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DECOMPOSING U.K. INFLATION EXPECTATIONS USING SURVEY-BASED MEASURES

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This paper derives a time-varying model to examine the dynamic interdependencies between realized and expected inflation. The results show inflation expectations at the short and long horizon have been uncorrelated over the past three decades, which is consistent with the anchored inflation expectations hypothesis. There is also little evidence that changes in realized inflation have been the result of self-fulfilling variations in the expectations of economic agents. Despite high commodity prices and above-trend inflation, expectations since the financial crisis in 2008 have not become unhinged from fundamentals.

Keywords: Inflation Expectations, Monetary Policy, Time Variation, Survey Data

1. INTRODUCTION

Expectations are an important channel through which monetary policy is transmitted to the real economy. This is because expectations influence the setting of prices and wages. An important concern for policy makers is whether inflation expectations remain anchored in the face of economic shocks. However, questions about how expectations are formed are viewed from conflicting perspectives. This paper examines the dynamics of U.K. inflation expectations using survey-based measures.

Examining survey data can help in understanding the role played by informational frictions, which influence macroeconomic dynamics.[1] The effectiveness of monetary policy could fall in an environment in which economic agents fail to observe actual inflation correctly in forming perceptions of true fundamentals. By engaging in contractionary monetary policy, the monetary authorities may be able to convince agents that inflation fundamentals have improved. However, for expectations to shift, the tightening in policy required may need to be larger than would be the case in the presence of lesser informational frictions. By engaging in excessively aggressive monetary policy the central bank may be able to convince agents that realized inflation has fallen, but at the cost of a possible prolonged period of economic stagnation. By aligning theory and empirics, a

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greater understanding of how U.K. inflation expectations are formed will allow academics and policy makers alike to construct models that more accurately reflect the development of agents' price expectations.

There are a number of advantages in using such survey measures to gauge price expectations. First, as noted by Barnett et al. (2010), survey-based measures on inflation expectations are probably more robust than using proxies, such as forecasts from the U.K.'s National Institute of Economic and Social Research (NIESR), as they encompass expectations of a large number of economic agents. This could be important if, as noted in Sims (2009), individuals are more likely to form their expectations heterogeneously.[2] Using survey responses across cohorts from various surveys, Blanchflower and Kelly (2008) find strong evidence in support of price expectations being formed heterogeneously in the United Kingdom.[3] Surveys on inflation expectations usually attain responses from a broad cross section—business economists, finance directors, academic economists, and trade unions—for their expectations. In contrast, market-based measures of inflation expectations could be influenced by institutional factors, for instance, if large institutional investors favored attaching a higher value to inflation protection. Additionally, such measures reflect risk premia associated with liquidity.

Additionally, as noted in Bianchi et al. (2009), from an econometric standpoint, the use of survey data represents independent information on inflation expectations and, thus, avoids having to impose modeling restrictions to extract those expectations. Finally, as noted in Clark and Davig (2009), survey expectations are superior to model-based forecasts, in part, because models cannot possibly include all the information available to economic agents when they form their expectations. Using independent sources of information and connecting survey-based measures of inflation expectations with macroeconomic observables can reassure policy makers that they have not become unhinged from economic fundamentals.

This paper explores three main questions using survey data:

- What determines or influences U.K. inflation expectations at the macro level?
- What is the relative importance of forward-looking versus backward-looking components in U.K. inflation dynamics?
- Do short- and medium-term inflation expectations signal risks for price stability in the near team in the aftermath of the great recession?

There has, thus far, been a relatively limited amount of work, especially when compared to that in the U.S., examining U.K. inflation expectations. This gap in the literature is even more acute when it comes to using survey data.[4] This in part reflects a lack of data on U.K. inflation expectations. These questions are examined using a generalized version of some common reduced-form models that embed inflation expectations. This paper extends these models by allowing time-varying stochastic volatility. The model in this paper therefore accounts for the possibility of structural breaks in the dynamics that characterize the real economy. This paper arrives at a number of findings:

- The time-varying responses show that inflation expectations generated by survey data, in general, reflect true fundamentals. Said differently, the response of inflation expectations to macroeconomic shocks reflect broader inflation and real output changes. This finding would constrast with expectations that exhibit sunspot shocks that are uncorrelated with changes in the underlying macro fundamentals.
- In a break with the Great Moderation era, this paper finds that real output and inflation volatility have risen considerably since early 2000. Much of the rise in macroeconomic volatility is accounted for by a rise in the variance of short-term inflation expectations.
- The results in this paper provide evidence in support of hybrid New Keynesian models that place some onus on forward- and backward-looking components of inflation dynamics. The standard Phillips curve linking inflation to the output gap has low forecasting power for U.K. inflation. Since Bank of England independence in 1997, observed inflation has been increasingly driven by forward inflation expectations.
- This paper reports U.K. inflation expectations to have been relatively anchored over the last 20 years. This is reflected in the relatively low correlation between short- and longer-term inflation expectations and the relatively benign response of expectations to shocks in realized inflation. The commodity price boom during mid-2000 and the financial crisis in 2008 did little to change this.
- The estimates show that monetary policy moves inflation expectations at various horizons. This finding lends weight to the expectations channel of monetary policy. The time-varying response functions also imply there has been a decline in the weight given by monetary policy to stabilizing output volatility in favor of managing inflation expectations and actual inflation.

This paper is structured as follows. The following section and subsections provide a brief description of the time-varying macro model and data descriptions. Sections 3 and 4 describe the estimates from the model. Section 5 looks at the role of commodity prices in inflation expectations, while also providing some robustness analysis with Section 6 concluding.

2. TIME-VARYING STOCHASTIC VOLATILITY MODEL

To capture sources of time variation, the model is based on a VAR framework with time-varying stochastic volatility. Given the limited size of the data set, this paper restricts the autoregressive coefficients to be fixed, thus limiting the number of parameters that need to be estimated and easing the convergence of the Gibbs sampler. The fixing of the autoregressive parameters should not unduly bias the results, because most of the sample covers the inflation targeting period, which should ensure stable coefficient values. The emphasis on time variation in the stochastic volatility component is motivated by findings in Primiceri (2005), Canova et al. (2007), and Benati (2008). To capture the changing dynamics of the macroeconomy, these studies placed particular emphasis on time variation in the stochastic volatility (size of shocks) over time variation in the reduced-form autoregressive coefficients. Allowing for such changes in the heteroskedasticity of shocks is consistent with the shifts that have occurred in the U.K. economy over the last 30 years, which have been widely documented in the "Great Moderation" literature. The basic outline of the framework is expressed as follows:

$$y_t = a_0 + \phi_1 y_{t-1} + \cdots + \phi_p y_{t-p} + \varepsilon_t \equiv X_t'\theta + \varepsilon_t, \qquad (1)$$

where y_t is a $(k \times 1)$-vector of observations of the dependent variables, with θ a $k(k \cdot p + 1)$-vector containing the VAR reduced-form coefficients (ϕ_i) and the constant term (a_0), $X_t = I_k \otimes [1, y_{t-1}', \cdots, y_{t-p}']$, and ε_t is a $(k \times 1)$-vector of unobservable heteroskedastic disturbance terms with zero mean. The vector ε_t has a time-varying covariance matrix,

$$\mathrm{Var}(\varepsilon_t) \equiv \Omega_t = \left(A_t^{-1}\right) H_t \left(A_t^{-1}\right)'. \qquad (2)$$

The matrix A_t is a lower triangular matrix that models the contemporaneous interactions among the endogenous variables and H_t is a diagonal matrix that contains the stochastic volatilities,

$$A_t \equiv \begin{pmatrix} 1 & 0 & \cdots & 0 \\ a_{21,t} & 1 & \cdots & \vdots \\ \vdots & \vdots & \ddots & 0 \\ a_{k1,t} & \cdots & a_{kk-1,t} & 1 \end{pmatrix}, \quad H_t \equiv \begin{pmatrix} h_{1,t} & 0 & \cdots & 0 \\ 0 & h_{2,t} & \cdots & \vdots \\ \vdots & \vdots & \ddots & 0 \\ 0 & \cdots & 0 & h_{k,t} \end{pmatrix}. \qquad (3)$$

The coefficients in A_t allow for the possibility of nonlinearity or time variation in the lag structure of the model. The multivariate time-varying variance–covariance matrix allows for heteroskedasticity of the shocks. Cogley and Sargent (2005) showed that ignoring movements originating from the heteroskedastic covariance structure would be picked up by the VAR coefficients leading to an upward bias. The two driving processes of the model and their distributional assumptions are

$$\begin{array}{l} a_t = a_{t-1} + \xi_t \\ \ln h_{i,t} = \ln h_{i,t-1} + \eta_t \end{array} \qquad \begin{pmatrix} \varepsilon_t \\ \xi_t \\ \eta_t \end{pmatrix} \sim N\left(0, \begin{pmatrix} \Omega_t & 0 & 0 \\ 0 & S & 0 \\ 0 & 0 & Z \end{pmatrix}\right). \qquad (4)$$

The a_t parameters, which also evolve as driftless random walks, are nonzero and non-one elements of the matrix A_t stacked by rows. The $\ln h_{i,t}$ evolve as geometric random walks, independent of one another, and contain the diagonal elements of H_t. The priors for the initial states of the regression coefficients, the covariances and the log volatilities—$p(a_0)$ and $p(\ln h_0)$—are assumed to be normally distributed and independent of each other. Following Primiceri (2005), this paper adopts the simplifying assumption that S is block-diagonal

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with $S_1 \equiv \mathrm{Var}(\xi_{21,t})$, $S_2 \equiv \mathrm{Var}[(\xi_{31,t}, \xi_{32,t})']$, $S_3 \equiv \mathrm{Var}[(\xi_{41,t}, \xi_{42,t}, \xi_{43,t})']$, and $S_4 \equiv \mathrm{Var}[(\xi_{51,t}, \xi_{52,t}, \xi_{53,t}, \xi_{54,t})']$. This block-diagonal structure implies that the $a_{ij,t}$ parameters of A_t belong to different rows and evolve independently. This simplifies estimation by making it possible to undertake Gibbs sampling on the nonzero and non-one elements of A_t equation by equation.

