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FINANCIAL CRISES AND MONETARY POLICY: EVIDENCE FROM THE UK

Financial Crises and Monetary Policy: Evidence from the UK

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Abstract

We analyse UK monetary policy using monthly data for 1992-2010. We have two main findings. First, the Taylor rule breaks down after 2007 as the estimated response to inflation falls markedly and becomes insignificant. Second, policy is best described as a weighted average of a "financial crisis" regime in which policy rates respond strongly to financial stress and a "no-crisis" Taylor rule regime. Our analysis provides a clear explanation for the deep cuts in policy rates beginning in late 2008 and highlights the dilemma faced by policymakers in 2010-11.

1. Introduction

The global economic crisis that began in 2007 has presented a series of severe challenges to monetary policy. Deep and rapid reductions in output opened up an output gap of over 5% in many countries. Profound shocks to the financial system disrupted the transmission mechanism linking monetary policy to the real economy and created fears for the stability of the system. Objections have been raised to low and stable inflation being the main aim of monetary policy and dissatisfaction has been expressed with the New Keynesian and DSGE models that provided the theoretical underpinning for that aim. In this context, it would not be surprising if the behaviour of policymakers had changed during the crisis.

This paper explores the interest rate setting behaviour of monetary policymakers in the UK using monthly data for the period 1992-2010. We have two main findings. First, although policymaking can be described using a simple Taylor rule in the period before the 2007 financial crisis, the Taylor rule then breaks down. The estimated response of the policy rate to inflation falls markedly and becomes insignificant, while the estimated response to the output gap is sharply reduced. Second, policy rates over the period from 1992 can best be described as a weighted average of two regimes, a "financial crisis" regime and a "no-crisis" regime, where the weights on these regimes reflect the probability of a financial crisis. The no-crisis regime is a conventional Taylor rule, whereas the financial crisis regime has a reduced response to the output gap, a strong response to measures of financial stress but no response to inflation.

This model gives a plausible account of UK monetary policy. The no-crisis regime is dominant in 1992-2007, explaining the success of the Taylor rule over that period. But the onset of the major financial crisis in 2007 led to a marked change:

the policy rate ceased to respond to inflation and the weight on the output gap fell as financial stress became the dominant influence on UK monetary policy. On this account, the sharp fall in interest rates beginning in late 2008 reflected difficulties in financial markets and the urgent need for policy measures to respond to the crisis. The rapid fall in the policy rate occurred despite inflation being above target and exceeding 3% for much of the crisis period; in our view, this explains the failure of the Taylor rule after 2007. This account also highlights the dilemma facing policymakers in early 2010. On some measures of financial stress, focussed on financial markets, the crisis ended in late 2009; our model implies that policy reverted to the no-crisis regime at this time. The no-crisis regime increasingly pointed to higher policy rates through early 2010 to the end of our sample in July, driven by persistently high rates of inflation. By contrast, other measures of financial stress, focussed on the banking sector, pointed to a continuation of the financial crisis as banks struggled to rebuild their balance sheets and so argued for a continuation of the policy of exceptionally low interest rates. This dilemma arguably became more acute in the latter half of 2010 and early 2011, beyond the end of our sample.

The paper is structured as follows. In section 2) we estimate a simple Taylor rule representation of monetary policy. We show that estimates of this model using a sample that ends in 2007 conform to expectations with a response to inflation in excess of unity and a strong response to the output gap. Estimates that use the full sample that ends in 2010 are very different. Although the crisis period represents less than 20% of the sample, the estimate on inflation becomes insignificant and the point estimate is negative. The response to output remains significant but is more than halved. We detect a structural break around the time the crisis began.

2

In section 3) we investigate whether the addition of measures of financial stress to a Taylor rule gives more satisfactory estimates. Some writers, most prominently Curdia and Woodford (2009), have suggested that including the determinants of credit spreads in a policy rule may be optimal in the presence of financial frictions. We use three measures of financial stress as determinants of credit spreads. The first is the spread between unsecured and secured borrowing rates on three-month money market instruments. This measure has been used by Taylor and Williams (2009) to measure risk on financial markets. The second is Credit Default Swap (CDS) premia on large UK Commercial banks. This measure focuses on the banking sector, proving a measure of default risk for UK banks. Our third measure is a composite index of financial stress compiled by the IMF, providing a broad spectrum measure of stress across money, foreign exchange and equity markets. We find that inclusion of these measures in a Taylor rule does not give satisfactory estimates. We continue to detect a structural break and still observe a marked reduction in the estimated response to inflation after 2007. From this we conclude that no model with a constant response of interest rates to inflation, the output gap and financial stress can explain UK monetary policy over 1992-2010.

This evidence suggests that models of monetary policy must allow for changes in the behaviour of policymakers. Accordingly in section 4) we develop a model in which the policy rate is a weighted average of two alternative policy regimes and where the weight of these regimes reflects the probability of a financial crisis. We find that this model provides a satisfactory explanation of UK monetary policy and that the estimates are econometrically superior to those of the constant parameter policy rules considered above. We find a strong response to inflation in the no-crisis regime but no response in the financial crisis regime. Our estimates

3

suggest a strong response to the output gap in the no-crisis regime and a much weaker response in a crisis. We find a strong response to measures of financial stress in the crisis regime but none in the no-crisis regime. Section 5) concludes the paper.

