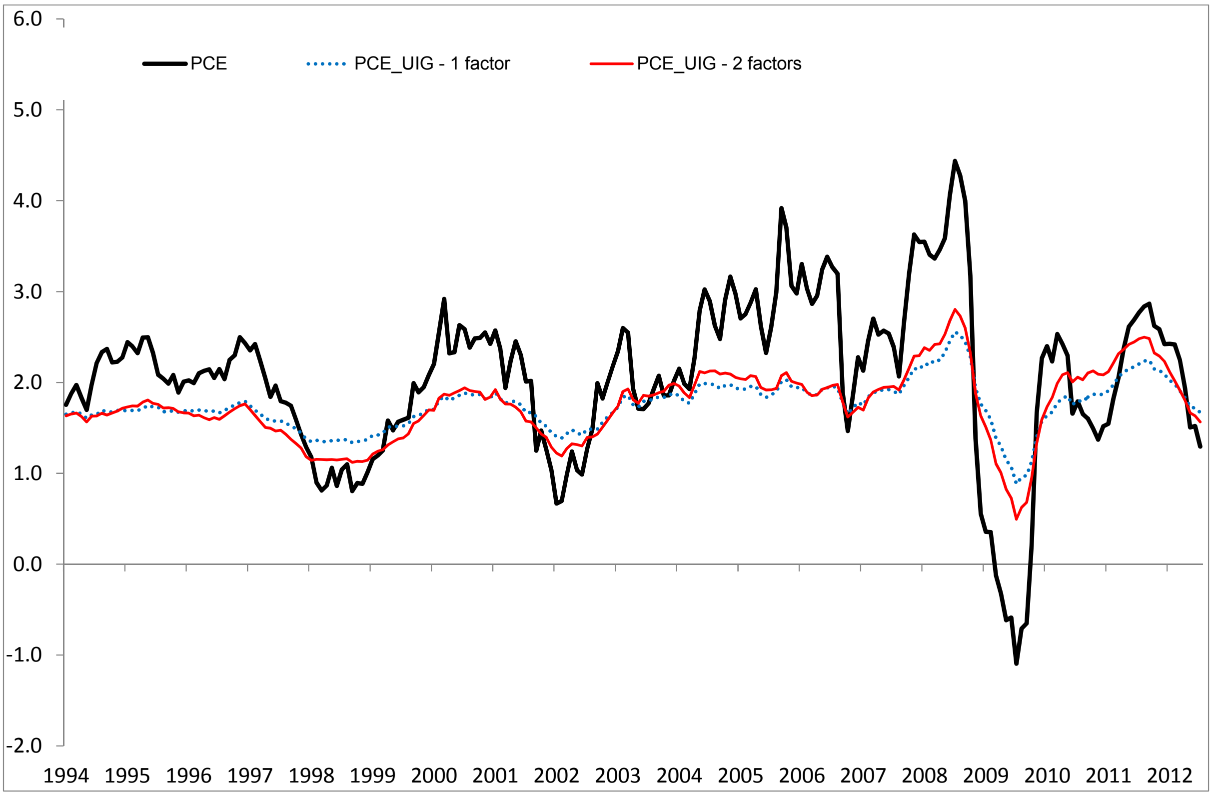
CPI_UIG_Prices Only

Figure 2a



PCE_UIG_Prices Only

Figure 2b

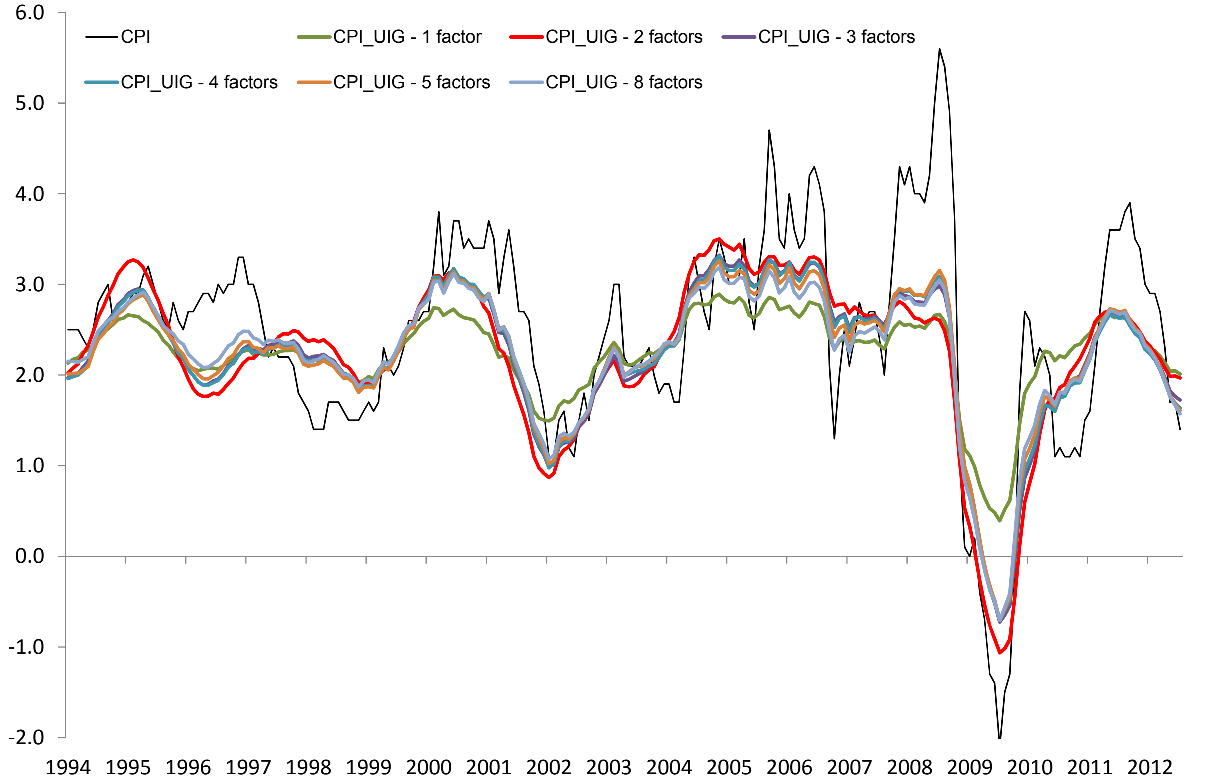


generally very smooth when we only consider frequencies of 12 months or longer, with the exception of those observed during the 2008-2011 period.[18]

Figures 3a and 3b show the estimated UIG for a range of 1 through 8 total factors, where we now add the non-price variables in our dataset through July 2012. Three findings are noteworthy. First, the estimates now show larger cyclical fluctuations. Second, starting in 2005 they correctly capture a broadly downward sloping trend despite the temporary large increase in inflation in the first half of 2008. Third, there is usually little difference between the estimates based on 2 or more factors, with the exception of two episodes that occurred during the mid-1990s and from 2008 through the end of 2011.

CPI_UIG

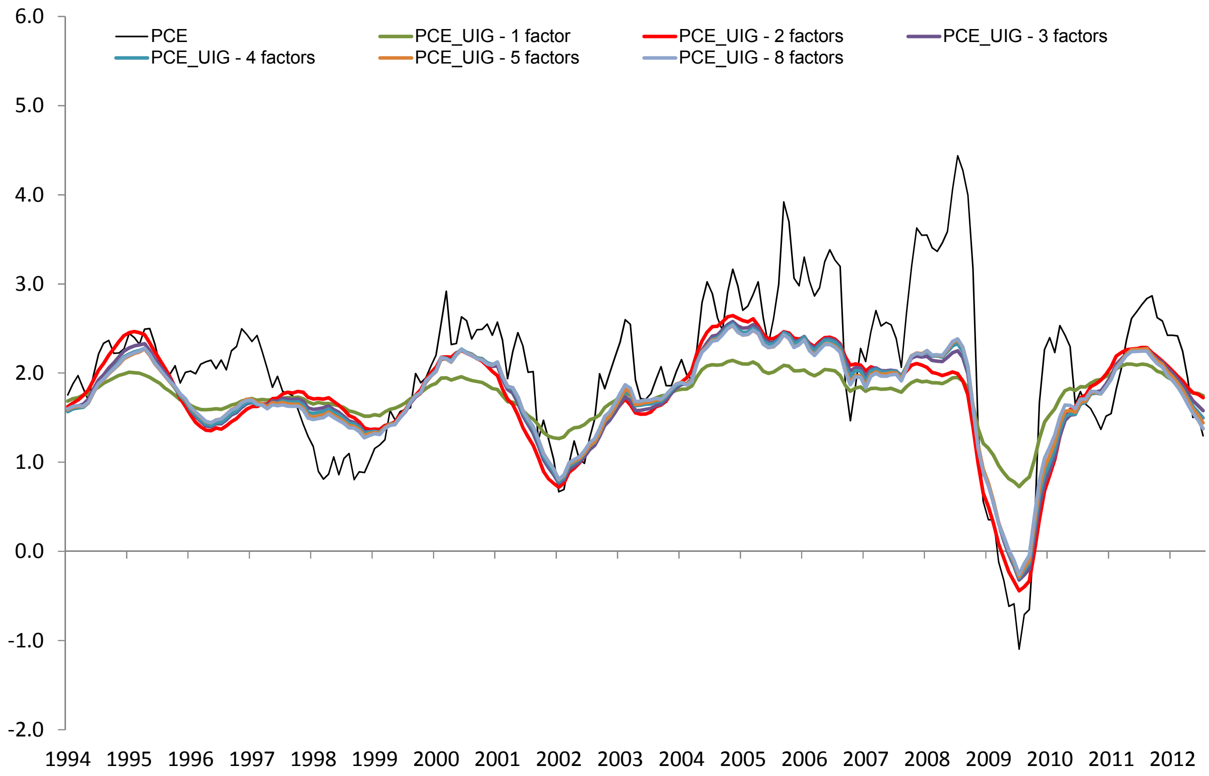
Figure 3a



18 We investigated the issue of smoothness during our initial work in the initial construction of the UIG in 2005 through the following experiment: take a monthly CPI release and scale up all of the 211 time series by a fixed amount. The result of the experiment was a big upward movement in the UIG indicating that the method could capture a common movement in all of the individual price series. Later, during the financial crisis in 2008/09, the smoothness of the UIG was revisited through a real world example. Again, as will be further illustrated in section 4, the UIG displayed a big change that reflected the large movements in the underlying data. It should be noted that if we were to include all frequencies in the estimation of the UIG, then as would be expected there would be a very close correspondence between the movements in total inflation and the UIG.