In the case of the stochastic volatility estimates (A_t and H_t), this paper sets the key elements of the priors from the point estimates of a constant-coefficient VAR(2) with a training sample of five years of data.[5] The following denote initial values of time-varying elements of the model at period 0:

$$\phi \sim N(0, 1000^2 I),$$
$$A_0 \sim N[\hat{A}^{\mathrm{OLS}}, 4 \cdot V(\hat{A}^{\mathrm{OLS}})],$$
$$S_i \sim IW(0.001 \cdot (i-1+4) \cdot V(\hat{A}^{\mathrm{OLS}}), [i-1+4)], i = 2, \ldots, p,$$
$$\ln h_{i,0} \sim N(\ln \hat{h}_i, 4), i = 1, \ldots, p,$$
$$z_i \sim IG(4 \cdot 0.01, 4), i = 1, \ldots, p.$$

Following Primiceri (2005), the prior mean on the variances ($S_i, i = 2, \ldots, n$) of innovations to the coefficients of A_t is 0.001 times the variance–covariance matrix of estimates of a constant matrix A that is estimated from the training sample. The prior degrees of freedom are set to ensure that for each equation i, which has $j = 1, \ldots, i-1$ coefficients, $a_{i,j,t}$ has $i - 1 + 4$ degrees of freedom. Finally, the prior on the variances for shocks to volatility (z_i) is based on Cogley and Sargent (2005) and Primiceri (2005) by setting the prior mean at 0.01 with four degrees of freedom.

2.1. Estimation of the Time-Varying Stochastic Volatility VAR

Following Clark and Davig (2009), the model is estimated using a five-step Metropolis-within-Gibbs Markov chain Monte Carlo algorithm. This involves the following steps:

1. The first step is to draw the VAR coefficients, θ, based on the conditional history of A_t, Ω_t, S_i, and Z_i, where $i = 1, \ldots, n$.
2. The time-series coefficients contained in A_t are drawn conditional on θ and past values of Ω_t, S_i, and Z_i, where $i = 1, \ldots, n$.
3. The elements of the time-varying variance–covariance matrix Ω_t are drawn conditional on θ and past values of A_t, S_i, and Z_i, where $i = 1, \ldots, n$.
4. The stochastic volatilities contained within $Z = [z_1, \ldots, z_n]$ are drawn conditional on θ and past values of Ω_t, A_t, and S_i, where $i = 1, \ldots, n$.
5. Finally, the shocks of the structural equations S_i are drawn conditional on θ and past values of Ω_t, A_t, and z_i, where $i = 1, \ldots, n$.

The posterior estimates are based on a collection of 5,000 draws, obtained by generating 100,000 burn-in draws and then saving every 10th draw from another 50,000 draws. This is enough to ensure that the Gibbs sampler converges to the ergodic distribution, while preventing autocorrelation in the Gibbs chain.

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2.2. Data and Structural Identification

The data run from 1986:3 to 2011:2 at a quarterly frequency. The sample contains a number of signature events. This includes the collapse of the exchange rate mechanism in 1991, the first and second Gulf Wars, which in both cases precipitated a hike in hydrocarbon prices, the introduction of inflation targeting in 1994, Bank of England operational independence in 1997, and the recent financial crisis in 2008–9.

To keep the analysis tractable in a TVP-VAR model, this paper develops a small five-equation macro model. The choice of the number of variables was also in part motivated by Del Negro (2003), which illustrated estimation uncertainty to grow significantly in TVP-VAR models as the number of endogenous variables increases. The U.K. model in this paper generalizes some recent reduced-form models in the literature, including Leduc et al. (2007), Clark and Davig (2008, 2009), Clark and Nakata (2008), and Mehra and Herrington (2008), by embedding inflation expectations in a VAR framework.[6] The model is also consistent with reduced-form hybrid New Keynesian Phillips curve equations, which embed a backward- and a forward-looking component, as well as forward-looking Taylor rules.

Let $X_t = [\pi^e_{t+8|t}, \pi^e_{t+4|t}, \pi_t, y_t, i_t]'$, which is a 5×1 column vector of the system variables. This paper follows Clark and Davig (2009) by embedding inflation expectations at two different horizons (one- and two-year horizons). The first two variables, $\pi^e_{t+8|t}$ and $\pi^e_{t+4|t}$, are the one- and two-year survey-based inflation expectations from the Barclays BASIX survey. This survey data has two unique advantages: (i) relative to nearly all survey data for the United Kingdom, the availability of a long time series (from 1986) and (ii) the large number of individuals surveyed from a wide variety of backgrounds: business economists, academics, trade unions, and finance directors. The surveys are based on the general public and ask, “from this list, can you tell me what you would expect the rate of inflation to be over the next 12/24 months?” with responses “below zero,” “about 1 percent,” “about 2 percent,”. . . ,“about 10 percent,” “above 10 percent,” “don’t know.”

As opposed to rational expectation models, economic agents are likely to form expectations heterogeneously, relying on different information sets. Agents may be entirely forward-looking or entirely backward-looking, or a combination of both. In inflation-targeting countries, agents may simply assume inflation will equal the target. By surveying people from a broad background, there is a higher probability of survey data being able to capture these differences.[7] The Barclays BASIX inflation expectations survey data are regularly reported on by the Bank of England and H.M. Treasury. The Bank of England inflation report illustrates the one- and two-year Barclays BASIX inflation expectations survey as a proxy for the general public’s short- and medium-term inflation expectations.[8] Including a medium-term price expectation variable in the TVP-VAR is consistent with the Bank of England’s remit to control inflation over the medium term.

Longer-run expectations are more central in gauging the credibility of monetary policy.

The inflation variable, π_t, is retail price index (RPIX) inflation, minus mortgage interest payments. This constitutes a measure of core inflation. Finally, following the Castelnuovo and Surico (2006) U.K. VAR model, as a measure of real economic activity y_t represents the real output gap, and i_t is the three-month treasury bill rate from the Bank of England statistics database.[9] Using the output gap has been shown to reduce the probability of encountering evidence of a price puzzle. The output gap in empirical models is also consistent with New Keynesian theory. If prices are sticky, inflation becomes a function of expected inflation as well as the pressure of demand, as captured by the output gap.[10] All data are plotted in Figure 1.

Following Leduc et al. (2007) and Clark and Davig (2009), inflation expectations are ranked first and second. Given the timing of survey respondent submissions, their expectations will have been based on inflation data from the previous month or quarter, at best. This minimum-delay assumption between inflation expectations and shocks to the real economy is also consistent with inertia in how agents update their expectations.[11] Following Clark and Davig (2008, 2009), long-term expectations are placed before short-term expectations, because a revision of long-term expectations will also likely lead to a revision in the short-term forecast,[12] the corollary being that a revision in short-term expectations need not necessarily lead to a shift in longer-term inflation expectations. This paper follows the convention in the literature by placing the real variable, y_t, before the interest rate measure. This structural identification scheme assumes that shocks are uncorrelated. As noted by Leduc et al. (2007), assuming uncorrelated shocks implicitly determines an equilibrium path if the economy is characterized by sunspot equilibria. This is because, in theory, sunspot shocks are completely undetermined.

3. ESTIMATION RESULTS

This section examines the time-varying dynamic interdependencies between realized and expected inflation derived from the data embedded in the model.

3.1. Size of Inflation Expectations and Macroeconomic Shocks

The previous one-and-a-half decades had been designated as the “NICE” decades by U.K. policy makers.[13] This view was born out of the decline in inflation volatility and the Great Moderation in real output volatility. The process of characterizing stylized facts about economic volatility helps to define the set of questions laid out in the introduction. Stochastic volatility is measured by

$$\sigma_{j,t} = (\Xi_j' A_t^{-1} H_t H_t' A_t'^{-1} \Xi_j)^{.5}, \tag{5}$$

where Ξ_j is a $(k \times 1)$ - with a one in the jth element and zeros elsewhere, and H_t contains the stochastic volatilities. Figure 2 reports the posterior medians of the

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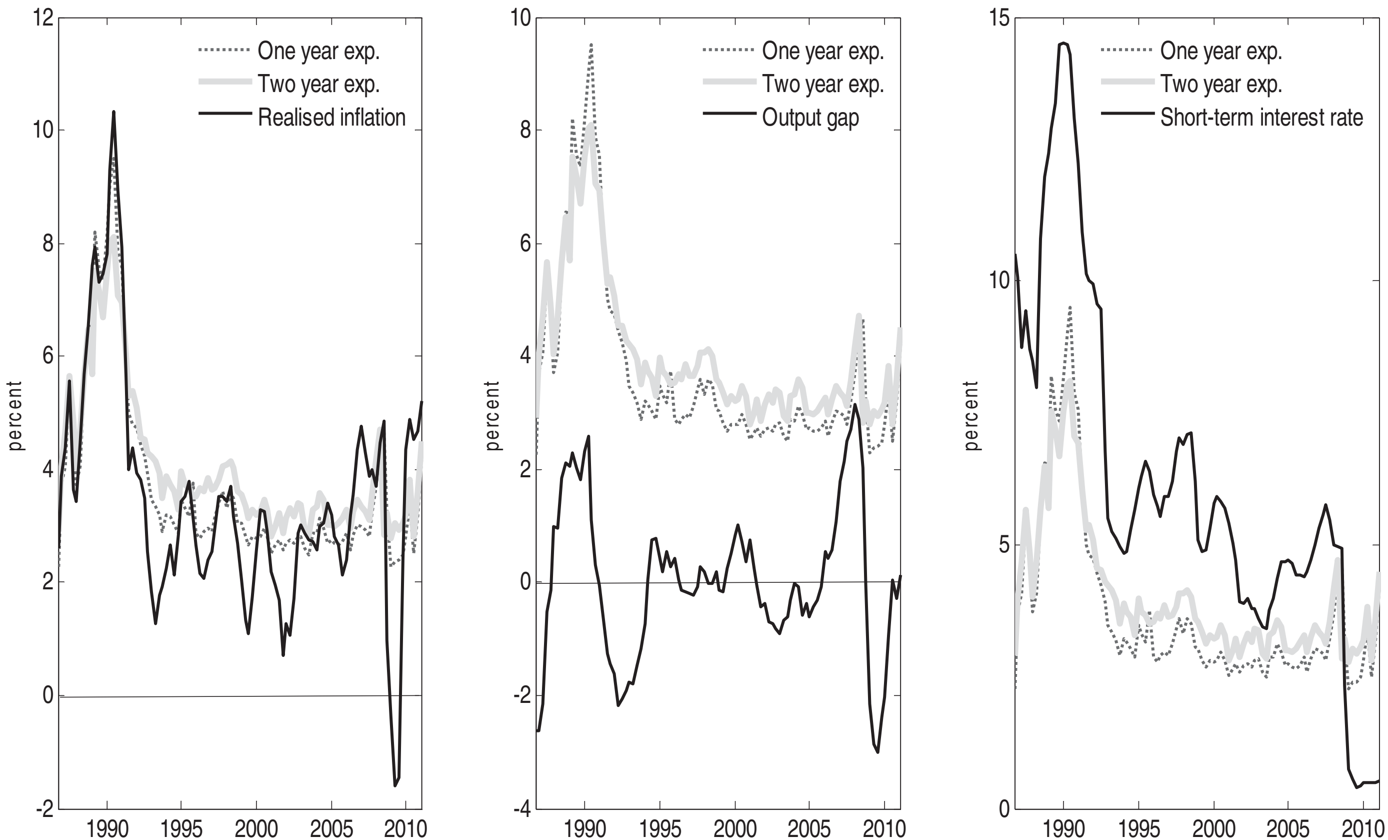

FIGURE 1. Time-series plot of inflation expectations, inflation, economic activity, and the short-term interest rate (1986–2011).