2. Taylor Rules and the Financial Crisis

In this section we present evidence on a Taylor (1993)-type rule model of monetary policy using monthly data for the period 1992M10-2010M7. Our model is

(1) $$i_t = \rho_i i_{t-1} + (1 - \rho_i) \hat{i}_t$$

In this standard Taylor rule with interest rate smoothing, i is the nominal policy rate and $\hat{i}$ is the desired steady-state nominal policy rate. We assume the steady-state policy rate is set with reference to expected inflation and output gaps one period ahead[1]. The appropriate mapping from a time period in a theoretical model to a real-world time interval is unclear, but we follow convention in interpreting a time period in the underlying theoretical model as representing three calendar months. We therefore assume that policymakers respond to forecasts of inflation and the output gap over the coming quarter, giving

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[1] This policy rule can be shown to be optimal in a structural model where the real interest rate affects aggregate demand with a one-period lag and where aggregate demand affects inflation with a similar lag (eg Svensson, 1997).

(2) $$\hat{i}_t = \bar{i} + \rho_\pi \sum_{k=1}^{3}(E_{t-1}\pi_{t+k} - \pi^T) + \rho_y \sum_{k=1}^{3}(E_{t-1}y_{t+k})$$

where $\bar{i}$ is the equilibrium nominal policy rate, assumed constant, $(\pi - \pi^T)$ is the inflation gap, the difference between the targeted rate of inflation and the inflation target and y is the output gap. The assumption of a 3-month horizon makes our specification similar to models estimated on quarterly data in which policymakers react to expected inflation and output in the next period. Combining (1)-(2), our empirical model is

(3) $$i_t = \rho_i i_{t-1} + (1 - \rho_i)\{\bar{i} + \rho_\pi \sum_{k=1}^{3}(E_{t-1}\pi_{t+k} - \pi^T) + \rho_y \sum_{k=1}^{3}(E_{t-1}y_{t+k})\} + \xi_t$$

where ξ is the error that results from substituting expected with actual values of explanatory variables.

We measure i using the policy rate set by the Bank of England. For π, we use the RPIX measure of the inflation rate from 1992-2003 and the CPI inflation rate for 2004-2010; this matches the inflation rate targeted by monetary policy at different dates. Correspondingly, the inflation target is 2.5% for the 1992-2003 period and 2% for 2004-2010. The output gap, y, is constructed as the proportional difference between an ex-post measure of monthly GDP (available from the National Institute of

Economic and Social Research) and its Hodrick and Prescott (1997) trend [2].   Figure 1 plots these data.

Column (i) presents Generalised Method of Moments (GMM, see Hansen, 1982) estimates of (3) using monthly data for 1992M10 to 2010M7. We treat all variables as endogenous and use the first four lags of each as instruments, exploiting the moment restrictions implied by (3). We find no evidence of a monetary policy response to inflation. The estimate of ρ_π is insignificant and the point estimate is negative: ρ_π=-0.76. We find a significant response to the output gap, ρ_y=1.12, estimate the equilibrium nominal interest rate to be 4.8% and find the usual high degree of interest rate smoothing, ρ_i=0.93. The estimates fail a test of parameter stability as the Quandt-Andrews breakpoint test detects a single structural break, dated at 2007M4[3].

These estimates are in marked contrast to estimates of Taylor rules using data from before 2007, which generally find a response to inflation in excess of unity. One prominent explanation of this change is a shift in UK monetary policy to reflect a lesser emphasis on inflation. This is consistent with the most dramatic movements in interest rates in more than a generation, the rapid and deep cuts in late 2008, occurring when inflation was above target. The remainder of Table 1) explores this

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[2] To tackle the end-point problem in calculating the Hodrick-Prescott trend (see Mise et al, 2005a,b), we applied an autoregressive AR(n) model (with n set at 4 to eliminate serial correlation) to the output measure. The AR model was used to forecast twenty-four additional months that were then added to the output series before applying the Hodrick-Prescott filter. In calculating the filter, we use the Ravn and Uhlig (2002) adjustment.

[3] The finding of a single structural break may be questionable. Since the Quandt-Andrews test has been found to be unreliable at the extremes of the sample, it is usual to trim 15% of observations from the start and end of the sample. This trimming excludes the period from September 2008 when the financial crisis entered its most intense phase. We also ran the Quandt-Andrews test with trimming rate of 5%; in this case two structural breaks were detected, in October 2008, and again in April 2007. There are too few observations on the post-Lehmann period in our sample to permit estimation of a separate policy rule for this period.

possible explanation in more detail. Column (ii) presents GMM estimates of (3) using monthly data for 1992M10 to 2007M4, terminating our sample at the break point detected in column (i). Comparing columns (i) and (ii), the estimated response to inflation in the pre-2007 period is much higher and satisfies the Taylor principle. The response to output is also stronger in the pre-2007 period, but there is no significant change in the equilibrium nominal interest rate or the degree of interest rate smoothing. There is no evidence of a structural break in this sample. These estimates are consistent with other policy rule estimated for the pre-2007 period (e.g. Martin and Milas, 2004, Mihailov, 2005).

Column (iii) of Table 1) presents GMM estimates of (3) using monthly data for 2007M5-2010M7. The estimates in columns (i) and (iii) are similar and in sharp contrast to those in column (ii). This is striking since column (i) is estimated using a sample largely drawn from the pre-2007 period used in column (ii). There is a marked change in the estimates for the 2007-2010 sample; the response to inflation is insignificant with a negative point estimate, the response to output is sharply lower as is the equilibrium nominal interest rate. Columns (iv) and (v) repeat columns (ii) and (iii) but with an alternative break point in August 2007, the consensus date for the onset of the financial crisis. The estimates are similar, showing that the conclusions from table 1) are robust to alternative dates for the change in monetary policy.

3. Augmented Taylor Rules

Table 1) reveals a shift in UK monetary policy dating from the onset of the financial crisis, after which time the Taylor Rule no longer provides a plausible account of UK monetary policy. This section considers whether adding variables that reflect the

financial crisis to the Taylor Rule can deliver a more satisfactory account of monetary policy.