PCE_UIG

Figure 3b



4. Comparing measures of underlying inflation

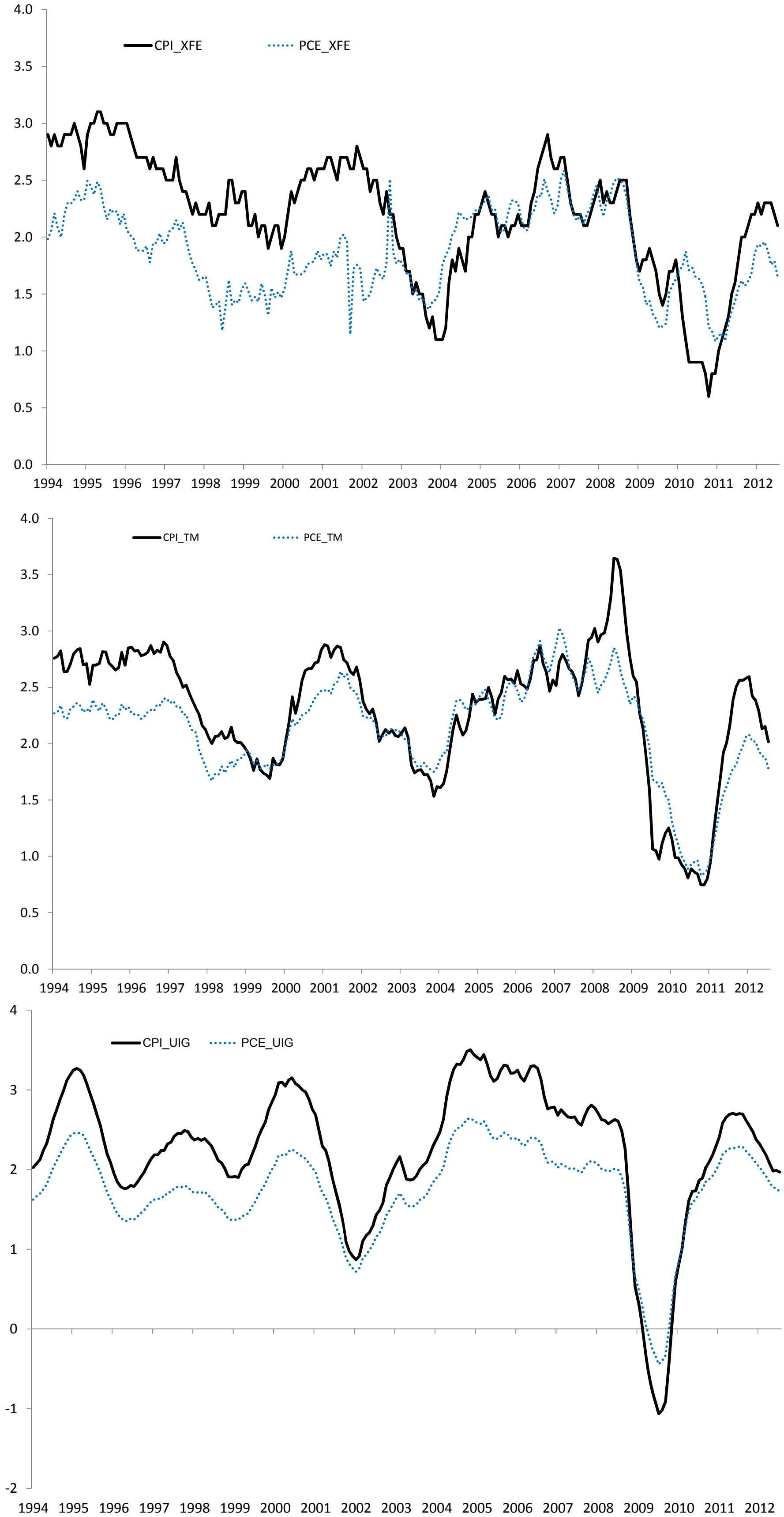
This section compares well-known traditional underlying inflation measures (core inflation measures) and the UIG measure for CPI and PCE inflation. First we comment on general statistical differences. Next we turn to the time series features of the various underlying inflation measures and compare their ability to track as well as to forecast inflation.

4.1 General statistical properties

We find that the general behaviour of the different measures of underlying inflation is mainly driven by the choice of methodology (see section 2) and less by the choice of the price index. This is illustrated by the time series plots in Figures 4a-c that depict the same underlying inflation measure for different price indices. In Figures 5a and 5b we show the various underlying inflation measures for each price index. We now comment on three main statistical features of the underlying inflation measures: smoothness, correlation with headline CPI inflation and headline PCE inflation, and the correlation between the UIG for CPI inflation and the UIG for PCE inflation.

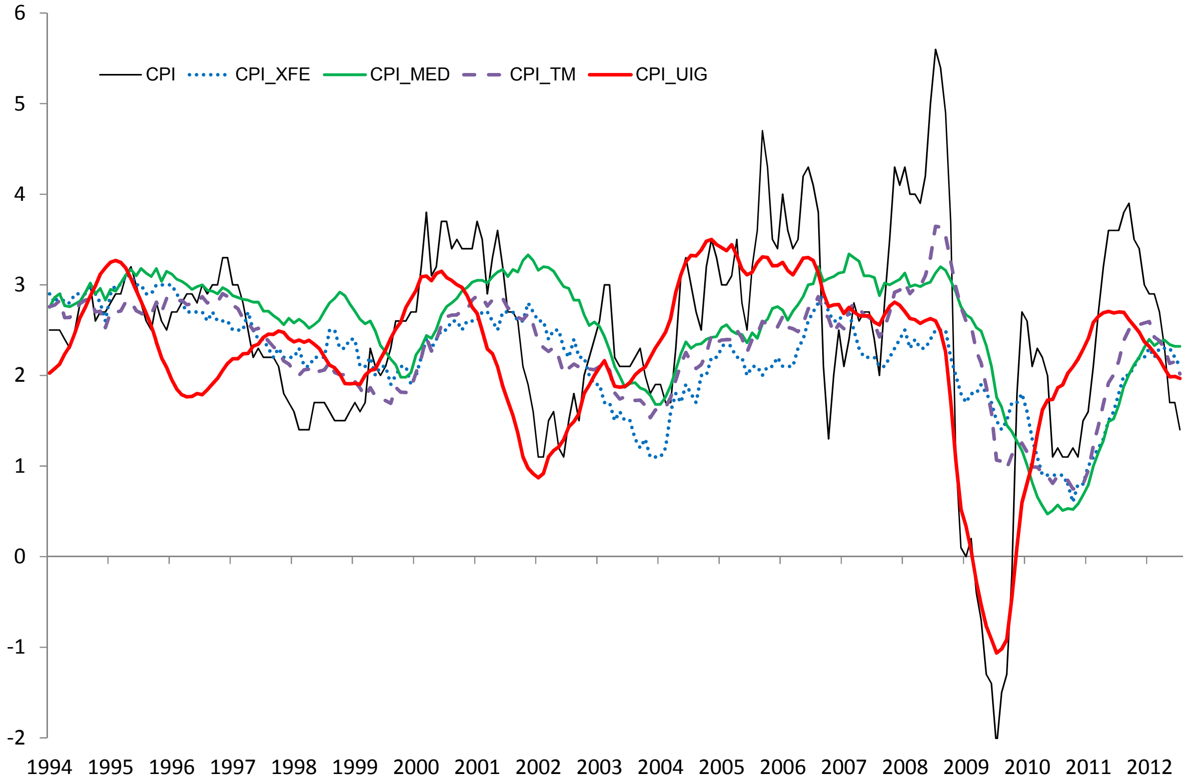
Comparing different underlying inflation gauges for CPI and PCE

