



BANK OF ENGLAND

External MPC Unit

Discussion Paper No. 24

The causal relationship between inflation and inflation expectations in the United Kingdom

Roger Kelly

July 2008



BANK OF ENGLAND

External MPC Unit

Discussion Paper No. 24

The causal relationship between inflation and inflation expectations in the United Kingdom

Roger Kelly⁽¹⁾

Abstract

Two major events have affected the monetary regime in the United Kingdom in recent years, namely the introduction of inflation targeting, and the granting of operational independence to the Bank of England. In this paper we examine what impact, if any, these events have had on inflation expectations. A series of Granger causality tests are used in order to examine the causal relationship between a measure of prices and inflation expectations. We find evidence that the introduction of inflation targeting caused both the general public and professionals to anchor their expectations, rather than basing them on current RPI inflation.

(1) Bank of England. Email: roger.kelly@bankofengland.co.uk

The views expressed in this paper are those of the author, and not necessarily those of the Bank of England. I am grateful to Kate Barker, Ronnie Driver, Andrew Holder, Andrew Sentance, Tracy Wheeler, Fabrizio Zampolli and an anonymous referee for comments.

Information on the External MPC Unit Discussion Papers can be found at www.bankofengland.co.uk/publications/externalmpcpapers/index.htm

External MPC Unit, Bank of England, Threadneedle Street, London, EC2R 8AH

1. INTRODUCTION

As one might expect, there is a strong correlation between inflation and inflation expectations. It has been empirically verified by a number of authors and can be seen in chart 1, below, which plots inflation expectations of the general public and professionals against RPI inflation¹.

Chart 1: Survey-based expectations and RPI inflation



Source: Barclays BASIX, Bank of England

However, the direction of causality – in other words the lead-lag relationship between inflation and inflation expectations - has remained a contentious issue. This warrants some investigation, as inflation expectations are deemed to play an important part in an inflation targeting regime. In the neo-Keynesian model (see, for example, Clarida et al. 2000), sticky prices result in forward looking behaviour; inflation today is a function of expected future inflation as well as the pressure of demand, captured in an output gap term. Thus expectations are deemed to be an important link in the monetary transmission mechanism, and monetary policy can be more successful when inflation expectations are well anchored (which is taken to mean insensitive to incoming data (Bernanke 2007)).

¹ Although, as noted by Driver and Windram (2007), the strength of the correlation depends on the period under consideration.

This paper looks at the issue of the direction of causality (in the lead-lag Granger sense) between inflation and inflation expectations. Clearly, the mechanism assumed above is that if inflation expectations were to become de-anchored, they may cause inflation to move away from target. But at the same time, if inflation were persistently away from the target, this in turn could cause expectations to become deanchored. One could speculate that the introduction of inflation targeting in 1992, and/or the change in the monetary arrangements that gave the Bank of England independence in 1997 might have had an impact on the relationship – notably making expectations less sensitive to changes in the inflation rate². This will be investigated in what follows.

If the causal relationship between inflation and inflation expectations has changed, this suggests that either the mechanism by which inflation expectations influence inflation has changed, or else the manner in which agents form their expectations has changed. Most models assume that expectations are formed rationally. In practice this is unlikely to be the case; it is more likely that agents form their expectations heterogeneously, relying on different models and datasets, and having different capabilities for processing information (see Branch, 2004; Carroll, 2003, Brock and Hommes, 1997). Furthermore there may be a degree of learning taking place over time (see Pfajfar and Santoro, 2006, Orphanides and Williams, 2003). More generally, Driver and Windram (2007) note that some agents may form

² There has been some work done in this area, most obviously a submission by the Bank of England to the Treasury Select Committee entitled ‘The MPC Ten Years On’. Further papers address the issue of whether inflation targeting has changed the time series properties of the economic system (see Benati, 2007, 2005), and documents the fall in the persistence and predictability of inflation. Benati also shows how inflation targeting has affected inflation in several countries, and relates the results to theoretical New Keynesian models (Benati 2008).

their expectations based on a structural relationship, such as the trade off between inflation and unemployment or demand; others may use an empirical approach, e.g. their recent memories of inflation data. Furthermore, people may be entirely forward looking or entirely backward looking. More simplistically, in inflation targeting countries, people may simply assume inflation will equal the target. The issue of how agents form their expectations has attracted an extensive literature (see Bakhshi and Yates 1998), and investigation of this aspect is beyond the scope of this paper; rather this paper will simply seek to assess whether a change may have occurred.