Some analyses of optimal monetary policy in New Keynesian models with financial frictions (e.g. Curdia and Woodford, 2009, Teranishi, 2009) suggest the Taylor Rule should be augmented by the determinants of credit spreads between policy rates and the interest rates that affect the behaviour of the private sector[4]. Intuitively, since aggregate demand depends on private sector borrowing rates, a widening of spreads between these and policy rates implies a lower policy rate is required to deliver desired output and inflation rates. Since the financial crisis saw a dramatic widening in credit spreads, exclusion of the determinants of these credit spreads from (3) may explain the poor performance of the estimated Taylor rules in Table 1).

Incorporation of credit spreads implies an augmented policy rule of the form

$$(4) \qquad i_t = \rho_i i_{t-1} + (1 - \rho_i)\{\bar{i} + \rho_\pi \sum_{k=1}^{3}(E_{t-1}\pi_{t+k} - \pi^T) + \rho_y \sum_{k=1}^{3}(E_{t-1}y_{t+k}) + \rho_\mu \mu_t\} + \varepsilon_t$$

where μ are factors that reflect credit spreads. We use three alternative measures for this. The first is the spread between 3-month Libor and Gilt-repo rates, the difference between rates on unsecured and secured lending. This measure has been used by Michaud and Upper (2008) and Taylor and Williams (2009) to model risk in the inter-bank market, and by Martin and Milas (2010) to explain UK policy rates in the early stages of the financial crisis. Our second measure is the credit

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[4] In other models, optimal policy rates also reflect factors relevant to the external finance premium (such as the cost of monitoring loans).

default swap premia on major UK commercial banks. This measure is only available from 2004 but provides a direct measure of the default risk of the banking sector, a nexus for most channels of the transmission mechanisms from policy rates to aggregate demand, inflation and output. Our third measure is the IMF index of financial stress in the UK (Balakrishnan et al, 2009). This index is a composite of the TED, term and corporate debt spreads, returns and volatility in equity markets and exchange rate volatility, providing a broader measure of stress in the financial sector than the other two measures. These measures are shown in Figure 2. The Libor-Gilt Repo spread rarely rose above 25 basis points in the five years before the crisis but jumped to 100 points in July 2007 and close to 250 points in late 2008, before gradually declining throughout 2009 and 2010. The credit default swap (CDS) premium and the IMF measure of financial stress also rise sharply in July 2007 and late 2008[5]. However these measures diverge in the later stages of the financial crisis; the Libor-Gilt Repo spread retuned to pre-crisis levels in mid-late 2009 and the IMF index fell sharply in mid-2009, but commercial banks' CDS premia remain elevated until the end of the sample. This divergence has implications that we will address towards the end of the paper.

Estimates of (4) for the whole period are reported in panel A) of Table 2)[6]. Although estimates of ρ_μ are all significant and correctly-signed, the model is not successful. Estimates of ρ_π are broadly similar to those in table 1), with only one significant response to inflation and none exceeding unity and a structural break is

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[5] The correlations between the Libor-Gilt Repo spread and the CDS premium and IMF measure of financial stress are 0.73 and 0.90, respectively. The correlation between these latter measures is 0.85.

[6] Sample sizes are smaller than in Table 1) due to issues of data availability; the Libor-Gilt Repo spread is available from 1996, CDS premia from 2004 and the IMF stress index until October 2009.

detected in all three specifications[7]. Panels B) and C) present estimates of (4) on separate pre- and post-2007 samples where the sample split is dated at May 2007, the break point estimated in Table 1. There are sharp differences in estimated parameters between these sub-samples. In the pre-2007 sample, estimates of ρ_μ are insignificant in two out of three cases, while the other estimates are broadly similar to those in column (ii) of Table 1. This confirms that the simple Taylor rule in (3) provides a good explanation of UK monetary policy prior to 2007, in line with previous evidence. In the post-2007 sample, by contrast, estimates of ρ_μ are all significant and correctly signed and the estimated responses to inflation are all insignificant. Panel D) of Table 2) emphasises this point by presenting estimates of (4) that exclude the inflation term[8].

4. A Switching Monetary Policy Rule

From Tables 1) and 2), it is clear that any plausible account of UK monetary policy since 1992 must allow for structural breaks and parameter change. Based on the estimates in Tables 1) and 2), one might assume that policymakers followed a conventional Taylor rule from 1992-2007 but then switched to an alternative linear policy rule that includes financial stress but not inflation. This implies the model

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[7] The estimated break points differ, varying between August 2006 and February 2009, possibly reflecting the limited number of observations available since the onset of the financial crisis.

[8] Similar results are obtained using a breakpoint in August 2006; the other breakpoints detected in Panel A) imply a post-crisis sample too small to allow sensible estimates for this regime. A breakpoint in August 2007 also produces similar estimates.

(5a) $\quad i_t = \rho_i i_{t-1} + (1 - \rho_i)\{\bar{i} + \rho_\pi \sum_{k=1}^{3}(E_{t-1}\pi_{t+k} - \pi^T) + \rho_y \sum_{k=1}^{3}(E_{t-1}y_{t+k})\} + \varepsilon_t$

for 1992-2007 and

(5b) $\quad i_t = \rho_i i_{t-1} + (1 - \rho_i)\{\bar{i} + \rho_y \sum_{k=1}^{3}(E_{t-1}y_{t+k}) + \rho_\mu \mu_t\} + \varepsilon_t$

thereafter. This simple model separates the data into a "no-crisis" sample running from 1992-2007 and a "crisis" sample covering 2007-2010.