Figure 4a-c



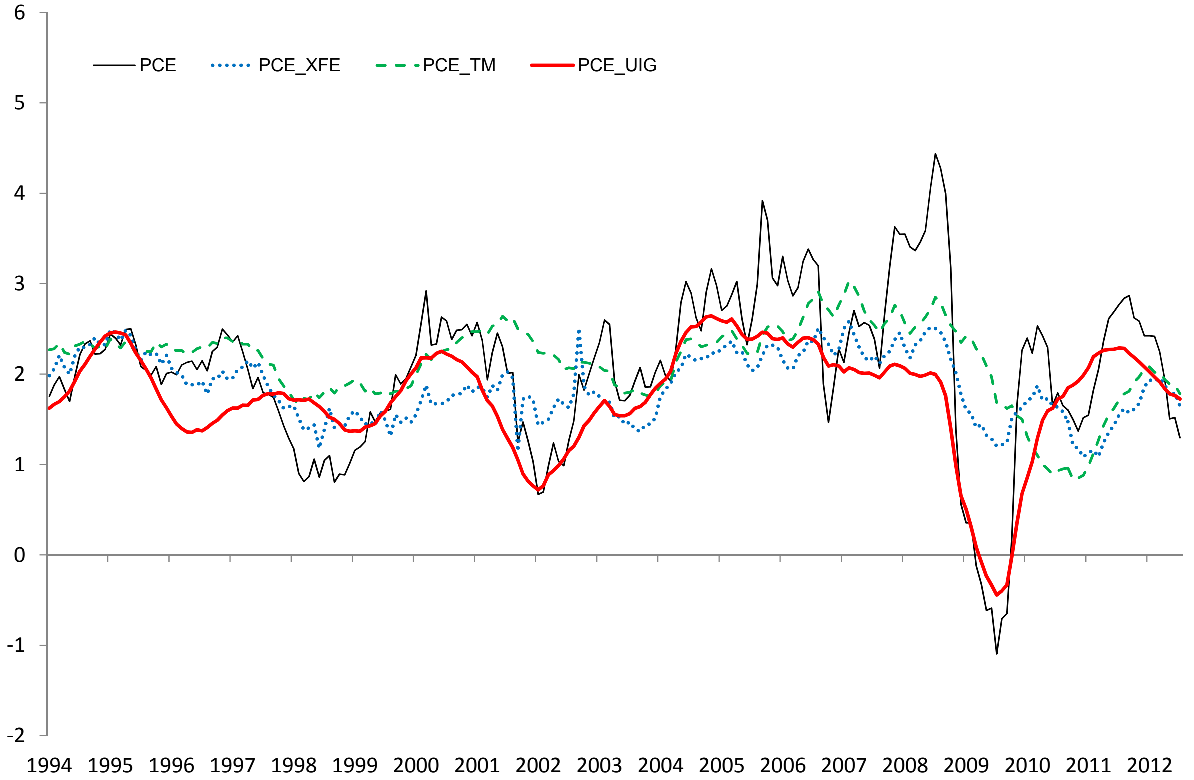
Different underlying inflation gauges for CPI

Figure 5a



Different underlying inflation gauges for PCE

Figure 5b



First, based on standard deviation metrics (see Table 1), the UIG (augmented by the non-price variables) is less volatile than CPI / PCE inflation but more volatile than the traditional underlying inflation measures. However, standard deviation metrics consider volatility across all frequencies, from high to low. Figures 4a–c show that the UIG displays the lowest short run volatility – that is, the UIG provides the smoothest signal at high frequencies. This should not be surprising because the UIG focuses on cycles of 12 months or longer. Thus, the ex-food and energy measure and, to a lesser extent, the trimmed mean provide a signal that retains some high frequency volatility, which then makes it more difficult for a policymaker to determine if a change in core inflation measures merit a policy action.

Second, the UIG closely tracks headline CPI/PCE inflation and at the same time is able to provide additional information to the policymaker that is not included in traditional underlying inflation measures. Compared to popular core inflation measures, the UIG displays the highest correlation with CPI inflation and PCE inflation respectively (see Tables 2a and 2b). Meanwhile, the UIG is less correlated with traditional underlying inflation measures, although this finding holds more for the CPI than PCE. However, in both cases it is evident that the UIG is providing a different signal than the traditional underlying inflation measures. This conclusion is confirmed by a simple principal components analysis (PCA) on the CPI and underlying inflation measures that include the UIG.[19] As shown by the factor loadings given in Table 3, the traditional underlying inflation measures are grouped in the first principal component, while the UIG and CPI inflation are grouped in the second principal component.

Third, although there are clear differences between the UIG for CPI inflation and the UIG for PCE inflation, they are highly correlated with each other as can be seen in Table 2c. This is also true if we restrict the data set for extracting factors to prices only. Going forward, we will focus more on the CPI-based UIG to save space and because it has the advantage that the CPI is only subject to very minor and rare revisions whereas the PCE is subject to major revisions especially in the non-market based prices.[20]

4.2 Forecast Performance

A central reason for developing underlying measures of inflation is that they should produce more accurate forecasts of inflation than those generated using only the headline measure. For any evaluation, it is particularly important that the forecast exercise reflects a realistic setting. Following Cogley (2002) and others, we initially evaluate the within-sample performance of the various measures of underlying inflation by estimating the following regression equation for horizon *h*:

$$\pi_{t+h} - \pi_t = \alpha_h + \beta_h \left(\pi_t - \pi_{mt} \right) + \mu_{t+h} \qquad (3)$$

[19] Principal component analysis arranges variables in groups (referred to as principal components) based on their statistical behaviour. This is done in a way to assure by construction that variables with similar behaviour are grouped in the same principal component, with each of the principal components uncorrelated with each other.

[20] However, both underlying inflations gauge for CPI (CPI_UIG) and for PCE (PCE_UIG) are calculated by the FRBNY internally.

where π_{mt} denotes the relevant measure of underlying inflation. Two desirable properties of an underlying measure of inflation are unbiasedness $(\alpha_h = 0 \; and \; \beta_h = -1)$ and the capability to explain a substantial amount of the future variation in inflation. If β_h were negative but less than one in absolute value, then the deviation between headline inflation and the underlying inflation measure $(\pi_t - \pi_{mt})$ would overstate the magnitude of subsequent changes in inflation, and thus would also overstate the magnitude of the current transitory deviation in inflation. Similarly, if β_h were negative but greater than one in absolute value, then the deviation between headline inflation and the underlying inflation measure would understate the magnitude of the current transitory deviation in inflation. This specification also nests the random walk model of Atkeson and Ohanion (2001) when $\alpha_h = \beta_h = 0$.

When equation (3) is estimated within sample, our main interest is testing for unbiasedness and whether the transitory deviation in inflation displays the correct size $(\beta_h = -1)$. Using a long sample period and examining traditional underlying inflation measures, Rich and Steindel (2007) find that the property of unbiasedness can be rejected, but there is less evidence against the hypothesis that the coefficient on the deviation equals -1. In our shorter sample, we are unable to reject either hypothesis. However, it should be noted that the test for unbiasedness of the UIG suffers from pre-test bias as the UIG must be centered separately from the estimation of the factors[21]. Further, while it is always possible to reject the model of Atkeson and Ohanion based on within sample estimation, this is not informative about a model's out of sample performance, which we address in the following section.

Note of caution for forecasting exercises

We now investigate the relative performance of underlying inflation measures through their ability to forecast inflation in real-time. It is often argued that a forecasting exercise will be able to identify the best underlying inflation measure. However, there are several aspects of these types of comparisons that require care, particularly when it comes to producing underlying measures of inflation for use by policymakers. Therefore we want to add some preliminary remarks and use them as a note of caution before we undertake the usual forecasting exercise in the broadly accepted setting of Rich and Steindel (2007).

The most difficult aspect – which should be considered in the interpretation of forecasting results – is the appropriate loss function to measure forecast accuracy. The standard approach is to use a quadratic loss function for the forecast errors. Consider the following example:

- case 1: For total inflation between 1% and 3% the RMSE at 12 months for underlying measure A is 1 percentage point, while for measure B it is 1.1 percentage points.

[21] As mentioned in section 3.1 and in footnote 14, the standardization of the variables requires us to assign an average value for the underlying inflation gauges for CPI inflation and PCE inflation.

- case 2: For total inflation outside of 1% and 3% the RMSE at 12 months for underlying measure A is 2 percentage points, while for measure B it is 1.2 percentage points.

If the policymaker uses measure A, then they will be slower to recognize a change in the trend in underlying inflation compared to using measure B. Suppose the policymaker successfully uses measure B to conduct monetary policy so that total inflation is rarely outside of a range of 1-3%, then a forecast evaluation would favour measure A if actual inflation was outside the 1-3% range less than 10 percent of the time. Therefore, forecast accuracy may not be informative about the usefulness of an underlying inflation measure for stabilization purposes.

Besides recognizing that the results may need to be interpreted with some caution, another important issue for the exercise concerns the choice of the forecasting sample period. Long time periods can be problematic because they might cover different inflation regimes. Furthermore, because most industrialized countries successfully stabilised their inflation rates before the financial crisis, the signal associated with the least variation (e.g. a constant) might have had an advantage compared to signals generated from earlier periods when there were more fluctuation in inflation. The opposite result might hold for measures with more variability during the financial crisis. Therefore it is important to run the exercise over a sample displaying significant variation in inflation as well as over different sub-samples. The behaviour of inflation in the US since 2000 displays these features as it is relative tranquil during the pre-2008 period, but extremely volatile during the post-2008 period.

Finally, forecasting exercises are often undertaken in a "pseudo" real-time manner in which estimation is conducted using a single vintage data set. In practice, the actual data used might have been revised subsequently. In our case, the UIG is constructed from data that is either not revised or only revised slightly (some PPI prices) but, unlike more traditional exclusion-based measures, future data can lead to reassessments of its previous values. Consequently, we will focus on the CPI because its revisions are very minor (correction of small technical mistakes) and thus the forecast target and the underlying measures used for comparison can be treated as if they are real-time data.[22]

A "horse race": UIG versus traditional underlying inflation measures ('core measures')

We first consider the results of a forecasting exercise based on an estimated version of equation (3):[23]

$$\hat{\pi}_{t+h} = \pi_t + \hat{\alpha}_h + \hat{\beta}_h \left(\pi_t - \pi_{mt} \right) \quad (4)$$

where $\hat{\alpha}_{h,t}, \hat{\beta}_{h,t}$ are the estimated regression coefficients using data through time t. Estimation starts in 1994, while the forecasting range spans the period from 2000

22 Because we focus on the 12 month horizon there is no meaningful difference between seasonally adjusted and non-seasonally adjusted measures.