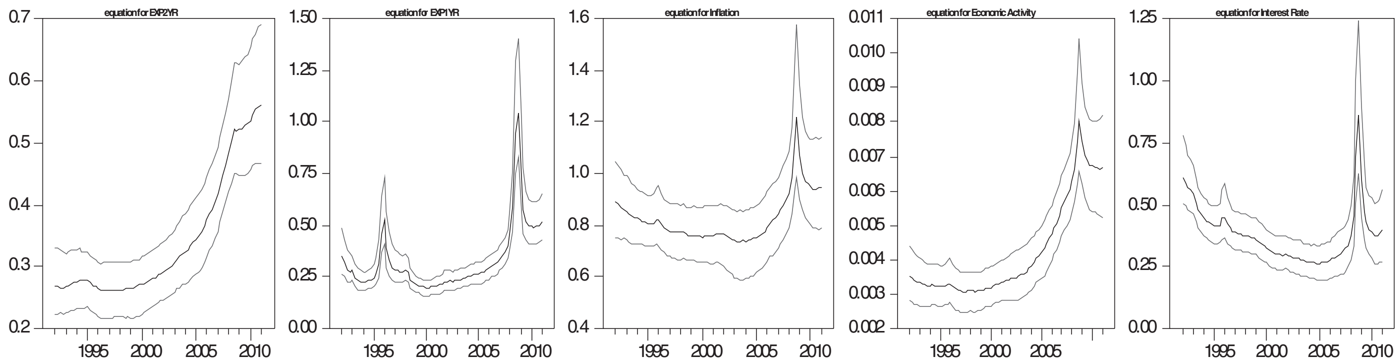

FIGURE 2. Stochastic volatility and approximate one-standard-deviation error bands.

time-varying stochastic volatilities. It is assumed that the stochastic volatilities are orthogonal to one another. There is, therefore, no reason to suppose shifts in the volatility of inflation to be correlated with the volatility of price expectations.

Figure 2 shows that the volatility in inflation expectations rose during the 1990s, which contrasts with the decline in actual inflation volatility. During the commodity price boom of the mid-2000s, inflation volatility began to rise in tandem with short-term inflation expectations. However, the magnitude of the rise in inflation volatility was smaller than that for inflation expectations. The rise in inflation volatility during the 2000s peaked at the height of the 2008 financial crisis, from which point volatility in short-term and actual inflation volatility declined.

The rise in inflation volatility during the 2000s was also mirrored by a rise in real output and short-term interest rate volatility. The increase in real output volatility was particularly pronounced from 2005. The severity of this rise has led some to ask whether the Great Moderation era is over.[14] Models based on the expectations trap, as in Chari et al. (1998), show that shifts in inflation expectations coupled with the reaction of the monetary policy maker may raise output volatility.

The stochastic volatility estimate for the short-term interest rate may be interpreted as the unanticipated actions of the monetary policy committee.[15] Since the early 1990s, changes in interest rate volatility have moved in phase with changes in actual inflation and real output volatility. From the early 1990s interest rate volatility declined. However, the size of interest rate shocks grew during the 2000s commodity price boom, peaking during the height of the financial crisis in 2008, at which point volatility declined.

3.2. Decomposing the Volatility in U.K. Inflation Expectations

Figure 3 reports the implied volatility as instantaneous variances broken down into the estimated contributions of each source of shocks. The share at time t is a function of θ, A_t, and Ω_t.[16] The height of the contours gives the total variance. Wider contours imply larger contributions.

The time-varying instantaneous variance estimates in Figure 3 show that the rise in CPI inflation volatility during the 2000s is primarily attributable to a sharp increase in the variance of short-term (one-year) inflation expectations. The instantaneous variances show that the spike in one-year inflation expectations is due entirely to shocks in the variable itself. The results also show that the rise in interest rate variability post-2005 was primarily driven by the increase in the variability of short-term inflation expectations. During this time the Bank of England tightened monetary policy because of rising commodity prices. Finally, the results show that the increased volatility in economic activity is down to a rise in the variance of short-term price expectations. Sims (2009) notes that shocks to inflation expectations may have real economic effects.

Figure 4 shows the time-varying variance decomposition estimates at a one-year horizon. Economic theory based on pure New Keynesian principles infers inflation to be a purely forward-looking phenomenon under an inflation-targeting regime.

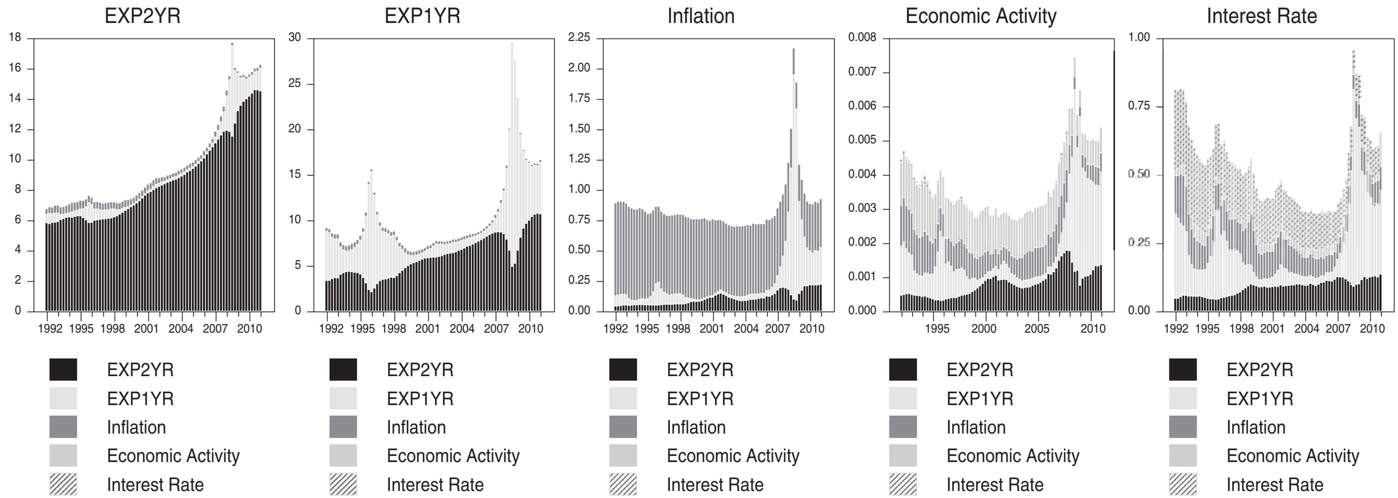

FIGURE 3. Instantaneous variance decomposition.

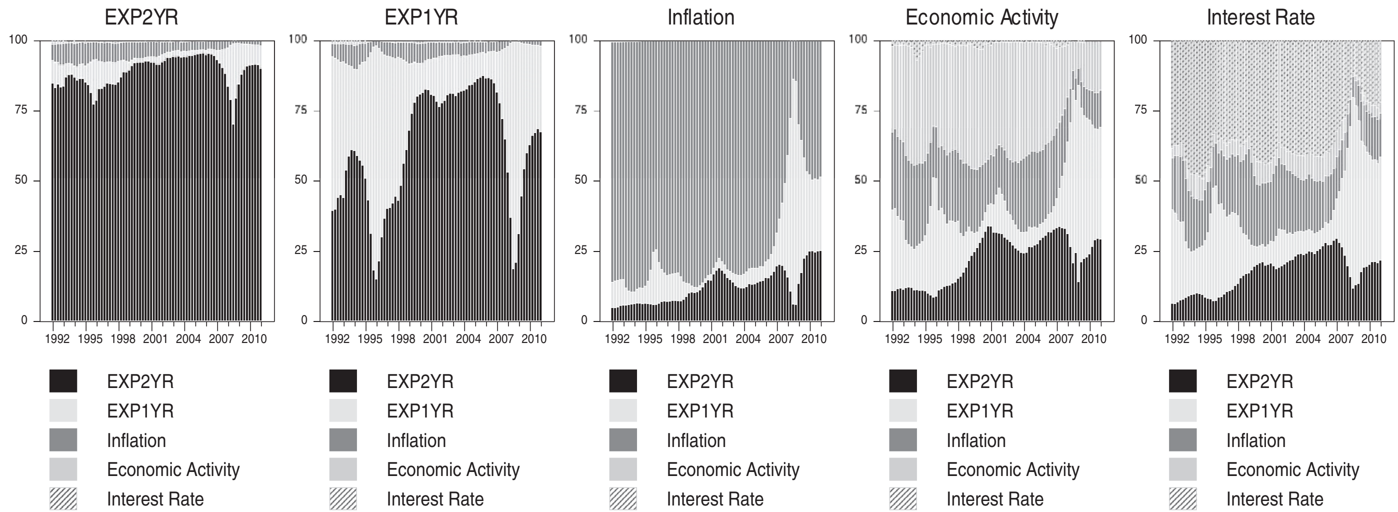

FIGURE 4. Variance decomposition results.

The time-varying variance decomposition results show domestic CPI inflation to have become progressively more influenced by forward-looking inflation expectations. For much of the 1990s and 2000s, the backward-looking component of inflation dominated. The importance of lagged values of inflation for forecasting actual inflation is consistent with sticky prices. However, the time-varying estimates show that shocks in short-term inflation expectations were a central factor in the dynamics of inflation during the commodity price boom of the mid-2000s. At its height, around 50% of actual inflation could be explained by shocks to short-term inflation expectations. Since the start of the financial crisis in 2007 this has fallen to around 26%. There has also been a progressive rise in the importance of longer-term inflation expectations for actual inflation dynamics. In the early 1990s, around 5% of the variation in CPI inflation was the result of shocks in two-year inflation expectations. By the end of the sample in 2011 this had increased to around one-fourth.