2. METHODOLOGY AND DATA ISSUES

The methodology followed in the paper seeks to improve on earlier methodologies by avoiding the use of standard Granger causality tests, instead using a more appropriate methodology for time series data. As noted by Mavrotas and Kelly (2001) testing the direction of causality (in the Granger sense of lead-lag relations) has generally been performed using either the Granger or Sims tests (see Granger, 1969, Sims, 1972). These tests are based on null hypotheses formulated as zero restrictions on the coefficients of the lags of a subset of the variables. However, such tests are grounded in asymptotic theory, which is only valid for stationary variables. Many macroeconomic variables are known to be non-stationary, meaning inferences based on asymptotic theory can only be made if a vector autoregression is estimated in differences, and therefore stationary. However, unit root tests to establish stationarity have low power against the alternative hypothesis of trend stationarity; and similarly, the tests for cointegrating rank in Johansen's tests are sensitive to the values of trend and constant terms in finite samples and so are not very reliable for typical time-series sample sizes. Since implementation of both the Sims and Granger tests for Granger

causality requires knowledge of cointegrating ranks, it is clear that incorrect inferences could be made about the issue of Granger causality simply because of the sensitivity of stationarity or cointegration tests.

While problems in testing for integration and cointegration have to be suffered if one's interests are in the cointegrating relations themselves, Toda and Yamamoto (1995) noted that in many applications of VAR models, for example Granger causality testing, the researcher has scant interest in the existence of unit roots or cointegration relations themselves, instead being interested in testing economic hypotheses expressed as restrictions on coefficients of the model. Thus they propose a causality test that fits a standard vector autoregression in the levels of the variables. This minimises the risks associated with wrongly identifying the orders of integration of the series, or the presence of cointegration, and minimises the distortion of the tests' sizes as a result of pre-testing (Giles, 1997, Mavrotas and Kelly, 2001).

Toda and Yamamoto's methodology proceeds as follows. First the model must be specified, which involves determining the optimal lag lengths of the levels of own and other variables in the model. This is done by minimising the Akaike's Information Criterion – this assesses the goodness of fit of the model, but improves on standard methods such as RSS or R^2 as it takes into account improvements in goodness of fit that arise simply due to increasing the number of explanatory variables in the model. Having specified the VAR, its robustness is tested using misspecification tests. Having determined a lag length k , we then estimate a $(k+d)$ th order VAR where d is the maximal order of integration that we suspect might occur in the process (The augmented Dickey-Fuller (ADF) test (Dickey and Fuller, 1981) is used to test for unit roots). The coefficient matrices of the last d lagged vectors in the model are ignored (since these are regarded as zeros) and we can test linear or

nonlinear restrictions on the first k coefficient matrices using standard asymptotic theory.

The question of data is an important one. There are two considerations – first, what measure of inflation expectations to use, and second, what measure of inflation? Mankiw, Reis and Wolfers (2003) undertake a comprehensive study in the area of measuring inflation expectations. There are a number of possible ways to measure expectations, which fall into two main groups. First, expectations can be measured through surveys, including surveys of consumer attitudes and behaviour, surveys of economists working in industry and surveys of professional forecasters. Second, expectations can be measured by the difference in yields between nominal and indexed bonds. For the purpose of this exercise, we use survey-based data³, more specifically data from the Barclays BASIX survey, due to the availability of a long time series (from 1986) and due to the large number of individuals surveyed from a wide variety of backgrounds. This is a quarterly survey that asks business economists, finance directors, academic economists and trade unions for their expectations of RPI inflation over the next 12 months. It also surveys members of the public, who are asked ‘from this list, can you tell me what you would expect the rate of inflation to be over the next 12 months?’ ‘below zero’, ‘about 1%’, ‘about 2%’,..., ‘about 10%’, ‘above 10%’, ‘don’t know’. Mean forecasts for each of the sectors are published, but individual forecasts are not so the sample size for each of the sectors is unknown in each survey.