23 To ensure comparability we use the same setting as in the paper of Rich and Steindel (2007), which compares forecast performance of traditional core measures. The same regression model has been used in studies such as Clark (2001), Hogan, Johnson and Laflèche (2001), Cutler (2001) and Cogley (2002).

through the middle of 2012. To account for possible sensitivity of the forecast comparisons to the selected sample periods, we consider two different sub-sample periods. First, a pre-crisis sub-sample from 2000-2007, a time range that could be considered a representative inflation cycle as it encompasses moderate cyclical phases in CPI inflation. Second, a crisis sub-sample that captures the period from 2008 until the middle of 2012. Finally, for comparison purposes we also consider a sample from 2001 to 2007 that exactly matches one considered in Stock and Watson (2008). We compare the forecast performance of the UIG to the ex-food and energy, trimmed mean, and median measures. We also include a prices only version of the UIG as well as the prior 12 month change in CPI inflation in the forecast exercise.

The results in Table 4 show that the UIG clearly outperforms the traditional underlying inflation measures in forecasting headline CPI before the crisis, during the crisis, as well as over the whole sample range. This is evident from the lowest reported RMSE over all samples. To analyse the UIG forecast performance further, we apply the Diebold-Mariano (1995) testing procedure[24]. The results show that the forecast errors from the UIG are lower than those from the traditional underlying inflation measures at a 5% statistical significance level during the crisis, and mostly at a 1% statistical significance level before the crisis as well as over the whole sample.

When we focus solely on the traditional underlying inflation measures, they do not differ much in their forecasting performance, confirming the previous findings in Rich and Steindel (2007). However, there are three notable observations for the traditional underlying inflation measures. First, all underlying inflation measures do better than the 12 month change in total CPI inflation – the random walk forecast – which, not surprisingly, displays the highest forecast errors among the reported measures and samples during the crisis.[25] Secondly, the forecasting performance of the CPI trimmed mean and CPI median are remarkably similar over all samples. Third, the forecasting performance of the popular CPI ex-food and energy measure relative to the other measures is better during the crisis than before the crisis[26].

An important consideration in evaluating the results in Table 4 is that the UIG has the advantage of being derived from a process that uses information from revised values of the non-price components in the dataset. One approach to assess the significance of this advantage is to re-estimate the UIG at each time period. However, such a procedure would not be necessary if the revisions to past UIG estimates were small as new data was added. We examine this issue in the next section.

[24] Diebold and Mariano (1995) propose and evaluate explicit tests of the null hypothesis of no difference in the forecast accuracy of two competing models.

[25] The forecast from the random walk model is the current value of the variable, which would be expected to perform poorly during episodes when inflation is particularly volatile.

[26] Before the crisis, the CPI ex-food and energy measure displayed the poorest forecast performance of the reported measures. During the crisis, the CPI ex-food and energy measure generated lower forecast errors than the CPI trimmed mean and the CPI median.

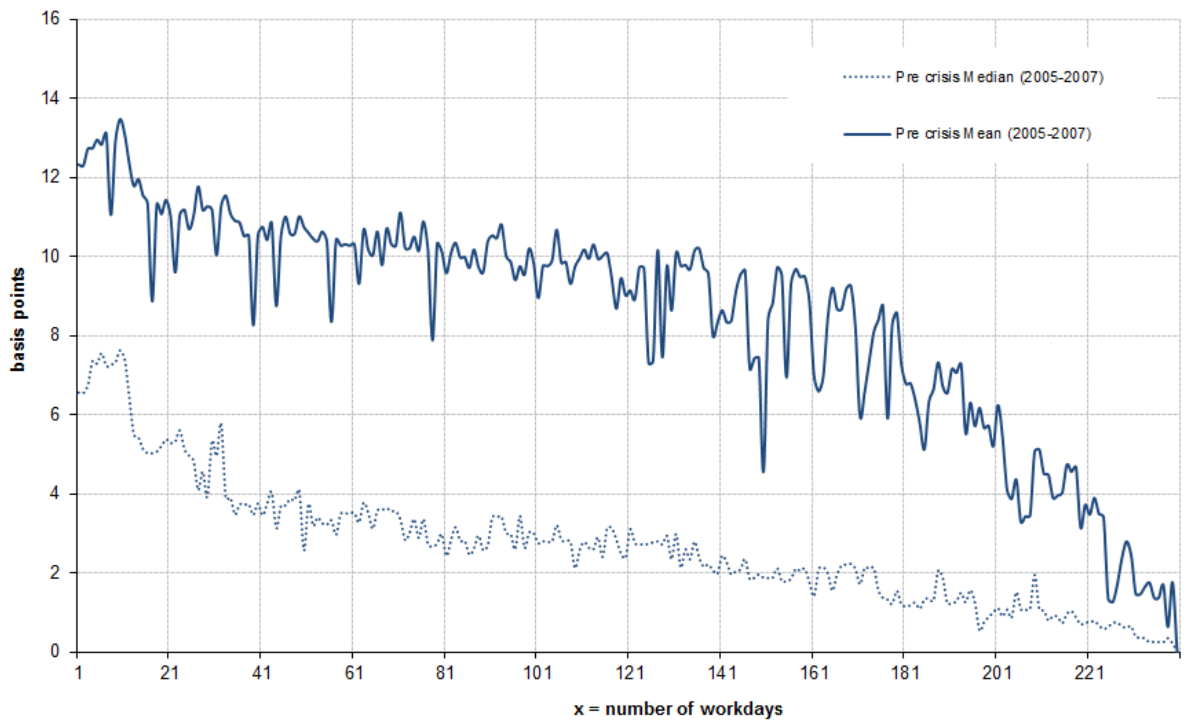
UIG revisions historically and during the crisis period

The UIG is constructed using the most current information, with revisions to the UIG resulting either from new observations of the input variables or from revisions to previous values of the input variables. Revisions of an underlying inflation gauge can be judged as either helpful or uninformative. An ideal measure should show only modest revisions during normal economic times. On the other hand, such a measure is expected to be highly responsive to changes in a volatile economy and to reflect this through revisions that readily incorporate new information in the course of providing updates of the past.

To examine whether the UIG behaves in a manner similar to that of the ideal measure described above, we examine a 26-month period before the crisis from November 2005 to December 2007 and a 44-month period during the crisis from January 2008 to August 2011. The first phase covers a time period with economic changes that were very typical when judged on an historical basis, while the second phase covers a time period of historically large economic changes. Given the events in the current crisis, we think of the second sub-sample as a real world stress test that provides an assessment of the maximal revision that can occur to the UIG.

Pre crisis sample 2005-2007: Absolute changes in UIG estimate from first estimate to one year(240 workdays) later

(mean/median over "Pre crisis: 2005-Nov to 2007-Dec") Figure 6a

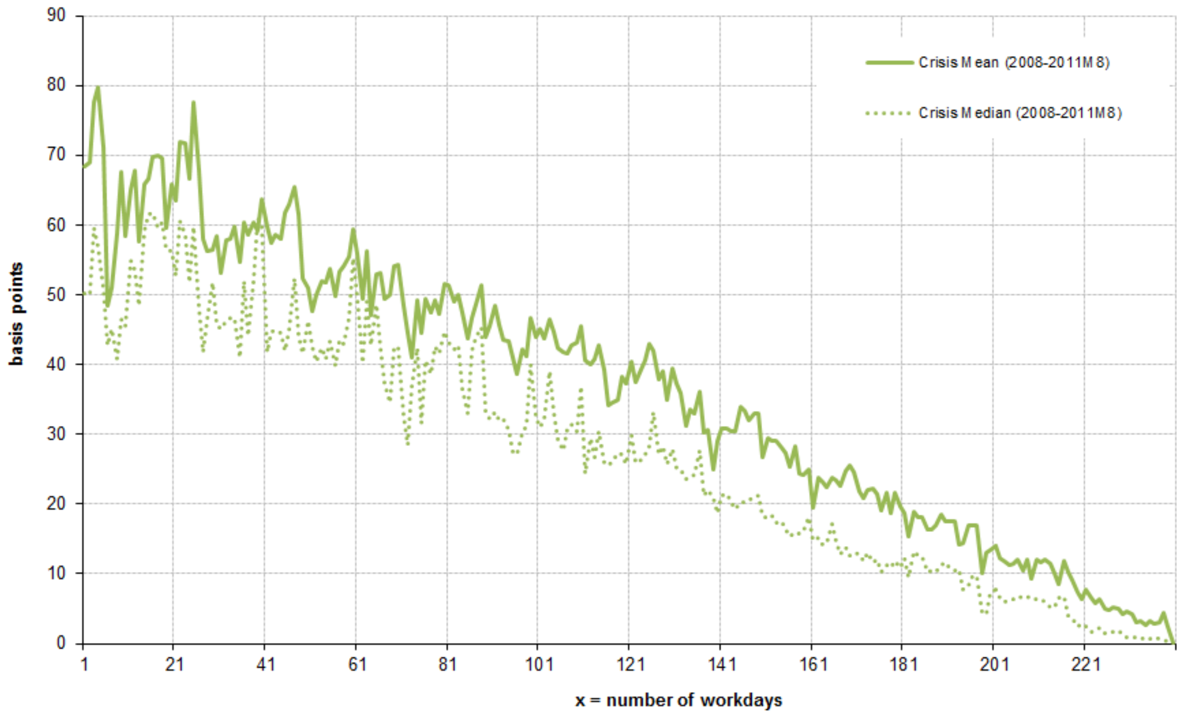


We examined the daily revisions to each of the estimates of the monthly UIG estimates over 240 workdays (approximately one year). The results of this exercise are presented in Figures 6a and 6b for the absolute size of the change, where we plot the mean and median of the change of the UIG estimate from the x-th workday compared with the final estimate. We examine the absolute values to ensure that large changes in one direction are not cancelled out by large changes in the opposite direction. As shown, during a normal business cycle (November 2005 to December 2007) the largest changes in the estimate of the UIG for a month usually occur within the first month (20 workdays). The maximal median and mean revision in UIG amounts to a change of about 8 and 14 basis points, respectively (Figure 6.a). The source of these changes is the publication of the monthly CPI report. After that the mean and median revisions converge to zero.[27] Since 2008, with the large decline in CPI inflation and the deep recession in the US, the revisions in the input variables and therefore also the UIG have been considerably larger. During this period of extremely volatile news flows, the maximal mean and median revision in UIG amounted to 80 and 60 basis points, respectively (Figure 6.b).