Combined, these results provide credence to New Keynesian models and hybrid New Keynesian Phillips curves, where some weight is given to the forward-looking behavior of economic agents.[17] This result also casts doubts on recent work in Blanchflower and MacCoille (2009), which used microdata to study the formation of U.K. inflation expectations in a fixed coefficient model, reporting inflation expectations to be mainly backward-looking.

The Phillips curve is often seen as a helpful guide for policy makers aiming to maintain low inflation and stable economic growth. In terms of the debate over whether 'expectations trump the gap' for actual inflation, the results show that information contained within survey expectations has been more useful than shocks in the output gap.[18] This finding is consistent with a number of studies documenting the low forecasting power of the output gap for domestic inflation. Among many others, Orphanides and van Norden (2005) and Stock and Watson (2007) find little forecasting improvement by the inclusion of the output gap over a simple autoregressive equation for inflation. The results imply that the traditional Phillips curve linking inflation to the output gap may not be the optimal model to forecast U.K. inflation.

According to the time-varying variance decomposition estimates, the proportion of historical developments in short- and medium-term inflation expectation dynamics over the past 20 years that can be accounted for by current and lagged actual inflation has been minimal. With the exception of two occasions—one in the mid-1990s and the other in 2007—over 50% of the variation in short-term inflation expectations has been driven by shocks in longer-term (two-year) price expectations. This implies that if longer-term inflation expectations became unhinged, short-term expectations would rise. On the average, over the past two decades, in line with intuition from the anchored inflation expectations hypothesis, around 80% of the variation in medium-term inflation expectations has been driven by innovations in itself. The minimal contribution of short-term expectational shocks for medium-term price expectations suggests that there has been little pass-through. This implies that revisions to longer-term inflation expectations filter down, as opposed to short-run revisions leading to an uptick all the way up the inflation expectations horizon. This finding is supportive of the view that inflation expectations, at least at horizons that are of interest to monetary policy makers, have been anchored. Longer-term inflation expectations more closely reflect the credibility of monetary policy.

Mehra and Herrington (2008) and Clark and Davig (2009) note that there is little agreement on whether exogenous movements in expected inflation represent omitted fundamentals or nonfundamentals that represent inflation scares. Clark and Davig (2009) attribute inflation expectation shocks to unforecastable movements in expectations resulting from changes in omitted fundamentals, rather than pure sunspot or expectational types of shocks. Omitted variables may reflect factors such as central bank communication or commodity prices, both of which affect private sector inflation expectations. It is unlikely that a VAR model will incorporate all the information available to agents when price expectations are being formed. It is therefore plausible that shocks to inflation expectations are themselves the result of omitted fundamentals. As noted in Leduc et al. (2007), however, the distinction between omitted fundamentals and expectational/sunspot shocks need not bias the results. Whether a shock is expectational or fundamental may still have long-lasting effects on actual inflation through the interaction of expectations and the actions of monetary policy.

Finally, the variance decomposition results show that monetary policy changes have been increasingly driven by changes in inflation expectations, particularly one-year inflation expectation developments. During the mid-1990s, around 25–30% of the variation in the monetary policy rate was the result of inflation expectation shocks. This had risen to around 75% by 2006. This finding is consistent with the view that monetary policy has become more forward-looking since the introduction of inflation targeting and central bank independence in the United Kingdom.[19] However, the weight given to information contained within lagged values of the output gap for monetary policy has declined to around 5%.

3.3. How Anchored Are Inflation Expectations?

Because the some parameters in the model are time-varying, the impulse responses—shown in Figures 5a–5e—are based on parameter values drawn from the median posterior at five dates of the sample.[20] To facilitate comparison across each time period, the size of the shock at each date is normalized to be the same on impact. The response functions drawn in bold represent responses that are statistically significant at the approximate one-standard-deviation level.

Inflation expectations are perceived to be anchored if they are unresponsive to shocks in realized inflation, as well as to more general macroeconomic shocks. A second definition, by Potter and Rosenberg (2007), argues that inflation expectations are anchored when medium- to long-term expectations do not increase in response to a rise in short-term inflation expectations; i.e., there is no

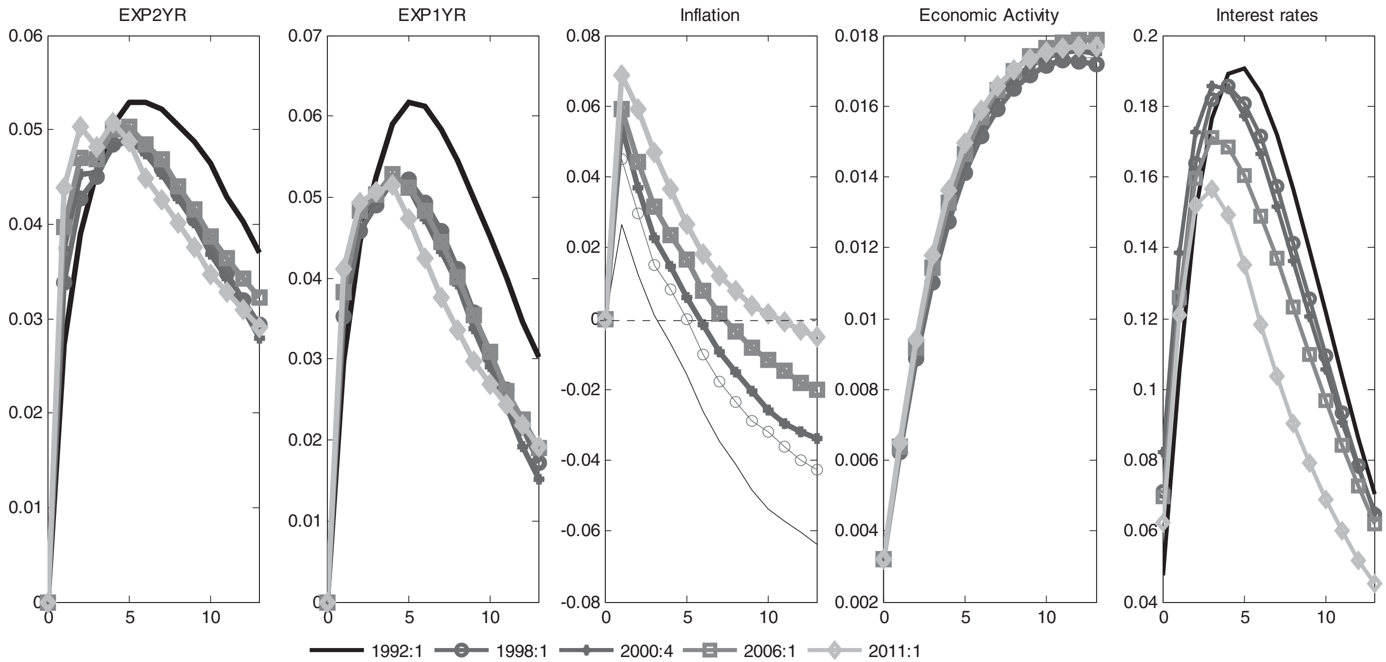

FIGURE 5a. Real economic activity shock (posterior medians).

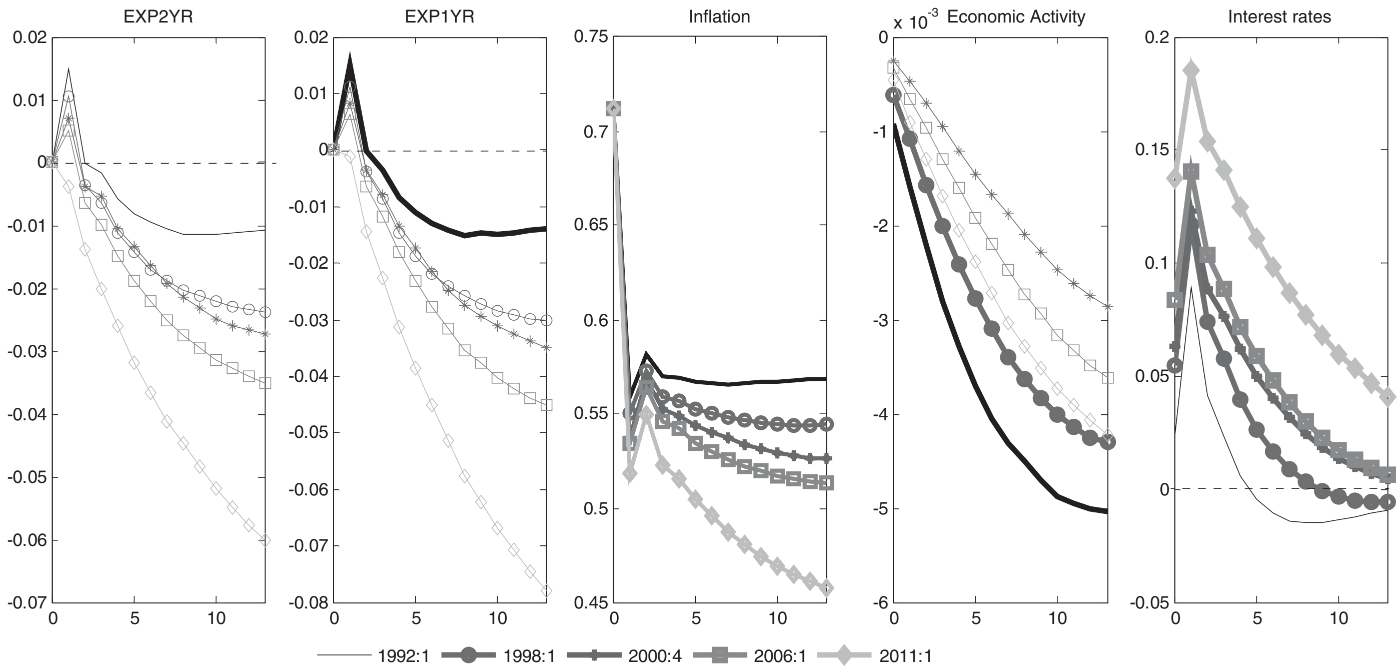

FIGURE 5b. Observable inflation shock (posterior medians).