However the estimates might also be consistent with a more flexible model of monetary policy given by

(6) $\quad i_t = \phi_t R_{ct} + (1 - \phi_t)R_{nct}$

where ϕ_t is the probability of there being a financial crisis at time t and

$$R_{\theta t} = \rho_{\theta i} i_{t-1} + (1 - \rho_{\theta i})\{\bar{i}_\theta + \rho_{\theta\pi} \sum_{k=1}^{3}(E_{t-1}\pi_{t+k} - \pi^T) + \rho_{\theta y} \sum_{k=1}^{3}(E_{t-1}y_{t+k}) + \rho_{\theta\mu}\mu_t\}$$

where $\theta \in \{c, nc\}$ and c and nc denote the crisis and no-crisis policy regimes respectively. We model the probability of a crisis as

(7) $$\phi_t = \Pr\{\mu_t > \mu^O\} = \frac{1}{1 + e^{-\gamma^\mu (\mu_t - \mu^O)/\sigma_\mu}}$$

In (6), the policy rule is a weighted average of crisis and no-crisis policy regimes, each similar to (4) above, where the weight on these alternative policy rules is the probability of there being a financial crisis. This probability is modelled as a logistic function in (7), where μ^0 is the threshold value of μ above which a crisis is triggered.

The model in (6)-(7) has a number of advantages when compared to the model in (5). First, it is a more general model; (6) simplifies to (5) if $\phi_t = 0$ before the financial crisis began and $\phi_t = 1$ thereafter. Second, equation (6) endogenises switches between policy regimes in response to financial crises, in contrast to the exogenous switch between regimes in (5). Third, the model in (6) allows for multiple switches, thus allowing for crisis periods before the onset of the 2007 financial crisis (for example in the late 1990s or following the exit from the ERM in 1992). Fourth, we can date the beginning and end of crisis periods by examining when μ rises above and then falls below the threshold value μ^0. And fifth, (7) allows us to estimate these threshold values.

The model in (6)-(7) is prompted by the econometric estimates above. However there are several theoretical arguments that suggest that switches in policymaking in response to a financial crisis might be optimal[9]. Cecchetti and Li

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[9] Evidence from Threshold VAR models (eg Li and St-Amant, 2010) finds a differing response of output and inflation gaps to shocks when there is a financial crisis. Since nonlinearities in macroeconomic relationships imply a nonlinear optimal monetary policy rule, this also suggests that a policy rule such as (6) may be optimal.

(2008) analyse a model with capital adequacy requirements in the financial sector. They show that the optimal policy rule switches between alternative Taylor rules depending on whether this constraint binds. Cohen-Cole and Marinez-Garcia (2008) embed this analysis within a DSGE framework and confirm the state-dependent nature of the monetary policy rule. Interestingly, they find that the optimal Taylor-Rule weight on inflation is negative in a financial crisis and that the optimal response to output is lower in this regime; both these features are apparent in our estimates.

Bauducco et al (2008) propose a switching policy rule in response to a financial crisis in which policymakers follow a Taylor rule similar to (1) above unless the rate at which firms become bankrupt exceeds a threshold value, in which case policymakers switch to an augmented Taylor rule in which the unexpected increase in the rate of bankruptcy is added to the policy rule. In the context of an articulated DSGE model, they argue that this switching rule returns the economy to equilibrium faster than if the simple Taylor rule is always used. The switching rule allows policymakers to stabilise the volatility of future inflation and output, trading this off against increased volatility in the short-term. This analysis is similar in spirit to Bean (2004), who develops a DSGE-based model in which financial crises act as a negative shock to total factor productivity and where the size of the shock is greater if the level of outstanding debt is higher [10].

Freixas et al (2010) argue that policymakers should reduce interest rates following an adverse shock to liquidity in the inter-bank market and that "a failure to cut interest rates during a crisis erodes financial stability by increasing the risk of

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[10] It is also consistent with the observation that "an aggressive easing of policy is optimal in response to adverse financial market shocks" in these models (de Fiore and Tristani, 2008).

banks runs". This argument for a switch in policy in response to a crisis in the interbank market is clearly relevant to the UK, where these markets were severely disrupted from mid-2007 to mid-2009, with a particularly intense phase in the 3 months after the events of October 2008[11].

After initial experimentation with a full specification, we were able to impose a series of restrictions that increased the precision of our estimates. We imposed: (a) $\rho_{nc\mu} = 0$ (implying no policy response to financial stress in the no-crisis regime); (b) $\rho_{c\pi} = 0$ (implying no policy response to inflation in the crisis regime); (c) $\rho_{ci} = \rho_{nci}$ (implying the same rate of interest rate smoothing in both regimes); and (d) $\bar{i}_c = \bar{i}_{nc}$ (the equilibrium nominal interest rate is the same in both regimes). These restrictions are broadly consistent with the estimates in tables 1) and 2)[12]. (6) then simplifies to

(8) $\qquad i_t = \rho_i i_{t-1} + (1 - \rho_i)\{\bar{i} + \phi_t R_{ct} + (1 - \phi_t)R_{nct}\}$

where $R_{ct} = \rho_{cy}\sum_{k=1}^{3}(E_{t-1}y_{t+k}) + \rho_{c\mu}\mu_t$ and $R_{nct} = \rho_{nc\pi}\sum_{k=1}^{3}(E_{t-1}\pi_{t+k} - \pi^T) + \rho_{ncy}\sum_{k=1}^{3}(E_{t-1}y_{t+k})$.

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[11] Schmitt-Grohe and Uribe (2010) propose a switching monetary policy rule in response to a possible liquidity trap. Policymakers follow a Taylor-like rule unless inflation falls below a threshold value; if this happens, they switch to a rule that keeps interest rates low for a specified period before gradually increasing. This is perhaps less relevant to the UK case.

[12] We also follow Granger and Teräsvirta (1993) and Teräsvirta (1994) in making γ^{μ} dimension-free by dividing it by the standard deviation of the indicator of credit spreads μ_t. van Dijk et al. (2002) argue that the likelihood function is very insensitive to γ^{μ}, suggesting that precise estimation of this parameter is unlikely. For this reason, we run a grid search in the range [0.1, 250] and fix the γ^{μ} parameter to the one that delivers the best fit of the estimated models.