The preceding evidence suggests two findings. First, the UIG appears to display the desired behaviour of an ideal measure of underlying inflation in that it remains very stable during normal economic times, but is able to adapt quickly in turbulent times. Second, given the fast convergence of the revisions to zero, particularly after the first month, and because the forecasting exercise uses only monthly data over several years, we consider the impact of the revisions on the forecasting performance of the UIG as limited.

Crisis sample 2008-2011M8: Absolute changes in UIG estimate from first estimate to one year (240 workdays) later.

(mean/median "during crisis 2008-Jan to 2011-Aug") Figure 6b



27 The finding that the mean converges more slowly to zero than the median likely reflects the sustained period of CPI inflation over 3% in the evaluation period - an ex ante unlikely event given our decision to center the UIG at 2.25% and the volatility of the CPI from 1993-2005.

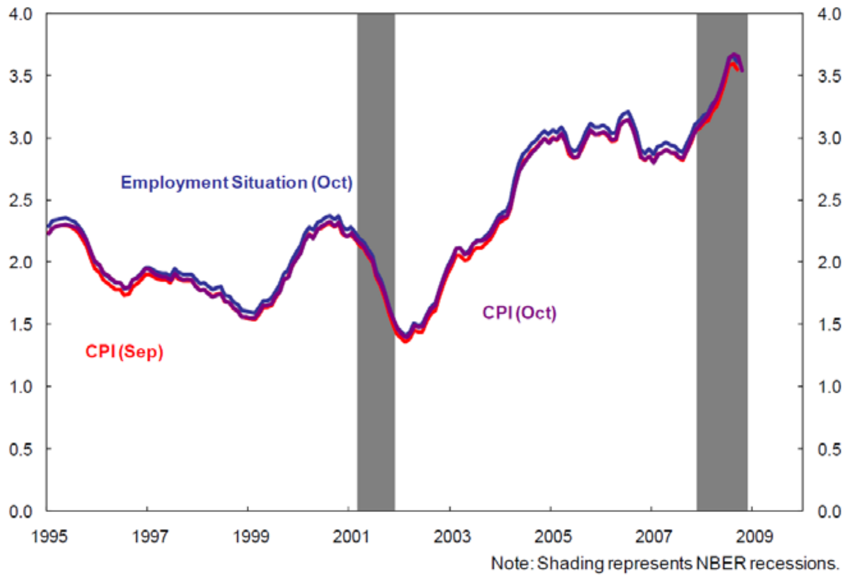
A real-time out of sample forecast comparison

After observing that the UIG displays greater accuracy in a pseudo out-of-sample-forecasting exercise and documenting the limited impact on its performance from revisions, we now conduct a real-time out-of-sample forecasting comparison. Real-time forecasts from the UIG have been produced each day starting in November 2005. These forecasts are produced directly from the statistical factor model underpinning the UIG rather than from prediction models based on equation (3). The original motivation for the daily real-time updates was to compare any changes in these forecasts with movements in inflation expectations from financial markets, which are also available daily. The real-time forecasts were produced for a range of horizons (1, 2-3 and 3-5 years). The real-time out-of-sample forecasts at the one year horizon were also used for comparisons to forecasts based on the prior 12 month change in the CPI and core CPI. The target variables were both the CPI and the core CPI. The results are presented in Table 5 for the sample period from November 2006 to April 2009. Using a real-time out-of sample exercise, we again find the UIG outperforms the traditional underlying inflation measures.

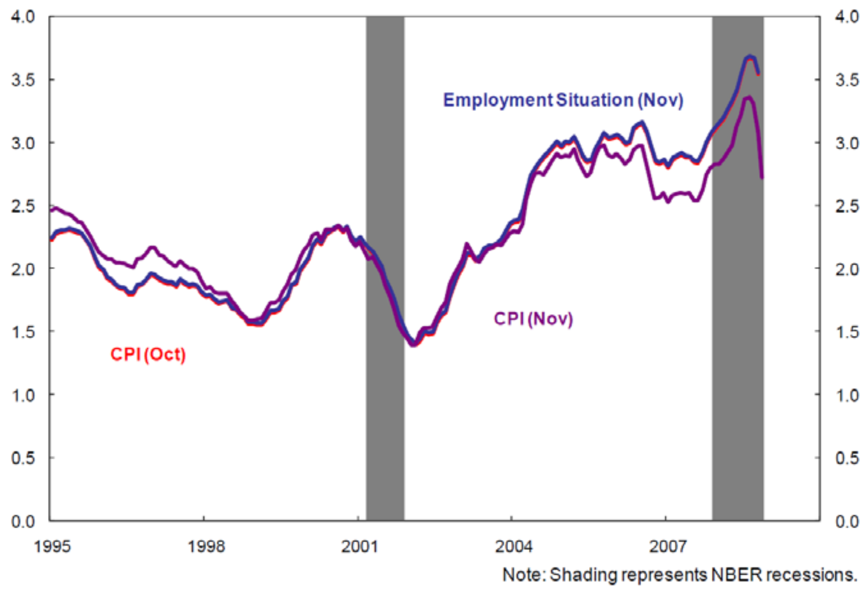
CPI and the labour market as drivers of UIG

Finally, we examine in more detail the changes in the estimated path of the UIG since 1995 using data through the last two months of 2008 and the first month of 2009. For each month we show the path of the UIG after the release of the CPI in the prior month (i.e., the CPI for two months earlier), the release of the U.S. employment situation for the prior month, and finally the release of the CPI for the prior month. The results are presented in Figures 7.a through 7.c. The results for November indicate little response to the CPI or the employment situation for October 2008. In December 2008 it can be seen that the November CPI had a large effect on the current value of the UIG and the estimates for the previous 24 months. Finally, the December 2008 employment situation produced a large change in the current estimate (i.e., January 2009) of the UIG and significantly altered its whole history.

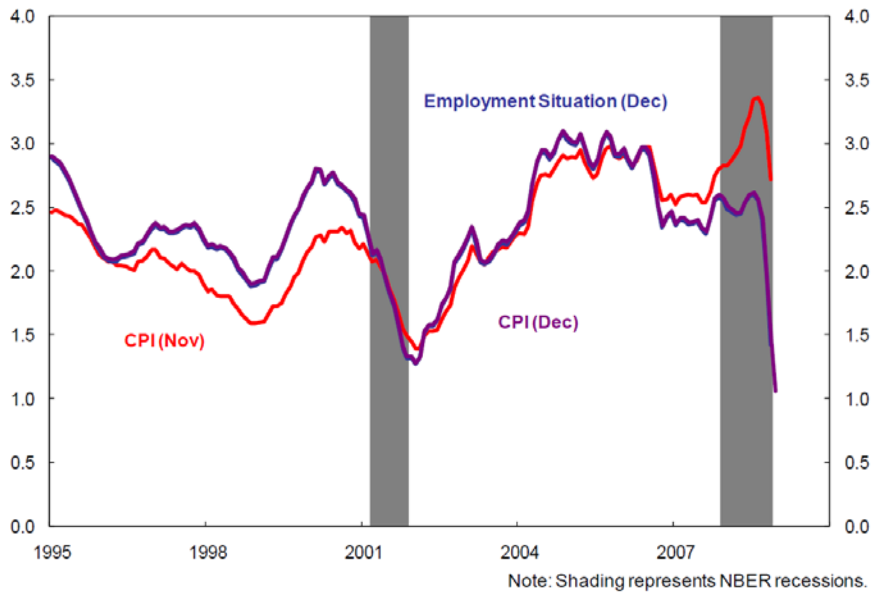
Change in UIG with Various Economic Indicator Releases November 2008 | Figure 7a



Change in UIG with Various Economic Indicator Releases December 2008 Figure 7b



Change in UIG with Various Economic Indicator Releases January 2009 Figure 7c



5. Conclusions

This paper presents some background and properties on the "Federal Reserve Bank of New York (FRBNY) staff underlying inflation gauge (UIG)". UIG adds to the existing literature on U.S. inflation and complements the standard measures of core and underlying inflation available to monetary policymakers and long-term investors in the following ways.

First, UIG summarises in a single number the information content in a broad data set including asset prices and real variables like unemployment rate. Unlike traditional core measures UIG does not restrict itself to price data in one point of time only, as many economic variables may affect the inflation process and may do so in a time varying manner. The carefully chosen data set reflects the information which is considered as informative to forecast inflation by FRBNY staff economists.

Second, similar to inflation expectation derived from financial markets, UIG can be evaluated daily and considers changing correlations in the data set.

Third, UIG is able to measure underlying inflation at a frequency of relevance to policymakers and long-term investors. The smooth cyclical patterns of UIG give policymakers and market participants a clear indication of which CPI movements and developments are likely to be persistent and therefore could require a response from monetary policy.