³ From the point of view of causality, the interest of financial market information is likely to be its influence on those surveyed, so looking at survey data is more instructive here. However, the relationship between expectations extracted from financial market information and inflation, and expectations extracted from financial market information and survey data is an interesting future area for research.

There are a number of reasons to anticipate that professionals and the general public may form their expectations differently⁴, and thus the causal relationship between inflation and expectations may differ for the two groups. Consequently, the causal relationship between RPI and the expectations of the two groups are tested separately.

Given the current target for the Bank of England is to maintain consumer price inflation at 2%, it may seem obvious to use CPI as the measure of inflation. However, this has only been the target since December 2003, prior to which the target (from 1992) was retail price inflation excluding mortgage costs (RPIX) at 2.5%. To complicate matters, the wording of the question to the general public in the BASIX survey is not explicit about whether the expectations relate to CPI or RPI. Given that the professionals are explicitly asked about RPI, and that studies (Bank of England 2008) suggest that the general public are more likely to refer to RPI than CPI when asked about inflation, the decision was taken to focus on RPI⁵. The fact that the Bank's inflation target is currently based on CPI is not considered to be an issue: from the point of view of this study what is of concern is the existence of a fixed target. The data are split into three periods, representing three monetary regimes. The first covers 1986 to the time when inflation targeting was introduced, following Sterling's exit from the ERM. The second covers 1992 Q4 to 1997 Q3, in other words the inflation targeting regime prior to Bank of England independence. The third covers the period to date in which the Monetary Policy Committee at the Bank of England has had operational responsibility for meeting the inflation target.

⁴ Not least on account of the use of different datasets.

⁵ In fact, both CPI and RPI were tested, but no relationship was found between CPI and inflation expectations

3. RESULTS

The first stage involves specifying the VAR by using Akaike's Information Criterion (AIC) to determine the lag structure. The results are given in table 1, with the optimal lag length indicated in italic type. GP indicates the expectations of the general public, and XGP representing a weighted mean of the expectations of business economists, finance directors, academic economists and trade unions.

Table 1: Lag structure: Akaike Information Criterion

1997Q3-2007Q4	Lags				
	0	1	2	3	4
Dependent variable					
RPI	2.682	1.327	1.083	1.086	<i>1.002</i>
GP	0.279	-0.269	-0.249	<i>-0.242</i>	-0.245
XGP	0.492	-0.433	-0.447	<i>-0.37</i>	-0.68
Other variable					
RPI (GP)	<i>1.002</i>	1.042	1.043	1.046	1.087
GP (RPI)	-0.242	-0.233	-0.23	<i>-0.199</i>	-0.258
RPI (XGP)	<i>0.636</i>	0.696	0.736	0.801	0.813
XGP (RPI)	-0.37	-0.381	-0.364	<i>-0.303</i>	-0.737
1993Q1-1997Q2					
Dependent variable					
RPI	1.471	1.033	<i>0.997</i>	1.132	1.271
GP	-0.646	-0.516	-0.396	-0.281	<i>-0.179</i>
XGP	-0.485	-0.522	-0.404	-0.323	-0.289
Other variable					
RPI (GP)	<i>0.997</i>	1.098	1.059	1.201	1.33
GP (RPI)	<i>-0.179</i>	-0.185	-1.053	-0.94	-1.069
RPI (XGP)	<i>0.997</i>	<i>0.975</i>	1.019	1.124	1.267
XGP (RPI)	-0.289	-0.187	-0.125	-0.141	<i>-0.006</i>
1986Q4-1992Q4					
Dependent variable					
RPI	4.593	3.013	<i>2.442</i>	2.488	2.576
GP	3.213	<i>2.184</i>	2.279	2.374	2.379
XGP	3.266	<i>1.823</i>	1.856	1.893	1.97
Other variable					
RPI (GP)	<i>2.442</i>	2.351	2.298	2.39	2.482
GP (RPI)	2.184	2.203	2.038	<i>1.944</i>	1.967
RPI (XGP)	<i>2.442</i>	1.961	<i>1.951</i>	2.029	1.755
XGP (RPI)	1.823	1.744	1.673	1.565	<i>1.39</i>