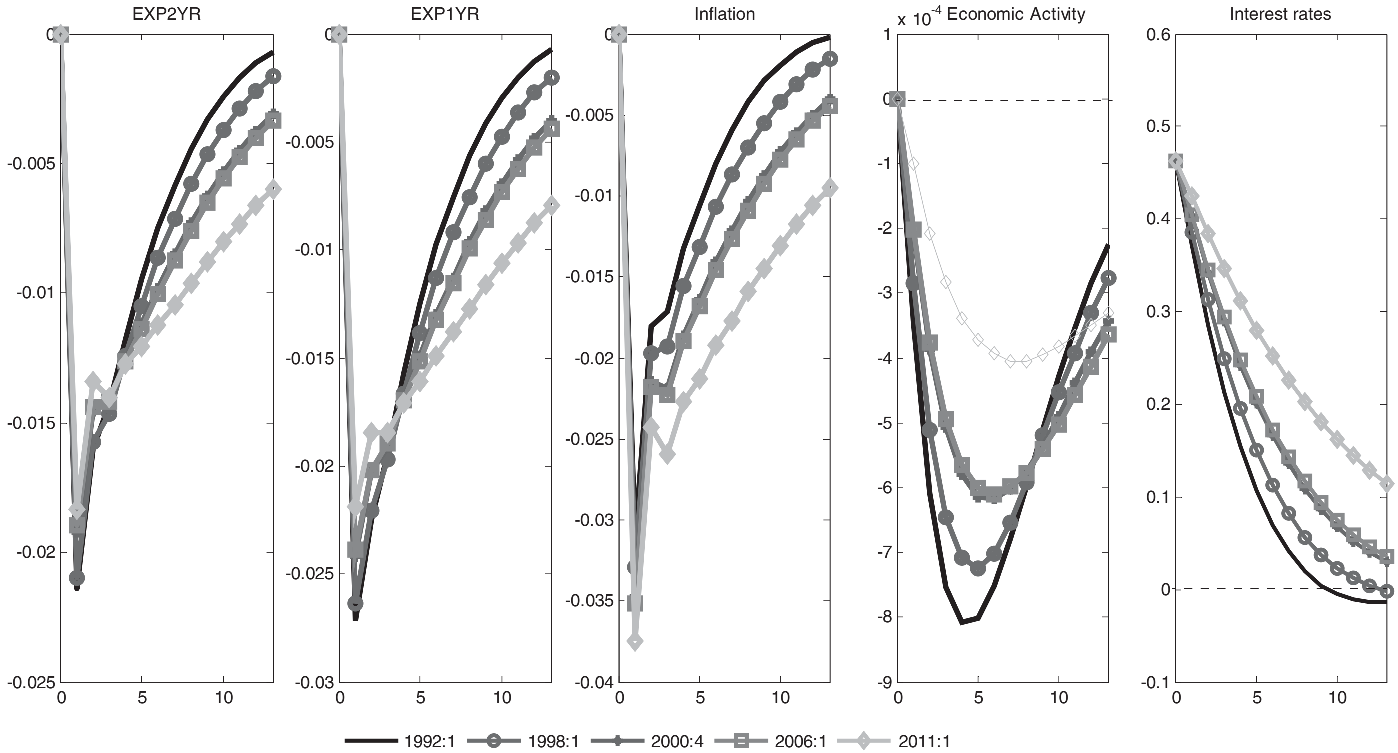

FIGURE 5c. Monetary policy shock (posterior medians).

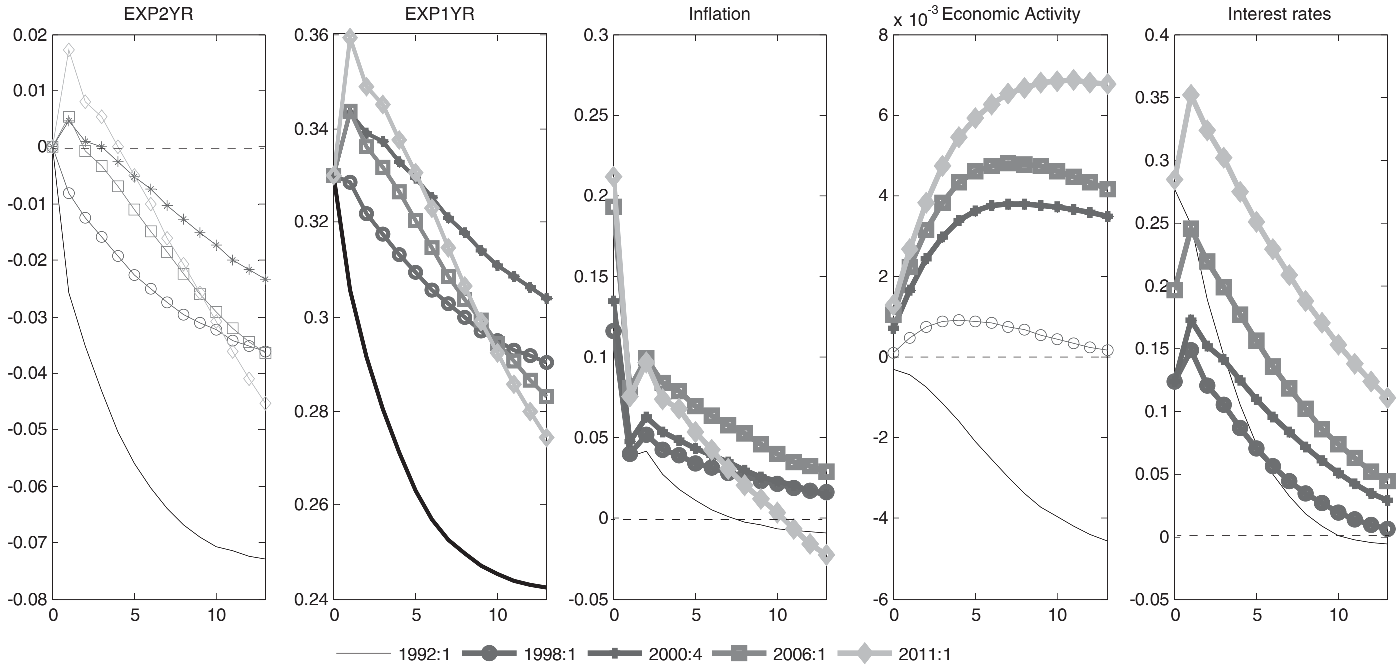

FIGURE 5d. One-year inflation expectations shock (posterior medians).

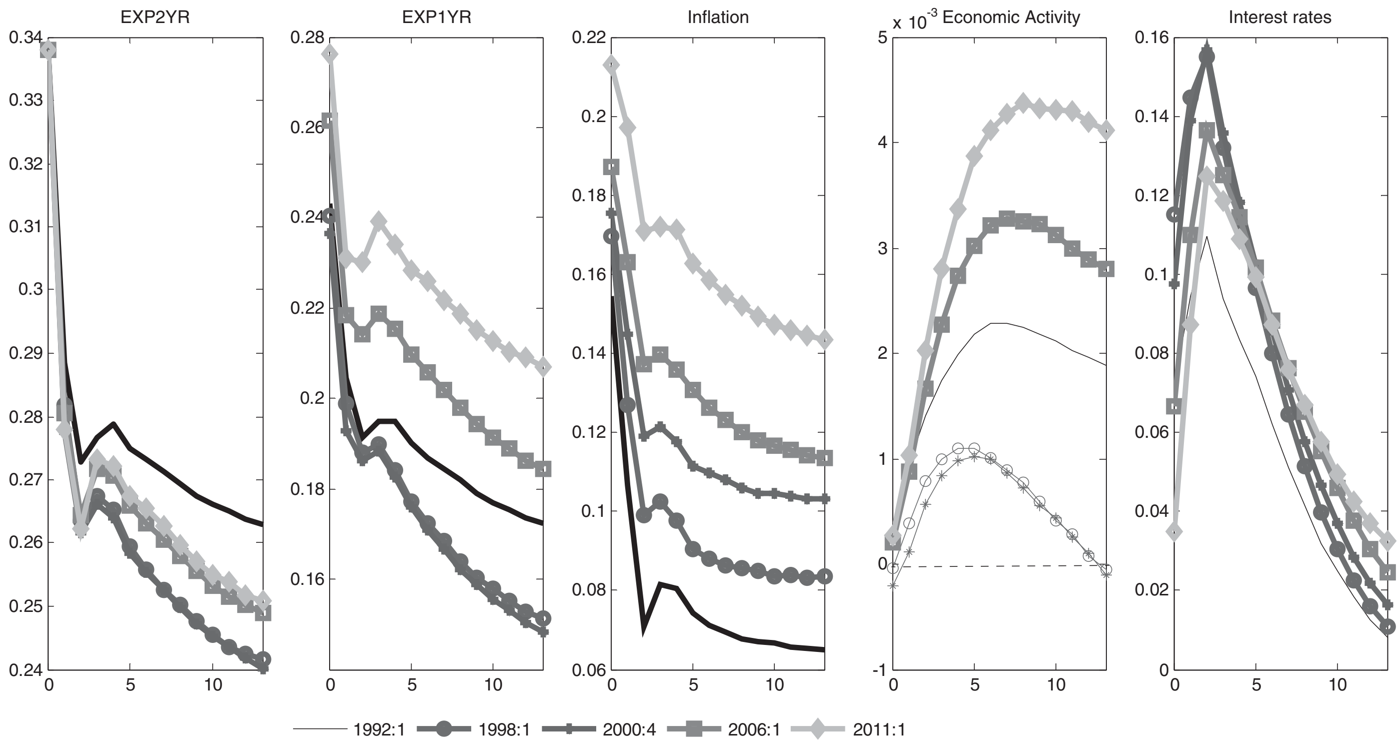

FIGURE 5e. Two-year inflation expectations shock (posterior medians).

pass-through. Shocks to one- (two-) year survey-based inflation expectations proxy short-term (medium-term) inflation expectations, which is consistent with the Bank of England's definitions for these horizons. The survey-based measures in the model capture expected average inflation over the next one to two years, so that a shock that is expected to have a persistent effect on the economy could potentially move inflation expectations. The responses in Figure 5a show that shocks to the output gap elicit a 12-month statistically significant hump-shaped rise in inflation expectations at both horizons. However, the hump-shaped response of inflation expectations to a real output shock contrasts with the persistent—almost unit-root-type—response needed to infer the presence of any second-round effects.