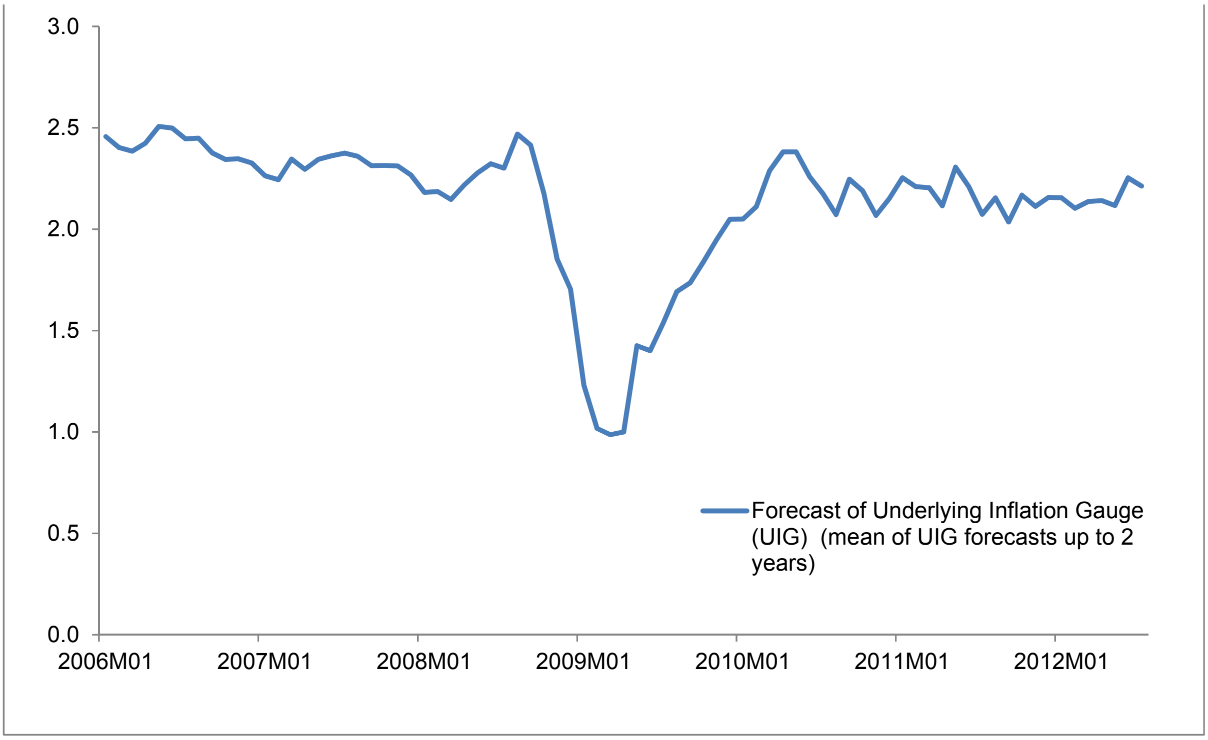
Fourth, while UIG is closely related to headline inflation, it at the same time adds important additional information on underlying inflation over that contained in traditional core measures. Therefore UIG can be used in addition to other core measures more mainly in a complementary than a substitutive way.

Finally, in a competitive horse race setting of forecasting head line inflation UIG significantly outperforms traditional core measures for different regimes of headline inflation. These findings hold for a sample from 2000 to mid of 2012 as well as for a sample focusing on an average economic regime before the crisis as well as an extremely volatile sample during the crisis.

These features make UIG particularly useful for policy makers and market participants.

Forecast of Underlying Inflation Gauge (UIG)

(mean of UIG forecasts up to 2 years) Figure 8



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Data Appendix: UIG Variables

Prices

1 CPI-U: All Items
2 CPI-U: All Items Less Energy (NSA, 1982-84=100)
3 CPI-U: All Items Less Food (NSA, 1982-84=100)
4 CPI-U: All Items Less Food & Energy (NSA, 1982-84=100)
5 CPI-U: All Items Less Medical Care (NSA, 1982-84=100)
6 CPI-U: All Items Less Shelter (NSA, 1982-84=100)
7 CPI-U: All Items less Food & Shelter (NSA, 1982-84=100)
8 CPI-U: All Items less Food, Shelter & Energy (NSA, 1982-84=100)
9 CPI-U: All Items less Food, Shelter, Energy/Used Cars & Trucks(NSA, 1982-84=100)
10 CPI-U: Commodities (NSA, 1982-84=100)
11 CPI-U: Durable Commodities (NSA, 1982-84=100)
12 CPI-U: Nondurable Commodities (NSA, 1982-84=100)
13 CPI-U: Services (NSA, 1982-84=100)
14 CPI-U: Services Less Rent of Shelter (NSA, Dec-82=100)
15 CPI-U: Transportation Services (NSA, 1982-84=100)
16 CPI-U: Other Services (NSA, 1982-84=100)
17 CPI-U: Services Less Medical Care Svcs (NSA, 1982-84=100)
18 CPI-U: Energy (NSA, 1982-84=100)
19 CPI-U: Apparel Less Footwear (NSA, 1982-84=100)
20 CPI-U: Energy Commodities (NSA, 1982-84=100)
21 CPI-U: Utilities and Public Transportation (NSA, 1982-84=100)
22 CPI-U: Food & Beverages (NSA, 1982-84=100)
23 CPI-U: Food (NSA, 1982-84=100)
24 CPI-U: Food At Home (NSA, 1982-84=100)
25 CPI-U: Domestically Produced Farm Food (NSA, 1982-84=100)
26 CPI-U: Cereals & Bakery Products (NSA, 1982-84=100)
27 CPI-U: Cereals & Cereal Products (NSA, 1982-84=100)
28 CPI-U: Flour and Prepared Flour Mixes (NSA, 1982-84=100)
29 CPI-U: Breakfast Cereal (NSA, 1982-84=100)
30 CPI-U: Rice, Pasta & Cornmeal (NSA, 1982-84=100)
31 CPI-U: Bakery Products (NSA, 1982-84=100)
32 CPI-U: White bread (NSA, 1982-84=100)
33 CPI-U: Bread Other Than White (NSA, 1982-84=100)
34 CPI-U: Cakes, Cupcakes and Cookies (NSA, 1982-84=100)
35 CPI-U: Fresh Cakes and Cupcakes (NSA, 1982-84=100)
36 CPI-U: Cookies (NSA, 1982-84=100)
37 CPI-U: Other Bakery Products (NSA, 1982-84=100)
38 CPI-U: Fresh Sweetrolls, Coffeecakes & Doughnuts (NSA, 1982-84=100)
39 CPI-U: Crackers, Bread & Cracker Products (NSA, 1982-84=100)
40 CPI-U: Frozen/Refrig Bakery Prdcts/Pies/Tarts/etc (NSA, 1982-84=100)
41 CPI-U: Meats, Poultry, Fish & Eggs (NSA, 1982-84=100)
42 CPI-U: Meats, Poultry & Fish (NSA, 1982-84=100)
43 CPI-U: Meats (NSA, 1982-84=100)
44 CPI-U: Beef & Veal (NSA, 1982-84=100)
45 CPI-U: Uncooked Ground Beef (NSA, 1982-84=100)
46 CPI-U: Pork (NSA, 1982-84=100)
47 CPI-U: Bacon & Related Products (NSA, 1982-84=100)
48 CPI-U: Ham (NSA, 1982-84=100)
49 CPI-U: Ham excluding Canned (NSA, 1982-84=100)
50 CPI-U: Pork Chops (NSA, 1982-84=100)
51 CPI-U: Other Meats (NSA, 1982-84=100)
52 CPI-U: Frankfurters (NSA, 1982-84=100)
53 CPI-U: Lamb and Organ Meats (NSA, 1982-84=100)
54 CPI-U: Poultry (NSA, 1982-84=100)
55 CPI-U: Fresh Whole Chicken (NSA, 1982-84=100)
56 CPI-U: Fresh & Frozen Chicken Parts (NSA, 1982-84=100)
57 CPI-U: Fish & Seafood (NSA, 1982-84=100)
58 CPI-U: Canned Fish & Seafood (NSA, 1982-84=100)
59 CPI-U: Frozen Fish & Seafood (NSA, 1982-84=100)
60 CPI-U: Eggs (NSA, 1982-84=100)
61 CPI-U: Dairy and Related Products (NSA, 1982-84=100)
62 CPI-U: Fresh Whole Milk (NSA, 1982-84=100)
63 CPI-U: Cheese and Related Products (NSA, 1982-84=100)
64 CPI-U: Ice Cream & Related Products (NSA, 1982-84=100)
65 CPI-U: Fruits & Vegetables (NSA, 1982-84=100)
66 CPI-U: Fresh Fruits & Vegetables (NSA, 1982-84=100)
67 CPI-U: Fresh Fruits (NSA, 1982-84=100)
68 CPI-U: Apples (NSA, 1982-84=100)
69 CPI-U: Bananas (NSA, 1982-84=100)
70 CPI-U: Oranges, including Tangerines (NSA, 1982-84=100)
71 CPI-U: Fresh Vegetables (NSA, 1982-84=100)
72 CPI-U: Potatoes (NSA, 1982-84=100)
73 CPI-U: Lettuce (NSA, 1982-84=100)
74 CPI-U: Tomatoes (NSA, 1982-84=100)
75 CPI-U: Other Fresh Vegetables (NSA, 1982-84=100)
76 CPI-U: Other Fresh Vegetables (NSA, 1982-84=100)
77 CPI-U: Frozen Vegetables (NSA, 1982-84=100)
78 CPI-U: Nonalcoholic Beverages & Beverage Matls (NSA, 1982-84=100)
79 CPI-U: Carbonated Drinks (NSA, 1982-84=100)
80 CPI-U: Coffee (NSA, 1982-84=100)
81 CPI-U: Roasted Coffee (NSA, 1982-84=100)
82 CPI-U:Instant Freeze-Dried Coffee (NSA, 1982-84=100)
83 CPI-U: Other Food At Home (NSA, 1982-84=100)
84 CPI-U: Sugar and Sweets (NSA, 1982-84=100)
85 CPI-U: Sugar and Artificial Sweeteners (NSA, 1982-84=100)
86 CPI-U: Fats and Oils (NSA, 1982-84=100)
87 CPI-U: Butter (NSA, 1982-84=100)
88 CPI-U: Margarine (NSA, 1982-84=100)
89 CPI-U: Other Foods At Home (NSA, 1982-84=100)
90 CPI-U: Soups (NSA, 1982-84=100)
91 CPI-U: Frozen & Freeze Dried Prepared Food (NSA, 1982-84=100)
92 CPI-U: Snacks (NSA, 1982-84=100)
93 CPI-U: Seasonings/Condiments/Sauces/Spices (NSA, 1982-84=100)
94 CPI-U: Other Condiments (NSA, 1982-84=100)
95 CPI-U: Food Away From Home (NSA, 1982-84=100)
96 CPI-U: Alcoholic Beverages (NSA, 1982-84=100)
97 CPI-U: Alcoholic Beverages At Home (NSA, 1982-84=100)
98 CPI-U: Beer, Ale and Malt Beverages At Home (NSA, 1982-84=100)
99 CPI-U: Distilled Spirits At Home (NSA, 1982-84=100)
100 CPI-U: Whiskey At Home (NSA, 1982-84=100)
101 CPI-U: Distilled Spirits ex Whiskey At Home (NSA, 1982-84=100)
102 CPI-U: Wine At Home (NSA, 1982-84=100)
103 CPI-U: Alcoholic Beverages Away From Home (NSA, 1982-84=100)
104 CPI-U: Housing (NSA, 1982-84=100)
105 CPI-U: Shelter (NSA, 1982-84=100)
106 CPI-U: Rent of Primary Residence (NSA, 1982-84=100)
107 CPI-U: Rent of Shelter (NSA, 1982-84=100)
108 CPI-U: Housing At School ex Board (NSA, Dec-82=100)
109 CPI-U: Other Lodging Away From Home incl Hotels/Motels(NSA, 1982-84=100)
110 CPI-U: Owners' Equivalent Rent of Primary Residence (NSA, Dec-82=100)
111 CPI-U: Fuels and Utilities (NSA, 1982-84=100)
112 CPI-U: Fuels (NSA, 1982-84=100)
113 CPI-U: Fuel Oil and Other Fuels (NSA, 1982-84=100)
114 CPI-U: Fuel Oil (NSA, 1982-84=100)
115 CPI-U: Other {Than Fuel Oil} Household Fuels (NSA, Dec-86=100)
116 CPI-U: Household Piped Gas & Electricity (NSA, 1982-84=100)
117 CPI-U: Household Electricity (NSA, 1982-84=100)
118 CPI-U: Utility [Piped] Gas Service (NSA, 1982-84=100)
119 CPI-U: Water and Sewerage Maintenance (NSA, 1982-84=100)
120 CPI-U: Garbage and Trash Collection (NSA, Dec-83=100)
121 CPI-U: Household Furnishings & Operation (NSA, 1982-84=100)
122 CPI-U: Household Furniture & Bedding (NSA, 1982-84=100)