From this table we can determine at the outset that, since the optimal lag length of GP in the RPI equation, and XGP in the RPI equation in the most recent period is zero, there is no Granger causality running from expectations of the general public or professionals to RPI. Following a similar rationale, there is no Granger causality between expectations of the general public and RPI in the second period. For the remaining relationships, the results indicate that there may be Granger causality, and further testing is required.

Before Granger causality testing can be undertaken, the econometric and statistical adequacy of the models must be examined. System linearity is tested using the Ramsey RESET test. Tests for departures from the independence assumption of the error term are performed using Lagrange Multiplier (LM1-LM3) tests, and system normality is tested using Jarque-Bera tests. The results are shown in table 2:

Table 2: Misspecification diagnostics

Equation	JB	LM1	LM2	LM3	RESET
1997Q3-2007Q4					
GP (RPI)	0.566 (0.754)	0.101 (0.753)	1.347 (0.275)	1.421 (0.257)	1.721 (0.199)
XGP (RPI)	4.303 (0.116)	4.725 (0.04)	6.211 (0.07)	3.979 (0.02)	1.102 (0.304)
1993Q1-1997Q2					
RPI (XGP)	5.027 (0.081)	0.216 (0.653)	0.153 (0.861)	0.297 (0.827)	0.063 (0.808)
XGP (RPI)	0.675 (0.714)	2.217 (0.211)	0.96 (0.476)	0.651 (0.653)	0.927 (0.390)
1986Q4-1992Q4					
RPI (GP)	2.755 (0.252)	0.139 (0.715)	0.278 (0.761)	0.173 (0.913)	0.025 (0.877)
GP (RPI)	1.413 (0.493)	0.613 (0.446)	1.193 (0.332)	0.759 (0.537)	1.247 (0.282)
RPI (XGP)	0.653 (0.722)	2.599 (0.128)	1.562 (0.244)	1.274 (0.324)	2.104 (0.168)
XGP (RPI)	0.169 (0.919)	5.099 (0.04)	4.387 (0.035)	2.792 (0.086)	4.206 (0.060)

The main figures are the test statistics, and the figures in parentheses are p-values. Overall the models appear to be robust. The next stage of the Toda-Yamamoto procedure involves adding an extra lag of each of the variables to each equation, according to the maximal order of integration we suspect might occur in the process, and using a standard Wald test to see if the coefficients of the lagged ‘other’ variables (except the additional one) are jointly zero. Thus as a first stage we must establish the suspected maximal order of integration, which is done using Augmented Dickey Fuller tests. The results are reported in table 3; an asterisk indicates that the null hypothesis is rejected at the 5% level.

Table 3: Stationarity test results

Variable	H0:I(1)	H0:I(2)
1997Q3-2007Q4		
RPI	0.458	5.617*
GP	-0.447	-6.776*
XGP	-0.877	-6.046*
1993Q1-1997Q2		
RPI	0.059	-3.483*
GP	-0.677	-6.623*
XGP	-0.897	-4.192*
1986Q4-1992Q4		
RPI	-0.858	-2.820*
GP	-0.024	-5.855*
XGP	-0.468	-3.877*

The 5% critical value is 1.95

From these results, we conclude that for all periods the maximum suspected order of integration of each of the variables is one, so we add one extra lag. The results of the Wald tests are given in table 4.