Estimates of (7)-(8) are presented in Table 3). The flexibility offered by this model is reflected in a superior econometric performance. Each of the specifications in Table 3) outperform their counterparts in Panel A) of Table 2) in that they have a closer fit to the data and do not fail the test for parameter stability. Column (i) presents estimates using the Libor-Gilt Repo spread as the measure of financial stress. The threshold value is estimated as 14 basis points. There are two distinct crisis periods (cf figure 2), from December 1996 to December 2000 and from August 2007 to December 2009. This highlights the importance of using a model that can allow for multiple regimes and implies that the pre-2007 estimates in columns (ii) and (iv) of Table 1) and panel B) of Table 2) cannot be interpreted as regarded as estimates of a single no-crisis regime. Column (ii) presents estimates using UK Commercial Banks CDS premia to measure financial stress. The short sample in this case made it difficult to estimate μ^0, whose value we were forced to fix (at the median value of 16 basis points). There is a crisis regime beginning in August 2007, but lack of data prevents consideration of earlier crises. Column (iii) presents estimates of (7) and (8) using the composite IMF index of financial stress. These estimates also reveal financial crises in the latter part of the 1990s, from June 1998 to February 1999 and then from April to September 2000. There is also an earlier crisis from November 1992 to March 1993[13].

The parameter estimates of the no-crisis regime are sensible. In columns (i) and (iii), the estimated response to inflation satisfies the Taylor principle (the estimate in column (ii) is implausibly low and insignificant; this probably reflects the

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[13] This is probably detected in column (iii) but not column (1) because the IMF composite index incorporates exchange rate volatility and so reflects the aftermath of exit from the ERM in late 1992, whereas the Libor-Gilt Repo spread is more narrowly focussed on short-term money markets.

small no-crisis sample in this case). The estimated responses to output are all significant and exceed unity. For the crisis regime, the estimated responses to output are all significant but smaller than in the no-crisis regime. The estimated responses to financial stress are all significant and correctly signed. In each case, the implied impact on interest rates is substantial, implying a sharp reduction in the policy rate after August 2007, especially at the height of the crisis in late 2008 [14].

The implications of our estimates are shown in figure 3) which compares the actual policy rate with the counterfactual policy rates implied by the crisis and no-crisis regimes, using the estimates from column (i) of Table 3)[15]. Our estimates imply that monetary policy was determined by the crisis regime after August 2007. Reflecting this, it is apparent that the policy rate implied by the estimated crisis regime rate is much closer to the actual rate than the implied policy rate from the no-crisis regime in this period. The policy rate from the crisis regime falls sharply in November 2008, closely matching movements in the actual rate. By contrast, the implied no-crisis policy rate only begins to fall several months later. This inability to match the most dramatic movement in interest rates in over 30 years may well explain the poor performance of the Taylor rule since 2007, documented in Tables 1) and 2).

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[14] Baxa et al (2011) find that a number of Central Banks (including the Bank of England) respond to the IMF Financial Stress Index in a policy rule model where the response coefficients to inflation, output, and the financial index follow a random walk process.

[15] Given by $\hat{i}_t^c = \hat{\rho}_i i_{t-1} + (1 - \hat{\rho}_i)\{\hat{\bar{i}} + \hat{\rho}_{cy}\sum_{k=1}^{3}(E_{t-1}y_{t+k}) + \hat{\rho}_{c\mu}\mu_t\}$ and

$\hat{i}_t^{nc} = \hat{\rho}_i i_{t-1} + (1 - \hat{\rho}_i)\{\hat{\bar{i}} + \hat{\rho}_{nc\pi}\sum_{k=1}^{3}E_{t-1}(\pi_{t+k} - \pi^T) + \hat{\rho}_{ncy}\sum_{k=1}^{3}E_{t-1}y_{t+k}\}$, respectively.

Our estimates also illustrate the policy issues facing the Monetary Policy Committee in 2010. Figure 4) plots the implied policy rates from crisis and no-crisis regimes using estimates from columns (i) and (ii) of table 3), alongside the actual policy rate[16]. Considering the counterfactual policy rates from column (i), the Libor-Gilt Repo spread fell below the crisis threshold of 14 basis points in December 2009. At that time both crisis and no-crisis regimes implied similar policy rates, so this transition had no discernable impact. However the implied policy rate from the no-crisis regime rose above the implied crisis regime rate in 2010. By July 2010 (the end of our sample), the no-crisis regime implied a policy rate of 1.2% whereas the crisis regime implied a rate of 0.8%, little different from the actual rate of 0.5%. These estimates therefore point to a rise in policy rates in 2010. By contrast, the implied policy rates from the estimates in column (ii), based on Commercial Bank CDS spreads, tell a rather different story. Commercial Bank CDS premia remained substantially above the threshold of 16 basis points from August 2007 to the end of the sample, implying that monetary policy was determined by the crisis regime throughout this period. The implied policy rate from this regime fell to 0.20%, 30 basis points below the actual policy rate, in April 2009 (we note that the Monetary Policy Committee began Quantitative Easing one month earlier, having decided not to cut the policy rate below 50 basis points); thereafter it was within 25 basis points of the actual rate from May 2009 until the end of our sample.