123 CPI-U: Bedroom Furniture (NSA, 1982-84=100)
124 CPI-U: Household Laundry Equipment (NSA, 1982-84=100)
125 CPI-U: Clocks, Lamps and Decorator Items (NSA, 1982-84=100)
126 CPI-U: Indoor Plants and Flowers (NSA, Dec-90=100)
127 CPI-U: Housekeeping Supplies (NSA, 1982-84=100)
128 CPI-U: Apparel (NSA, 1982-84=100)
129 CPI-U: Men's & Boys' Apparel (NSA, 1982-84=100)
130 CPI-U: Men's Apparel (NSA, 1982-84=100)
131 CPI-U: Men's Suits, Sport Coats & Outerwear (NSA, 1982-84=100)
132 CPI-U: Men's Furnishings (NSA, 1982-84=100)
133 CPI-U: Men's Pants and Shorts (NSA, 1982-84=100)
134 CPI-U: Boys' Apparel (NSA, 1982-84=100)
135 CPI-U: Women's & Girls' Apparel (NSA, 1982-84=100)
136 CPI-U: Women's Apparel (NSA, 1982-84=100)
137 CPI-U: Women's Outerwear (NSA, 1982-84=100)
138 CPI-U: Women's Dresses (NSA, 1982-84=100)
139 CPI-U: Girls' Apparel (NSA, 1982-84=100)
140 CPI-U: Footwear (NSA, 1982-84=100)

211 CPI-U: Land-line Intrastate Toll Calls (NSA, 1982-84=100)
212 CPI-U: Information Technology, Hardware, & Services (NSA, Dec 1988=100)
213 CPI-U: Other Goods & Services (NSA, 1982-84=100)
214 CPI-U: Tobacco & Smoking Products (NSA, 1982-84=100)
215 CPI-U: Personal Care (NSA, 1982-84=100)
216 CPI-U: Personal Care Products (NSA, 1982-84=100)
217 CPI-U: Cosmetics/Perfumes/Bath/Nail Preps & Impls(NSA, 1982-84=100)
218 CPI-U: Personal Care Services (NSA, 1982-84=100)
219 CPI-U: Miscellaneous Personal Services (NSA, 1982-84=100)
220 CPI-U: Legal Services (NSA, Dec-86=100)
221 CPI-U: Funeral Expenses (NSA, Dec-86=100)
222 CPI-U: Financial Services (NSA, Dec-86=100)
223 CPI-U: Stationery/Stationery Supplies/Gift Wrap (NSA, 1982-84=100)
224 PPI: Finished Consumer Goods (NSA, 1982=100)
225 PPI: Finished Consumer Foods (NSA, 1982=100)
226 PPI: Finished Consumer Foods: Unprocessed (NSA, 1982=100)
227 PPI: Finished Consumer Foods; Processed (NSA, 1982=100)
228 PPI: Finished Consumer Goods excluding Foods (NSA, 1982=100)
229 PPI: Consumer Nondurable Goods Less Food (NSA,1982=100)
230 PPI: Consumer Durable Goods (NSA, 1982=100)
231 PPI: Finished Capital Equipment (NSA, 1982=100)
232 PPI: Capital Equipment: Manufacturing Industries (NSA, 1982=100)
233 PPI: Capital Equipment: Nonmanufacturing Industries (NSA, 1982=100)
234 PPI: Finished Goods [Including Foods & Fuel] (NSA, 1982=100)
235 PPI: Intermediate Materials, Supplies & Components (NSA, 1982=100)
236 PPI: Crude Materials For Further Processing (NSA, 1982=100)
237 PPI: Finished Goods excluding Foods (NSA, 1982=100)
238 PPI: Offices of Physicians (Dec-96=100)
239 PPI: Home Health Care Services (Dec-96=100)
240 PPI: Commercial Natural Gas (NSA, Dec-90=100)
241 Import Price Index: All Imports (NSA, 2000=100)
242 Export Price Index: All Exports (NSA, 2000=100)
243 FRB Dallas Trimmed-Mean 12-month PCE Inflation Rate (%)

Real Variables

1 ISM: Mfg: New Orders Index (NSA, 50+ = Econ Expand)
2 ISM: Mfg: Production Index (NSA, 50+ = Econ Expand)
3 ISM: Mfg: Employment Index (NSA, 50+ = Econ Expand)
4 ISM: Mfg: Vendor Deliveries Index (NSA, 50+ = Econ Expand)
5 ISM: Mfg: Inventories Index (NSA, 50+ = Econ Expand)
6 ISM: Mfg: Prices Index (NSA, 50+ = Econ Expand)
7 ISM: Mfg: Backlog of Orders Index (NSA, 50+=Econ Expand)
8 ISM: Mfg: New Export Orders Index(NSA, 50+ = Econ Expand)
9 ISM: Mfg: Imports Index (NSA, 50+ = Econ Expand)
10 ISM: Nonmfg: New Orders Index (NSA, 50+ = Econ Expand)
11 ISM: Nonmfg: Business Activity Index (NSA, 50+ = Econ Expand)
12 ISM: Nonmfg: Employment Index (NSA, 50+ = Econ Expand)
13 ISM: Nonmfg: Supplier Deliveries Index (NSA, 50+ = Econ Expand)
14 ISM: Nonmfg: Inventory Change Index (NSA, 50+ =Econ Expand)
15 ISM: Nonmfg: Prices Index (NSA, 50+ = Econ Expand)
16 ISM: Nonmfg: Orders Backlog Index (NSA, 50+ = Econ Expand)
17 ISM: Nonmfg: New Export Orders Index (NSA, 50+=Econ Expand)
18 ISM: Nonmfg: Imports Index (NSA, 50+ = Econ Expand)