Table 4: Wald tests

<u>Equation</u>	
1997Q3-2007Q4	
GP (RPI)	1.729 (0.183)
XGP (RPI)	2.105 (0.129)
1993Q1-1997Q2	
RPI (XGP)	0.354 (0.578)
XGP (RPI)	1.282 (0.482)
1986Q4-1992Q4	
RPI (GP)	2.262 (0.141)
GP (RPI)	3.387 (0.048)
RPI (XGP)	9.547 (0.002)
XGP (RPI)	5.12 (0.012)

These results give the Wald statistic, with p-values in parentheses. These results indicate that for the period before inflation targeting was introduced, we find no Granger causality from expectations of the general public to RPI, but we find Granger causality running from RPI to expectations. Bidirectional Granger causality is found between XGP and RPI. However, for both subsequent periods, when inflation targeting was in use, there was no Granger causality from RPI to expectations of the general public, so overall we can conclude that there is no Granger causality running in either direction for this period. A similar result is found between RPI and the expectations of professionals⁶.

⁶ This result could also be explained by findings that inflation becomes unpredictable in a credible inflation targeting regime. Benati and Surico (2007) use a standard sticky-price model to show that a more aggressive policy stance towards inflation in the US caused a decline in inflation predictability.

4. INTERPRETATION AND CONCLUSION

In this paper a robust methodology has been used to examine the direction of Granger causality between inflation and inflation expectations of the general public and of professionals over three periods, corresponding to developments in the UK monetary regime. The findings have two possible interpretations: that a change in the Granger causality reflects a change in the mechanism by which inflation expectations influence inflation, or that the manner in which agents form their expectations has changed. The distinction between these two possibilities is quite subtle. We consider these in turn.

Prior to the introduction of inflation targeting, the expectations of both the general public and professionals were driven by the rate of RPI inflation. That inflation expectations might be caused by current inflation, or at least perceptions of current inflation, is consistent with findings by Driver and Windram (2007), who find a correlation coefficient of 0.92 between NOP/Bank of England survey data of public expectations and perceptions of current inflation. The fact that the expectations of professionals ‘cause’ inflation while those of the general public do not is entirely plausible if one considers that the class of professionals includes those that are involved in setting prices and wages. What is of interest is the fact that neither group exhibits any sort of Granger causality after inflation targeting is introduced. The most obvious interpretation of expectations becoming less sensitive to current inflation, is that they became anchored to the target (which also suggests that the target was credible), rather than being based on the current rate of RPI inflation itself⁷. This is in

⁷ Of course, we cannot discount the possibility that the general public have moved away from basing their inflation expectations on RPI and started basing them on CPI during the second period, and this has caused the result.

line with the literature on how agents decide to decide – with lower and more predictable inflation it is optimal to use less resources in forecasting inflation. In particular agents tend to use simple heuristics (see Diron and Mojon, 2005). The fact that the Granger causality from professionals’ expectations to inflation broke down after targeting had been introduced could be put down to faith in the target meaning that this group interpreted deviations of inflation from target as temporary.

What does this mean for expectation formation? Do these results suggest that the manner in which expectations are formed has changed? This is a plausible interpretation when one considers the results to refer to Granger causality, i.e. lead-lag relationships rather than causality *per se*. If expectations are ‘caused’ by past values of RPI, this suggests that they are backward looking. If, by contrast, RPI is ‘caused’ by expectations, rather than interpreting this as expectations *driving* RPI, we could interpret it as agents being forward-looking in forming their expectations. This explanation would sit well with the findings: the bidirectional Granger causality found among expectations of professionals might indicate that prior to independence they were both forward and backward looking in their formation of expectations – in other words adopted something proximate to rational expectations⁸. But does the breakdown of the causal relationship mean that agents have become ‘less rational’? It is perhaps more useful here to consider the concept of ‘economically rational’ expectations (Feige and Pearce, 1976). This concept suggests that people should collect and process information until the cost of an additional piece of information outweighs the benefits of an improved forecast. In this case, provided the target is seen as credible, it is clear that anchoring expectations to the target is more

⁸ The question of whether expectations are rational or not is the subject of a vast literature and beyond the scope of this paper.