Our estimates therefore highlight the dilemma facing policymakers in the first half of 2010. If the financial crisis that began in 2007 is seen as purely a crisis of financial markets, then the crisis ended at the end of 2009 and our model implies a

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[16] We have no data on the IMF financial stress after October 2009.

rise in policy rates in early 2010 (this course of action was consistently advocated by one member (out of nine) of the Monetary Policy Committee throughout that period). But if we regard the crisis as having started in financial markets but then becoming primarily focussed on the banking sector, then the crisis was ongoing until the end of our sample and our estimates imply no increase in policy rates. This policy dilemma was to become more acute after July 2010, as the very low policy rates implied by the continuing crisis in the banking sector appeared increasingly at odds with the lack of a policy response to an inflation rate that remained persistently above the official target.

5. Conclusions

This paper explores the interest rate setting behaviour of monetary policymakers in the UK over the period 1992-2010. We have two main findings. First, although interest rate setting behaviour can be described by a simple Taylor rule in the period before 2007, the Taylor rule then breaks down. Second, policy rates over the period from 1992 are best captured using as a nonlinear model in which policy switches between a no-crisis regime that resembles a simple Taylor rule and a crisis-regime in which there is not response to inflation but instead a powerful response to financial stress.

Our estimates raise the question of whether UK policymakers "abandoned" inflation targeting during the financial crisis. Although our estimates are suggestive, our model is not able to address that issue. Changes in the coefficients of a monetary policy rule can be due to a change in policymakers' preferences or from a

change in macroeconomic structure described by captured by aggregate demand and supply relationships. Although our results suggest there was a change in the monetary policy rule during the financial crisis, they tell us nothing about the causes of that change. Assessment of this requires joint estimation and analysis of aggregate demand and supply relationships alongside a monetary policy rule. That is a topic for future research.

References

Balakrishnan, R., S. Danninger, S. Elekdag, and I. Tytell (2009). The Transmission of Financial Stress from Advanced to Emerging Economies. IMF Working Paper No. 133. Available at:
http://www.imf.org/external/pubs/ft/wp/2009/wp09133.pdf

Bauducco, S., A. Bulir and M. Cihak (2008). Taylor Rule Under Financial Instability. IMF Working Paper WP/08/18.

Baxa, J., R. Horváth and B. Vašícek (2011). Monetary Policy Rules and Financial Stress: Does Financial Instability Matter for Monetary Policy? Working Paper No. 1, Department d' Economia Aplicada, Universitat Autònoma de Barcelona. Available from: http://www.ecap.uab.es/RePEc/doc/wpdea1101.pdf

Bean, C. (2004). Asset Prices, Financial Instability, and Monetary Policy. American Economic Review, 94, 14-18.

Cecchetti, S and L. Li (2008). Do Capital Adequacy Requirements Matter For Monetary Policy?. Economic Inquiry, 46, 643-659.

Cohen-Cole, E. and E. Martinez-Garcia (2008). The balance sheet channel. Quantitative Analysis Unit Working Paper QAU08-7, Federal Reserve Bank of Boston.

Curdia, V. and M. Woodford (2009). Credit Spreads and Monetary Policy, NBER Working Paper 15289, National Bureau of Economic Research, Cambridge/MA.

De Fiore, F. and O. Tristani (2009). Optimal Monetary Policy in a Model of the Credit Channel. ECB Working Paper No. 1043

Freixas, X, A. Martin and D Skeie (2010). Bank Liquidity, Interbank Markets and Monetary Policy. European Banking Center Discussion Paper 2010-35S.

Granger, C.W.J. and T. Teräsvirta (1993). Modelling Nonlinear Economic Relationships. Oxford: Oxford University Press.

Hansen, L.P. (1982). Large Sample Properties of Generalized Method of Moments Estimators. Econometrica, 82, 1029–1054.

Hansen, B.E. (1997). Approximate Asymptotic P Values for Structural-Change Tests. Journal of Business and Economic Statistics, 15, 60–67.

Hodrick, R. and E.C. Prescott (1997). Postwar U.S. Business Cycles: An Empirical Investigation. Journal of Money, Credit, and Banking, 29, 1-16.

Li, F. and P. St-Amant (2010). Financial Stress, Monetary Policy, and Economic Activity. Working Paper No. 10-12, Bank of Canada.

Martin, C. and C. Milas (2004). Modelling monetary policy: inflation targeting in practice. Economica, 71, 209-221.

Martin, C. and C. Milas (2010). The Sub-Prime Crisis and UK Monetary Policy. International Journal of Central Banking, 6, 119-144.

Michaud, F.-L. and C. Upper (2008). What Drives Interbank Rates? Evidence from the Libor Panel. Bank for International Settlements Quarterly Review (March). 47-58.

Mihailov, A. (2005). Has More Independence Affected Bank of England's Reaction Function under Inflation Targeting? Lessons from Taylor Rule Empirics". Economics Discussion Papers 601, University of Essex.

Mise, E., T-H. Kim and P. Newbold (2005a). On the Sub-Optimality of the Hodrick-Prescott Filter. Journal of Macroeconomics, 27, 53-67.

Mise, E., T-H. Kim and P. Newbold (2005b). Correction of the Distortionary end-effect of the Hodrick-Prescott Filter: Application. Mimeo. Available from: http://www.le.ac.uk/economics/staff/em92.html.

Schmitt-Grohe, S. and M. Uribe (2010). Liquidity Traps: An Interest-Rate-Based-Exit-Strategy, NBER working paper 16514r.

Svensson, L.E.O. (1997). Inflation Forecast Targeting: Implementing and Monitoring Inflation Targets, European Economic Review 41, 1111–1146.

Ravn, M.O. and H. Uhlig (2002). On adjusting the Hodrick-Prescott filter for the frequency of observations, The Review of Economics and Statistics, 84, pages 371-375.

Taylor, J.B. (1993). Discretion versus policy rules in practice, Carnegie-Rochester Conference Series on Public Policy, 39, 195-214.

Taylor J.B. and J.C. Williams (2009). A Black Swan in the Money Market, American Economic Journal: Macroeconomics, American Economic Association, vol. 1(1), 58-83.