Labor

1 Unemployment Rate: 16-24 Yrs (NSA, %)
2 Unemployment Rate: 25-34 Yrs (NSA, %)
3 Unemployment Rate: 35-44 Yrs (NSA, %)
4 Unemployment Rate: 45-54 Yrs (NSA, %)
5 Unemployment Rate: 55 Yrs & Over (NSA, %)
6 Civilian Employment-Population Ratio: 16-24 Yrs (NSA, Ratio)
7 Civilian Employment-Population Ratio: 25 to 34 Yrs (NSA, Ratio)
8 Civilian Employment-Population Ratio: 35 to 44 Yrs (NSA, Ratio)
9 Civilian Employment-Population Ratio: 45 to 54 Yrs (NSA, Ratio)
10 Civilian Employment-Population Ratio: 55 Yrs & Over (NSA, Ratio)
11 Average Weeks Unemployed: 16-19 yrs (NSA)
12 Average Weeks Unemployed: 20-24 yrs (NSA)
13 Average Weeks Unemployed: 25-34 yrs (NSA)
14 Average Weeks Unemployed: 35-44 yrs (NSA)
15 Average Weeks Unemployed: 45-54 yrs (NSA)
16 Average Weeks Unemployed: 55-64 yrs (NSA)
17 Average Weeks Unemployed: 65 yrs & over (NSA)
18 Unemployment (NSA, Thous)
19 Number Unemployed for less than 5 Weeks (NSA, Thous)
20 Number Unemployed for 5-14 Weeks (NSA, Thous)
21 Number Unemployed for 15-26 Weeks (NSA, Thous)
22 Number Unemployed for 15 Weeks & Over (NSA, Thous)
23 Unemployment Insurance: Initial Claims (#, NSA)

Money

1 Money Stock: M1 (NSA, Bil.$)
2 Money Stock: M2 (NSA, Bil.$)
3 Adjusted Monetary Base (NSA, Mil.$)
4 Adjusted Reserves of Depository Institutions (NSA, Mil.$)
5 Adjusted Nonborrowed Reserves of Depository Institutions (NSA, Mil.$)

Financials

1 Cash Price: Gold Bullion, London Commodity Price, PM Fix (US$/troy Oz)
2 Gold: London PM Fix (US$/Troy Oz)
3 Gold Spot ($/oz) NSA
4 Spot commodity price - West Texas Intermediate crude oil, Cushing OK
5 Federal funds effective rate
6 3-month Treasury bill rate coupon equivalent
7 6-month Treasury bill rate coupon equivalent
8 1-Year Treasury Bill Yield at Constant Maturity (% p.a.)
9 5-Year Treasury Note Yield at Constant Maturity (% p.a.)
10 7-Year Treasury Note Yield at Constant Maturity (% p.a.)
11 10-Year Treasury Note Yield at Constant Maturity (% p.a.)
12 LIBOR Eurodollar 11 A.M. Fixing 1 Month
13 LIBOR Eurodollar 11 A.M. Fixing 3 Month
14 LIBOR Eurodollar 11 A.M. Fixing 6 Month
15 LIBOR Eurodollar 11 A.M. Fixing 9 Month
16 LIBOR Eurodollar 11 A.M. Fixing 1 Year
17 Spot Price (Eur/$) (Revised Backwards)
18 Spot Price (GBP/$)
19 Spot Price (Yen/$)
20 Spot Price (Swiss Franc/$)

21 Board Narrow Nominal Effective Exchange Rate Index: U.S. (2000=100)
22 Board Broad Nominal Effective Exchange Rate: United States (2000=100)
23 Bank Credit: All Commercial Banks (NSA, Bil.$)
24 Total Revolving U.S. Consumer Credit Outstanding
25 Total Non-Revolving U.S. Consumer Credit Outstanding
26 Securities in Bank Credit: All Commercial Banks (NSA, Bil.$)
27 US Government Securities in Bank Credit:All Commercial Banks (NSA,Bil$)
28 Real Estate Loans in Bank Credit: All Commercial Banks (NSA, Bil.$)
29 C & I Loans in Bank Credit: All Commercial Banks (NSA, Bil.$)
30 Consumer Loans in Bank Credit: All Commercial Banks (NSA, Bil.$)
31 Moody's Seasoned Aaa Corporate Bond Yield (% p.a.)
32 Moody's Seasoned Baa Corporate Bond Yield (% p.a.)
33 Merrill Lynch High Yield Master II yield
34 New York Stock Exchange Composite Index
35 New York Stock Exchange Total Volume
36 Standard and Poor's 500 Price Earnings Ratio Index
37 Dow Jones Industrial Average
38 Dow Jones Wilshire 5000 Composite Index Full Cap
39 Light Sweet Crude Oil Futures Price: 1st Exp Contract Nearby Sttlmnt (EOP,$/bbl)
40 Light Sweet Crude Oil Futures Price: 3 Month Contract Settlement (EOP, $/bbl)
41 Light Sweet Crude Oil Futures Price: 6 Month Contract Settlement (EOP, $/bbl)
42 No 2 Heating Oil Futures Price: 1st Exp Contract Nearby Settlement (EOP, $/gal)
43 No 2 Heating Oil Futures Price: 3 Month Contract Settlement (EOP, $/gal)
44 No 2 Heating Oil Futures Price: 6 Month Contract Settlement (EOP, $/gal)
45 Unleaded Gasoline Futures Price: 1st Exp Contract Nearby Settlement (EOP, $/gal)
46 Unleaded Gasoline Futures Price: 3 Month Contract Settlement (EOP, $/gal)
47 New York Harbor Conventional Gasoline Regular Spot Price FOB (EOP Cents/Gallon)
48 Gas Oil Futures Price: 1st Exp Contract Nearby Settlement ($/metric tEOP, on)
49 Unleaded Premium Gasoline Price, NY gal (EOP, $/gal)
50 Unleaded Gas, Regular, Non-Oxygenated: NY (EOP, $/gal)
51 Natural Gas Price, Henry Hub, LA ($/mmbtu)
52 Dow Jones AIG Futures Price Index (Jan-2-91=100)
53 Dow Jones AIG Spot Price Index (Jan-7-91=100)
54 FIBER Industrial Materials Index: All Items (1990=100)
55 Goldman Sachs Commodity Nearby Index (EOP, Dec-31-69=100)
56 S&P 500 Futures Price: 1st Exp Contract Nearby Settlement (EOP, Index)
57 S&P 400 Midcap Futures Price: 1st Exp Contract Nearby Settlement (EOP, Index)

CPI and PCE Standard Deviation (sample: 1994. M1-2012.M6)

Table 1

	CPI	CPI_UIG	CPI_UIG_ prices only	CPI_XFE	CPI_TM	CPI_Med
S.D.	1.15	0.88	0.30	0.54	0.58	0.67

	PCE	PCE_UIG	PCE_UIG_ prices only	PCE_XFE	PCE_TM
S.D.	0.88	0.60	0.39	0.37	0.44

CPI correlations)

Table 2a

	CPI_UIG	CPI	CPI_XFE	CPI_TM	CPI_Med
CPI_UIG	1.00				
CPI	0.75	1.00			
CPI_XFE	0.25	0.36	1.00		
CPI_TM	0.36	0.59	0.83	1.00	
CPI_MED	0.20	0.31	0.88	0.88	1.00

PCE correlations

Table 2b

	PCE_UIG	PCE	PCE_XFE	PCE_TM
PCE_UIG	1.000			
PCE	0.764	1.000		
PCE_XFE	0.508	0.662	1.000	
PCE_TM	0.226	0.413	0.738	1.000

PCA on cores and UIG

Table 3

	PCA1	PCA2	PCA3	PCA4	PCA5
CPI	0.39	***0.55***	-0.59	0.27	0.36
UIG	0.32	***0.65***	0.64	-0.20	-0.14
CPI_XFE	***0.49***	-0.32	0.30	0.75	-0.11
CPI_TM	***0.53***	-0.15	-0.36	-0.36	-0.67
CPI_MED	***0.48***	-0.38	0.15	-0.45	0.63
Variance Prop.	0.54	0.31	0.10	0.03	0.02
Cumulative Prop.	0.54	0.86	0.95	0.98	1.00

Pseudo Out-of-Sample Forecast Performance in RMSE for CPI

Table 4

Out of sample performance for annual inflation through 2012.M6
(estimation sample starts in 1994M1)

Whole inflation cycle: 2000-2012.M6

	h=12	
UIG	**1.37**	
UIG_PONLY	1.54	*
CPI_XFE	1.81	***
CPI_TM	1.89	***
CPI_Median	1.92	**
CPI(t-h)	*2.03*	***

"Before crisis": 2000 - 2007

	h=12	
UIG	**0.90**	
UIG_PONLY	**0.88**	
CPI_XFE	*1.32*	**
CPI_TM	1.28	***
CPI_Median	1.26	***
CPI(t-h)	1.25	***

"In crisis": 2008-2012.M6

	h=12	
UIG	**1.92**	
UIG_PONLY	2.31	**
CPI_XFE	2.47	**
CPI_TM	2.72	**
CPI_Median	2.81	**
CPI(t-h)	*3.07*	***

"Stock and Watson (2008)" sample: 2001-2007

	h=12	
UIG	**0.93**	
UIG_PONLY	**0.91**	
CPI_XFE	1.27	*
CPI_TM	1.22	**
CPI_Median	1.24	**
CPI(t-h)	*1.28*	***

bold: sign. lowest RMSE; *italic: highest RMSE*
* 10 % sigificant level
** 5 % sigificant level
*** 1 % sigificant level
Diebold-Mariano test of the null hypothesis of equal RMSE against the alternative hypothesis that RMSE of UIG is lower. Test statistics uses the Newey-West covariance matrix estimator.

Real-time Out-of-Sample Forecast Performance — Table 5

Out of sample performance for annual inflation through April 2009
(estimation sample starts in November 2006)

Forecast Using:	*RMSE for CPI*	*RMSE for Core CPI*
UIG	**1.09**	**0.67**
12-month change in Core CPI	1.94	0.72
12-month change in CPI	2.81	1.63