Actual inflation also rises in the short run in response to a positive output shock. In contrast to inflation expectations, the time-varying responses show that the persistence in the response of actual inflation has grown over the sample. Inflation responses based on values drawn in the early 1990s (2000s) show the effects of a real output shock having completely dissipated on domestic inflation within 12 (24) months. One explanation for the rise in inflation persistence could be an increase in the size of real output shocks. The stochastic volatility estimates in Figure 2 show that the size of real output shocks rose during the 2000s. The responses also imply that monetary policy has been countercyclical over the sample period, with short-term interest rates rising in response to a positive real output shock. However, the rise in interest rates is smaller for responses drawn near the end of the sample.

Bernanke (2007) has argued that if inflation expectations do not persistently rise despite a spell of higher inflation then inflation expectations can be considered well anchored.[21] Figure 5b illustrates the response of inflation expectations to a realized inflation shock. The short-run responses do not illustrate much heterogeneity over time. Short- and medium-term inflation expectations rise for around six months, after which the effects completely dissipate, with the responses turning negative. The negative values imply that agents expect inflation to fall in future time periods despite the unexpected rise in actual inflation today. It is worth noting that for much of the sample the inflation expectation responses have been insignificant. Taken together, these findings support the anchored inflation expectations hypothesis. Monetary policy tightens despite the fall in real economic activity. This is supportive of the Christiano and Gust (1999) limited participation model, which implies declining output in response to an unexpected inflation burst due to rising nominal interest rates. The time-varying responses show that monetary policy has responded more aggressively to unexpected inflation shocks over the past 20 years. Interest rate responses drawn near the end of the sample are larger than those drawn in the early 1990s. Taken together with the shrinking response of expected inflation, this finding implies that the response of the real rate to an unexpected CPI inflation shock has become stronger over time. This contrasts with real output shocks, which drew interest rate responses that were smaller near the end of the sample. Together, these responses imply a movement toward a greater weight on inflation stabilization.

The responses to a monetary policy shock, shown in Figure 5c, give little evidence of the existence of a possible price puzzle over the sample period. Monetary policy moves inflation expectations in a statistically significant fashion at different horizons. This is supportive of the expectations channel of monetary policy. The shape of the time-varying impulse responses of inflation expectations to monetary policy shocks has remained remarkably consistent over the sample. This is perhaps not surprising given that the sample period mostly covers one monetary policy regime. A tightening in monetary policy has historically led to a statistically significant transitory 3–6 month decline in short- and medium-term inflation expectations. After 6 months inflation expectations begin to recede back to trend. In terms of magnitude, the impact of a contractionary monetary policy shock is slightly larger on short- than on medium-term inflation expectations. The dynamic response of inflation expectations to monetary policy tightening moves approximately in phase with the analogous response of realized inflation. Finally, the results show that real output displays the familial hump-shaped decline in response to a contractionary monetary policy innovation.

An orthogonal shock to inflation expectations that is unrelated to economic fundamentals may be interpreted as a “pure” expectations trap shock.[22] Figure 5d illustrates that shocks to short-term expectations do not necessarily spill over into a rise in longer-term inflation expectations, despite a short-run rise in realized inflation. In contrast, the responses in Figure 5 illustrate that a positive shock in two-year inflation expectations leads to a statistically significant rise in short-term inflation expectations of a similar magnitude. These findings are consistent with the idea that a revision of long-term inflation expectations lead to a revision in the short-term forecast. However, a revision in short-term inflation expectations need not necessarily imply a shift in longer-term inflation expectations. Actual inflation also rises in response to a positive shock in short- and medium-term inflation expectations. Relative to short-term expectations, the rise in actual inflation is greater in magnitude to a medium-term inflation expectation shock.[23] If, to some extent, two-year inflation expectation shocks reflect innovations to trend inflation, then the weight given to two-year expectations in determining inflation dynamics will be greater than the weight given to lagged realizations of inflation. As a result, even small movements in two-year inflation expectations will represent a persistent source of pressure on actual inflation.[24]

The responses in Figures 5d and 5e show that monetary policy tightens in response to a rise in inflation expectations. Relative to the response drawn at the start of the sample (1992:1), which was statistically insignificant, the statistically significant monetary policy responses drawn after this sample point are larger in magnitude and more persistent. These findings imply that monetary policy has become more forward-looking. Additionally, with the exception of responses drawn in 2011:1, monetary policy responses to inflation expectation shocks have been larger than analogous responses derived from shocks to CPI inflation. This again suggests a larger weight on the forward-looking component of monetary policy, consistent with a forward-looking Taylor rule. Finally, shocks in medium-term inflation expectations lead to a persistent humped shaped rise in real output growth. It is worth noting that the rise in real output is greatest for the response drawn in the most recent sample period (2011:1), with monetary policy stuck in a liquidity trap.

The response of survey-based inflation expectations to monetary policy and real output shocks imply that such measures of expectations have reflected "true" fundamentals of the economy. In the presence of large information frictions, expectations would not mirror macroeconomic fundamentals, responding in an altogether different fashion to shocks compared with actual CPI inflation. The findings are in line with Gerlach et al. (2011), which illustrated that inflation expectations have not become unmoored in the aftermath of the recent financial crisis. The results also add empirical evidence to the current debate on whether a higher inflation target (or an attempt to stimulate a rise in inflation expectations) in an environment of near-zero policy interest rates would lead to a rise in current economic activity.[25] Krugman (1998) cites very benign inflation expectations as a central factor behind Japan's failure to escape from a liquidity trap. It is assumed that higher inflation expectations lower real interest rates and encourage consumers to bring consumption forward. However, Bachmann et al. (2012) show that higher expected prices were never a major reason to buy durable goods in the United States. On the other hand, consistent with the fiscal theory of the price level, Christiano et al. (2009) show in a standard New Keynesian model that the fiscal multiplier is larger when monetary policy is stuck near the zero lower bound because of the interaction between inflation expectations and real interest rates.

4. HOW PREDICTABLE IS REALIZED AND EXPECTED INFLATION?

To assess the contribution of past shocks, this section computes a statistic analogous to the R^2 computed in linear regression models. Following Cogley et al. (2010), this is calculated as the ratio of the conditional variance to the unconditional variance,

$$R^2_{j,t} = 1 - \frac{\Gamma_i \left[\sum_{h=0}^{j-1} \left(D_t^h\right) \operatorname{var}(\varepsilon_{t+1}) \left(D_t^h\right)' \right] \Gamma_i'}{\Gamma_i \left[\sum_{h=0}^{\infty} \left(D_t^h\right) \operatorname{var}(\varepsilon_{t+1}) \left(D_t^h\right)' \right] \Gamma_i'}, \quad (6)$$

where the matrix D_t is the companion matrix and contains the autoregressive parameters, Γ_i is a selector vector for each variable i in the model, and ε_t is the error term for the current and lagged values of y_t contained in the matrix X_t in equation (1). Figure 6 shows the median posterior estimate and the posterior

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confidence intervals of the implied R^2. The estimates are calculated as the fraction of the conditional to unconditional variance of the one-step-ahead forecast error ($j = 1$) for each equation in the TVP-VAR. Values closer to 100% suggest a high degree of in-sample contribution of past shocks.

Based on the fundamental variables in the model, the predictability of medium-term inflation expectations has been higher than that of short-term expectations. Throughout the sample, the predictability of medium-term expectations has fluctuated within a ±25% margin. The corresponding range for one-year inflation expectations is ±20%. However, since 2007, the upper estimate illustrates that up to 70% of medium-term price expectation fluctuations are predicted based on in-sample shocks contained in the model. The relatively low median R^2 values for expected inflation could be the result of the VAR model only including lagged values of the fundamentals. Hence, the information is backward-looking, whereas survey participants may be responding to information about fundamentals that is forward-looking and not incorporated into the model. As noted previously, it is impossible to include all the information that agents may use to form expectations in the TVP-VAR model.

The predictability of actual inflation has risen over the last 20 years. This rise has been particularly pronounced since 2003, coinciding with the commodity price boom. This increase is also mirrored in the short-term interest rate, implying that in-sample shocks are able to explain an ever greater proportion of monetary policy movements over the past two decades. This is consistent with changes that have taken place in U.K. monetary policy over the last 20 years, which include the introduction of inflation targeting and Bank of England operational independence. These policies, in part, aimed to make monetary policy more transparent and predictable.

5. EXPECTATION MODEL WITH COMMODITY PRICES

The estimates from the baseline model report a rise in inflation volatility post-2003. This rise coincided with a large increase in oil prices. This section examines the baseline estimates by augmenting the model with oil prices. As noted previously, however, estimation uncertainty increases in TVP-VAR as the number of endogenous variables rises. Estimates from the previous section showed an insignificant role for the output gap. Therefore, the output gap is replaced with nominal oil prices.[26] Because the United Kingdom is a small economy and a price taker on international markets, the oil price is ranked first. Oil prices are therefore assumed exogenous: $X_t = [\text{oil}_t, \pi^e_{t+8|t}, \pi^e_{t+4|t}, \pi_t, i_t]'$.[27] This model can be thought of as an extended version of the bivariate VAR estimated in Blanchard and Gali (2009), which included inflation expectations from survey data and the nominal oil price.

The time-varying response functions in Figure 7 show that an unexpected rise in nominal oil prices precipitates an increase in both actual and expected inflation. Pre-2000 inflation expectation responses are statistically insignificant. The responses report a greater magnitude rise in inflation expectations and actual

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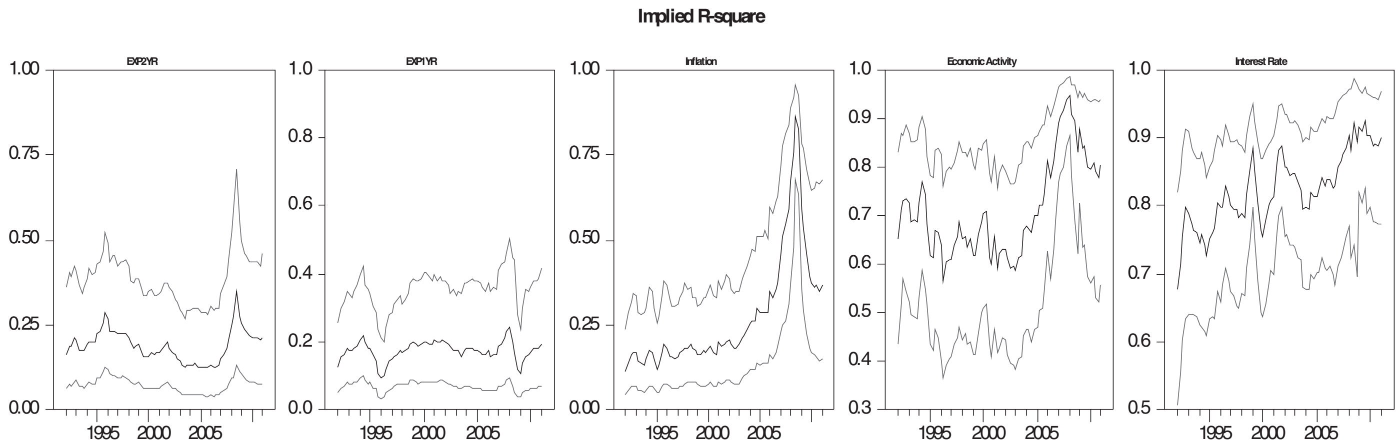

FIGURE 6. Time-varying R^2 and approximate one-standard-deviation error bands.