Teranishi, Y. (2009). Credit Spread and Monetary Policy. IMES Discussion Paper Series 09-E-14, Institute for Monetary and Economic Studies, Bank of Japan.

Teräsvirta, T. (1994). Specification, estimation, and evaluation of smooth transition autoregressive models, Journal of the American Statistical Association, 89, 208–218.

van Dijk, D., T. Teräsvirta, and P.H. Franses (2002). Smooth transition autoregressive models – a survey of recent developments, Econometric Reviews, 21, 1-47.

Table 1) Estimates of Taylor Rules

$$i_t = \rho_i i_{t-1} + (1 - \rho_i)\{\bar{i} + \rho_\pi \sum_{k=1}^{3}(E_{t-1}\pi_{t+k} - \pi^T) + \rho_y \sum_{k=1}^{3}(E_{t-1}y_{t+k})\} + \xi_t$$

	(i) Sample: 1992M10 2010M7	(ii) Sample: 1992M10 2007M4	(iii) Sample: 2007M5 2010M7	(iv) Sample: 1992M10 2007M8	(v) Sample: 2007M9 2010M7
ρ_i	0.932 (0.04)	0.922 (0.05)	0.941 (0.04)	0.941 (0.02)	0.935 (0.03)
$\bar{i}$	4.792 (0.27)	5.131 (0.19)	1.624 (1.17)	5.163 (0.18)	0.112 (1.38)
ρ_π	-0.760 (0.57)	1.453 (0.48)	-0.438 (1.01)	1.435 (0.48)	0.701 (1.15)
ρ_y	1.122 (0.39)	2.424 (0.41)	1.686 (0.46)	2.410 (0.39)	1.223 (0.50)
J-test	0.26	0.27	0.28	0.29	0.28
QA Break	0.00 (2007M4)	0.15	0.18	0.17	0.19
eqn s.e.	0.23	0.18	0.30	0.18	0.30

Notes: Numbers in parentheses are standard errors. J stat is the p-value from a chi-square test of the model's overidentifying restrictions. QA Break is the p-value of the Quandt-Andrews breakpoint test. We report the p-value of the maximum LR F-statistic using 15% observation trimming, calculated using Hansen's (1997) method. The estimated breakpoint is reported where the test statistic is significant at 5%.

Table 2) Estimates of

$$i_t = \rho_i i_{t-1} + (1 - \rho_i)\{\bar{i} + \rho_\pi \sum_{k=1}^{3}(E_{t-1}\pi_{t+k} - \pi^T) + \rho_y \sum_{k=1}^{3}(E_{t-1}y_{t+k}) + \rho_\mu \mu_t\} + \varepsilon_t$$

	A) Full Sample			B) Pre-Crisis Sample		
	(i) Sample: 1996M1 2010M7	(ii) Sample: 2004M1 2010M10	(iii) Sample: 1992M10 2009M10	(iv) Sample: 1996M1 2007M4	(v) Sample: 2004M1 2007M4	(vi) Sample: 1992M10 2007M4
μ measured as	Libor-Gilt Repo spread	UK Commercial Banks CDS premia	IMF Financial Stress Index	Libor-Gilt Repo spread	UK Commercial Banks CDS premia	IMF Financial Stress Index
ρ_i	0.930 (0.06)	0.932 (0.05)	0.930 (0.07)	0.931 (0.05)	0.921 (0.03)	0.933 (0.06)
$\bar{i}$	5.220 (0.24)	5.772 (0.48)	4.310 (0.25)	4.951 (0.42)	3.713 (1.28)	5.052 (0.24)
ρ_π	0.162 (0.19)	-0.573 (0.53)	0.788 (0.29)	1.121 (0.44)	1.528 (0.90)	1.021 (0.47)
ρ_y	1.558 (0.24)	1.320 (0.34)	1.061 (0.22)	2.293 (0.50)	2.044 (0.67)	2.503 (0.48)
ρ_μ	-0.058 (0.01)	-0.032 (0.01)	-0.527 (0.03)	0.023 (0.022)	0.159 (0.12)	-0.192 (0.10)
J-test	0.24	0.23	0.22	0.23	0.26	0.27
QA Break	0.02 (2006M8)	0.00 (2009M2)	0.00 (2008M11)	0.21	0.20	0.33
eqn s.e.	0.22	0.21	0.19	0.16	0.16	0.16

Notes: See the notes of Table 1.

	C) Post-crisis sample			D) Post-crisis sample: no Inflation		
	(i) Sample: 2007M5 2010M7	(ii) Sample: 2007M5 2010M7	(iii) Sample: 2007M5 2009M10	(iv) Sample: 2007M5 2010M7	(v) Sample: 2007M5 2010M7	(vi) Sample: 2007M5 2009M10
μ measured as	Libor-Gilt Repo spread	UK Commercial Banks CDS premia	IMF Financial Stress Index	Libor-Gilt Repo spread	UK Commercial Banks CDS premia	IMF Financial Stress Index
ρ_i	0.935 (0.06)	0.941 (0.05)	0.943 (0.06)	0.941 (0.05)	0.935 (0.04)	0.943 (0.06)
$\bar{i}$	4.681 (0.89)	4.691 (1.52)	5.322 (1.10)	4.251 (0.84)	4.767 (1.51)	5.331 (0.74)
ρ_π	-0.881 (0.77)	-0.991 (0.90)	0.153 (0.91)			
ρ_y	1.612 (0.34)	1.580 (0.54)	0.830 (0.37)	1.426 (0.322)	1.200 (0.38)	0.892 (0.33)
ρ_μ	-0.048 (0.01)	-0.023 (0.01)	-0.730 (0.19)	-0.053 (0.01)	-0.031 (0.01)	-0.713 (0.16)
J-test	0.29	0.26	0.27	0.29	0.26	0.27
QA Break	0.37	0.36	0.37	0.36	0.37	0.36
eqn s.e.	0.23	0.26	0.25	0.23	0.26	0.25

Notes: See the notes of Table 1.