'economically rational' than any other means of expectation formation. That there may no longer be a causal relationship follows directly from this.

REFERENCES

- Bakhshi, H., and Yates, A. (1998). 'Are UK inflation expectations rational?' *Bank of England Working Paper* 41.
- Benati, L. (2008). 'Investigating inflation persistence across monetary regimes', *European Central Bank Working Paper* no. 851.
- Benati, L. (2007). 'The Great Moderation in the United Kingdom'. *Journal of Money, Credit and Banking* 40(1) pp. 121-47.
- Benati, L. (2005). 'The inflation targeting framework from an historical perspective', *Bank of England Quarterly Bulletin*, Summer pp. 160-168.
- Benati, L., and Surico, P. (2007). 'Evolving US monetary policy and the decline of inflation predictability', *European Central Bank Working Paper* no. 824
- Bernanke, B. (2007). 'Inflation expectations and inflation forecasting', Remarks given at the Monetary Economics Workshop of the NBER Summer Institute, Cambridge Mass., July 10.
- Branch, W. (2004), 'The theory of rationally heterogeneous expectations: evidence from survey data on inflation expectations', *Economic Journal*, Volume 114, Issue 497, July, pp. 592-621.
- Brock, W., and Hommes, C. (1997), 'A rational route to randomness', *Econometrica*, Volume 65, No. 5, September, pp. 1059-95.
- Carroll, C. (2003), 'Macroeconomic expectations of households and professional forecasters', *Quarterly Journal of Economics*, Volume 118, Issue 1, February, pp. 269-98.
- Clarida, R., Gali, J., and Gertler, M. (2000). Monetary policy rules and macroeconomic stability: evidence and some theory, *Quarterly Journal of Economics* 115 (2000) pp. 147-80
- Dickey, D., and Fuller, W. (1981). 'Likelihood ratio tests for autoregressive time series with a unit root', *Econometrica*, Vol. 49(4) pp. 1057-72.
- Diron, M., and Mojon, B. (2005). 'Forecasting the Central Bank's inflation objective is a good rule of thumb', *ECB Working Paper* no. 564.

Driver, R., and Windram, R. (2007). 'Public attitudes to inflation and interest rates', *Bank Of England Quarterly Bulletin*, Q2 pp. 208-23

Feige, E., and Pearce, D. (1976). 'Economically rational expectations: are innovations in the rate of inflation independent of innovations in monetary and fiscal policy?', *Journal of Political Economy*, vol. 84, 3 pp. 499-522

Giles, D. (1997). 'Causality between the measured and underground economies in New Zealand', *Applied Economics Letters*, Vol.4 pp. 63-67.

Granger, C. (1969). 'Investigating causal relations by econometric models and cross spectral methods', *Econometrica*, Vol. 37 pp. 424-38.

Mankiw, G., Reis, R. and Wolfers, J. (2003). Disagreement about Inflation Expectations. *NBER Macroeconomics Manual*.

Mavrotas, G., and Kelly, R. (2001). 'Old wine in new bottles: testing causality between savings and growth', *The Manchester School*, Vol. 69 pp. 97-105

Orphanides, A., and Williams, J. (2003). 'Inflation scares and forecast-based monetary policy', *Federal Reserve Bank of San Francisco Working Paper* 11.

Pfajfar, D., and Santoro, E. (2006). 'Heterogeneity and learning in inflation expectation formation: an empirical assessment', *Universita degli studi di Trento Discussion Paper* No. 7.

Sims, C. (1972). 'Money, income and causality', *American Economic Review*, Vol 62 pp. 540-52.

Toda, H., and Yamamoto, T. (1995). 'Statistical inference in vector autoregressions with possibly integrated processes', *Journal of Econometrics*, Vol. 66 pp. 225-50.