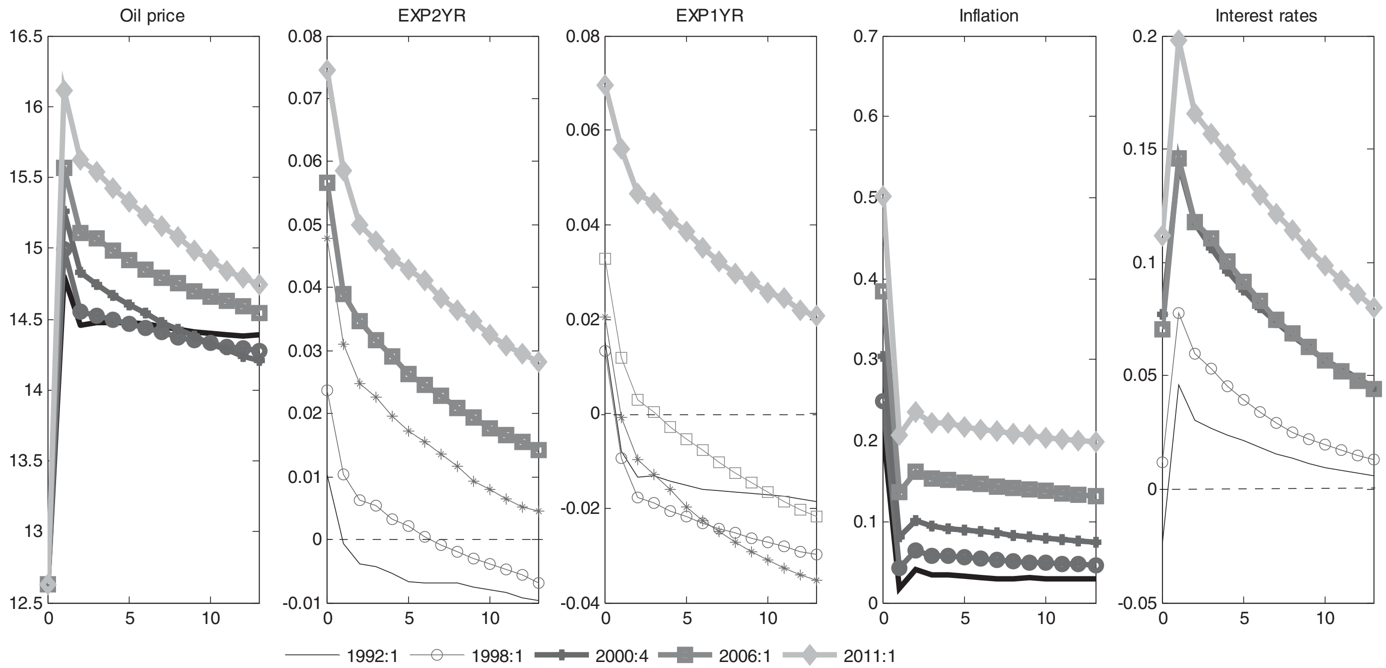

FIGURE 7. Responses to an oil price shock (posterior medians).

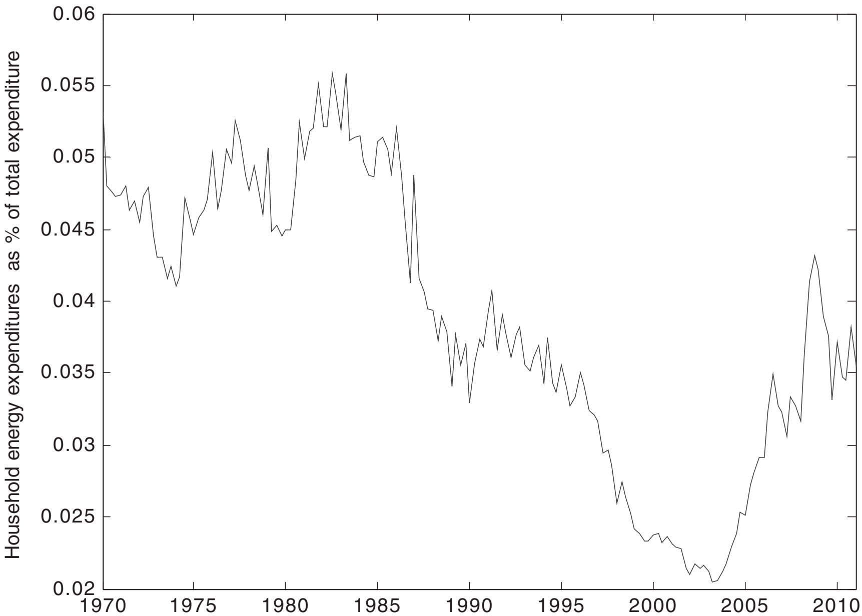

FIGURE 8. U.K. household energy expenditure as a percentage of total household expenditures.

inflation for those responses drawn during the 2000s relative to those 1990s. What could explain this rise? The first possibility is that there has been an increase in the size of oil price shocks during the 2000s. Assuming a constant propagation mechanism would imply an increase in the response of inflation to oil price shocks. The second concerns the rise in energy expenditures as a percentage of total household expenditures. Figure 8 shows that since 2000 there has been a reversal in the trend, with energy expenditures rising as a percentage of total household expenditures. This would have the effect of making agents' inflation expectations more sensitive to oil price shocks.

The estimates show that the impact of oil prices on actual inflation is larger than that for inflation expectations. Actual inflation rises by around 0.5 in 2011, whereas the analogous number for two-year inflation expectations is 0.07. The relatively inert response of inflation expectations during the recent commodity price boom has been cited as a key reason behind the absence of any wage–price spirals that emerged during the 1970s oil price shocks.[28]

The time-varying responses also show that the strength of the response of the nominal interest rate to oil price shocks has increased across sample periods. The rise in interest rates pre-2000 was insignificant. Responses drawn post-2000 show a statistically significant rise in interest rates. The stronger interest rate responses to oil price shocks post-1990 are consistent with evidence in Clarida et al. (2000) and Blanchard and Gali (2009). Under a credible central bank, more aggressive

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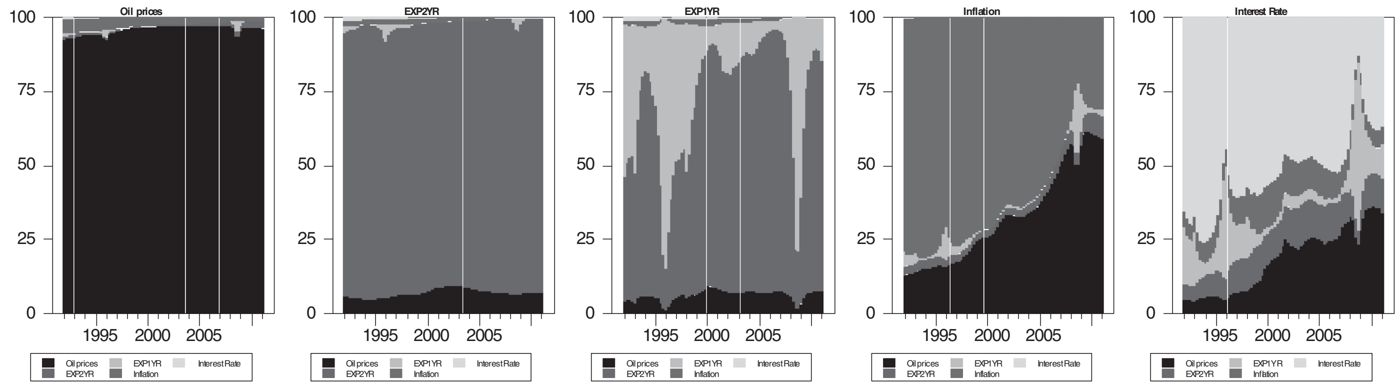

FIGURE 9. Time-varying variance decomposition with oil prices.

monetary policy would help keep inflation expectations under control by providing a signal of the banks' commitment in keeping inflation close to target.

Figure 9 illustrates the time-varying variance decomposition estimates.[29] The estimates show that the rise in oil prices is mostly reflected in its importance for realized inflation. The rise in the importance of oil price shocks for U.K. inflation was also reported in Rafiq (in press). The importance of oil price shocks for short- and medium-term inflation expectations remained relatively unchanged over the sample. The relative lack of change in the explanatory power of oil prices for inflation expectations is consistent with what one would expect under anchored inflation expectations.

6. CONCLUSION

This paper represents the first attempt to examine U.K. inflation expectations using survey data in a multivariate time-varying structural framework. To identify macroeconomic shocks, the model employs minimal identifying restrictions that are consistent with both the theoretical and empirical New Keynesian literature. In response to the set of questions laid out in the introduction, it is possible to draw a number of conclusions:

- The time-varying response show that inflation expectations generated by survey data, in general, reflect "true" fundamentals. Information extracted from survey data based on agents' price expectations can be useful in helping understand the future dynamics of U.K. inflation in response to shocks.
- With regard to the relative importance of the forward- and backward-looking components of U.K. inflation, the time-varying results show that shocks to expected inflation, particularly short-term expectations, have become an increasingly important source of variation for realized inflation. The results imply that forecasting U.K. inflation using standard Phillips curve equations linking inflation to the output gap will be suboptimal compared with New Keynesian Phillips curves that include a forward-looking component.
- Consistent with the anchored inflation expectations hypothesis, short- and medium-term inflation expectations have generally been uncorrelated over the last 20 years. Said differently, a rise in short-term expectations does not spill over into a revision of longer-term inflation expectations. Furthermore, very little of the variation in short- or medium-term inflation expectations has been the result of macroeconomic shocks. This suggests that inflation expectations have been relatively anchored since the introduction of inflation targeting in 1994. Additionally, the large commodity price shocks of the past decade and the financial crisis in 2008 did little to unmoor inflation expectations.
- The time-varying results lend credence to the idea that monetary policy has become more focused on inflation stabilization, making U.K. monetary policy predictable.

The results imply that with anchored inflation expectations the Bank of England could continue keeping interest rates low to stimulate economic activity in current depressed economic times, without the risk of endangering long-term price stability.

NOTES

1. See, among others, Sims (2009), Bachmann et al. (2010), and Mankiw and Reis (in preparation).
2. Mankiw et al. (2004) find that observed inflation expectations are not consistent with rational expectations nor with adaptive expectations.
3. Blanchflower and Kelly (2008) use the Bank of England/NOP and GFK surveys. These surveys began in the last decade.
4. See Leduc et al. (2007), Clark and Davig (2008, 2009), Clark and Nakata (2008), and Mehra and Herrington (2008) for studies using U.S. survey data.
5. The first responses can therefore be considered as being close to the average of the period.
6. A few studies for the United States have already used survey data in VAR models to examine inflation expecations. Leduc et al. (2007) used the Livingstone Survey, whereas Clark and Davig (2008, 2009) used the Federal Reserve Bank of Philadelphia's Survey of Professional Forecasters and Blue Chip Survey.
7. See Blanchflower and Kelly (2008), Kelly (2008), and Sims (2009).
8. See Bank of England, Inflation Quarterly Report, May 2010. Ideally, a longer horizon would be used to capture medium- and longer-term inflation expectations. However, there remains a dearth of survey data for U.K. inflation expectations beyond two years, with all of the data starting in early 2000. The Barclays Basix survey is the longest-running survey of inflation expectations in the U.K.
9. The use of the output gap helps reduce the prevalence of the price puzzle for U.K data—although, as noted by Harrison et al. (2008), the price puzzle appears to be a strong feature in U.K. macroeconomic time series data. Castelnuovo and Surico (2006) show that the T-bill rate closely mirrors changes in U.K. monetary policy. Rotemberg and Woodford (1998) noted that real output, inflation, and the interest rate variables are the "minimal set" needed for an analysis of the relationship between policy variables and macroeconomic time series.
10. See Clarida et al. (2000).
11. See Mankiw and Reis (2002).
12. This identification scheme is also consistent with recent work in Bachmann et al. (2010), which embeds qualitative survey-based data in a VAR framework.
13. The acronym "NICE" refers to noninflationary consistent expansion.
14. See Clark (2009).
15. See Cogley and Sargent (2005).
16. The estimates are obtained from 100-step ahead forecast error variance decompositions. The 100-step horizon is sufficient to ensure that the estimated variances correspond to the fitted variances.
17. See Stock and Watson (2002).
18. See Piger and Rasche (2006).
19. See Harrison et al. (2008).
20. This is for computational reasons, with some consideration of the reporting results. It is simpler to report complete responses for a handful of dates. Furthermore, with the coefficients gradually changing over time, the impulses would not change much from quarter to quarter.
21. Also see Levin et al. (2004).
22. See Christiano and Gust (1999).
23. Similar persistent median responses for actual inflation to expected inflation shocks were also uncovered for the United States in Clark and Davig (2008, 2009), who estimated a stationary VAR model. This result was also found in the stationary model of Clarida et al. (2000).

24. Clark and Davig (2008) note that long-term survey expectations of inflation can be viewed as professional forecasters' view of trend inflation.
25. See Mankiw and Weinzierl (2011).
26. The results change little with the inclusion of the output gap.
27. This assumption is consistent with the general literature.
28. See Blanchard and Gali (2009).
29. Oil prices are dominated by shocks in themselves, which implies that the identified oil price shocks are exogenous.

REFERENCES

Bachmann, R., T.O. Berg, and E.R. Sims (2012) Inflation Expectations and Readiness to Spend: Cross-Sectional Evidence. NBER working paper 17958.

Bachmann, R., S. Elstner, and E.R. Sims (2010) Uncertainty and Economic Activity: Evidence from Business Survey Data. NBER working paper series 16143.

Barnett, A., J.J.J. Groen, and H. Mumtaz (2010) Time-Varying Inflation Expectations and Economic Fluctuations in the United Kingdom: A Structural VAR Analysis. Working paper 392, Bank of England.

Benati, L. (2008) The "Great Moderation" in the United Kingdom. *Journal of Monetary Credit and Banking* 40, 121–147.

Bernanke, B. (2007) Inflation Expectations and Inflation Forecasting. Remarks given at the Monetary Economics Workshop of the NBER Summer Institute, Cambridge, MA, July 10.

Bianchi, F., H. Mumtaz, and P. Surico (2009) The great moderation of the term structure of UK interest rates. *Journal of Monetary Economics* 56(6), 856–871.

Blanchard, O.J. and J. Gali (2009) Why Are the 2000s so Different from the 1970s? A Structural Interpretation of Changes in the Macroeconomic Effects of Oil Prices. NBER Working Paper 15467.

Blanchflower, D. and R. Kelly (2008) Macroeconomic Literacy, Numeracy and the Implications for Monetary Policy. Working paper, Bank of England.

Blanchflower, D.G. and C. MacCoille (2009) The Formation of Inflation Expectations: An Empirical Analysis for the UK. NBER Working Paper 15388.

Canova, F., L. Gambetti, and E. Pappa (2007) The structural dynamics of output growth and inflation: some interest evidence. *Economic Journal* 117, 167–191.

Castelnuovo, E. and P. Surico (2006) The Price Puzzle: Fact or Artefact? Working paper 288, Bank of England.

Chari, V.V., L.J. Christiano, and M. Eichenbaum (1998) Expectation traps and discretion. *Journal of Economic Theory* 2, 462–492.

Christiano, L., M. Eichenbaum, and S. Rebelo (2009) When Is the Government Spending Multiplier Large. NBER working paper 15394.

Clarida, R., J. Gali, and M. Gertler (2000) Monetary policy rules and macroeconomic stability: Evidence and some theory. *Quarterly Journal of Economics* 115, 147–180.

Clark, T.E. (2009) Is the Great Moderation Over? An Empirical Analysis. Federal Reserve Bank Economic Review, Fourth Quarter.

Clark, T.E. and T. Davig (2008) An Empirical Assessment of the Relationship Among Inflation and Short- and Long-Term Expectations. Research working paper 08-05, Federal Reserve Bank of Kansas.

Clark, T.E. and T. Davig (2009) Decomposing the Declining Volatility of Long-term Inflation Expectations. Research working paper 09-05, Federal Reserve Bank of Kansas.

Clark, T.E. and T. Nakata (2008) Has the behavior of inflation and long-term inflation expectations changed? *Federal Reserve Bank of Kansas City, Economic Review* First Quarter, 39–51.

Cogley, T., G.E. Primiceri, and T.J. Sargent (2010) Inflation-gap persistence in the U.S.. *American Economic Journal: Macroeconomics* 2(1), 43–69.

Cogley, T. and T.J. Sargent (2005) Drifts and volatilities: monetary policies and outcomes in the post WWII US. *Review of Economic Dynamics* 8, 262–302.

Del Negro, M. (2003) Discussion of Cogley and Sargent's "Drifts and Volatilities: Monetary Policy and Outcomes in the Post WWII U.S." Working paper 2003-26, Federal Reserve Bank of Atlanta.

Gerlach, P., P.Hördahl, and R. Moessner (2011) Inflation expectations and the great recession. *BIS Quarterly Review*, March 2011.

Harrison, R., H. Mumtaz, and T. Yates (2008) Using Time-Varying VARs to Diagnose the Source of "Great Moderations": A Monte Carlo Analysis. CDMA conference paper series 0814, University of St. Andrews Centre for Dynamic Macroeconomic Analysis.

Kelly, R. (2008) The Causal Relationship between Inflation and Inflation Expectations in the United Kingdom. Discussion paper 24, External MPC Unit, Bank of England.

Krugman, P. (1998) It's baaack: Japan's slump and the return of the liquidity trap. *Brookings Papers on Economic Activity* 2, 137–205.

Leduc, S., K. Sill, and T. Stark (2007) Self-fulfilling expectations and the inflation of the 1970s: Evidence from the Livingston Survey. *Journal of Monetary Economics* 54, 433–459.

Levin, A., F. Natalucci, and J. Piger (2004) The macroeconomic effects of inflation targeting. *Federal Reserve Bank of St. Louis Review* 86(4), 51–80.

Mankiw, N.G. and R. Reis (2002) Sticky information versus sticky prices: A proposal to replace the new Keynesian Phillips curve. *Quarterly Journal of Economics* 117, 1295–1328.

Mankiw, N.G. and R. Reis (N.D.) Imperfect information and aggregate supply. *Handbook of Monetary Economic*s (in preparation).

Mankiw, N.G., R. Reis, and J. Wolfers (2004) Disagreement about inflation expectations. *NBER Macroeconomics Annual* 18, 209–248.

Mankiw, N.G. and M.C. Weinzierl (2011) An Exploration of Optimal Stabilisation Policy. NBER working paper 17029.

Mehra, Y.P. and C. Herrington (2008) On the sources of movements in inflation expectations: A few insights from a VAR model. *Federal Reserve Bank of Richmond Economic Quarterly* 94(2), 121–146.

Orphanides, A. and S. van Norden (2005) The reliability of inflation forecast based on output gap estimates in real time. *Journal of Money, Credit and Banking* 37(3), 583–600.

Piger, J.M. and R.H. Rasche (2006) Inflation: Do Expectations Trump the Gap? Federal Reserve Bank of St. Louis working paper 2006-013B.

Potter, Simon M. and Joshua Rosenberg (2007) Are US Inflation Expectations Anchored, Contained, or Unmoored? Unpublished working paper, Federal Reserve Bank of New York.

Primiceri, G.E. (2005) Time varying structural vector autoregressions and monetary policy. *Review of Economic Studies* 72, 821–852.

Rafiq, S. (in press) What do energy prices tell us about U.K. inflation. *Economica*.

Rotemberg, J.J. and M. Woodford (1998) An Optimization-Based Econometric Framework for the Evaluation of Monetary Policy: Expanded Version. NBER technical working paper 233.

Sims, C. (2009) Inflation Expectations, Uncertainty and Monetary Policy. BIS working paper 275. Bank of International Settlements.

Stock, J.H. and M.W. Watson (2007) Why Has U.S. Inflation Become Harder to Forecast?*Journal of Money, Credit and Banking* 39(1), 3–34.