Table 3) Estimates of

$$i_t = \rho_i i_{t-1} + (1 - \rho_i)\{\bar{i} + \phi_t R_{ct} + (1 - \phi_t)R_{nct}\}$$

where $R_{ct} = \rho_{cy}\sum_{k=1}^{3}(E_{t-1}y_{t+k}) + \rho_{c\mu}\mu_t$ and $R_{nct} = \rho_{nc\pi}\sum_{k=1}^{3}(E_{t-1}\pi_{t+k} - \pi^T) + \rho_{ncy}\sum_{k=1}^{3}(E_{t-1}y_{t+k})$

	(i) Sample: 1996M1 2010M7	(ii) Sample: 2004M1 2010M7	(iii) Sample: 1992M10 2009M10
μ measured as	Libor-Gilt Repo spread	UK Commercial Banks CDS premia	IMF Financial Stress Index
ρ_i	0.931 (0.06)	0.943 (0.06)	0.935 (0.07)
$\bar{i}$	5.615 (0.24)	5.180 (0.54)	5.395 (0.25)
ρ_{cy}	1.427 (0.31)	1.184 (0.38)	1.209 (0.34)
$\rho_{c\mu}$	-0.077 (0.01)	-0.035 (0.01)	-0.775 (0.08)
$\rho_{nc\pi}$	1.330 (0.55)	0.675 (0.50)	1.870 (0.50)
ρ_{ncy}	2.961 (0.53)	1.755 (0.28)	1.740 (0.59)
μ^o	14.12 (2.33)	15.62 (-)*	1.270 (0.13)
J-test	0.29	0.26	0.27
QA Break	0.17	0.16	0.17

eqn s.e.	0.16	0.19	0.17

Notes: See the notes of Table 1. * Estimate restricted to median value.

Figure 1: UK policy rate, inflation and output gap
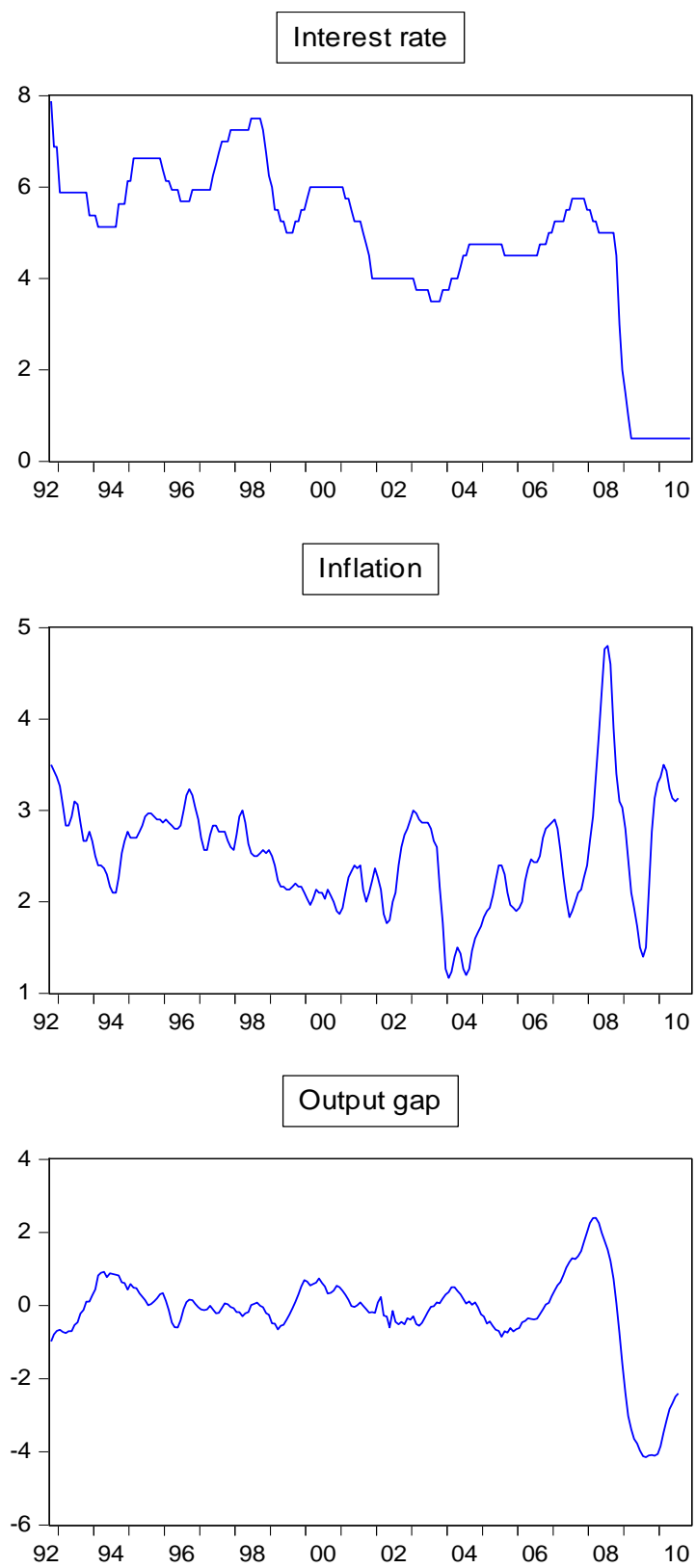

Interest rate

Inflation

Output gap

Figure 2: 3-month Libor minus 3-month Repo, CDS and IMF Financial Stress Index

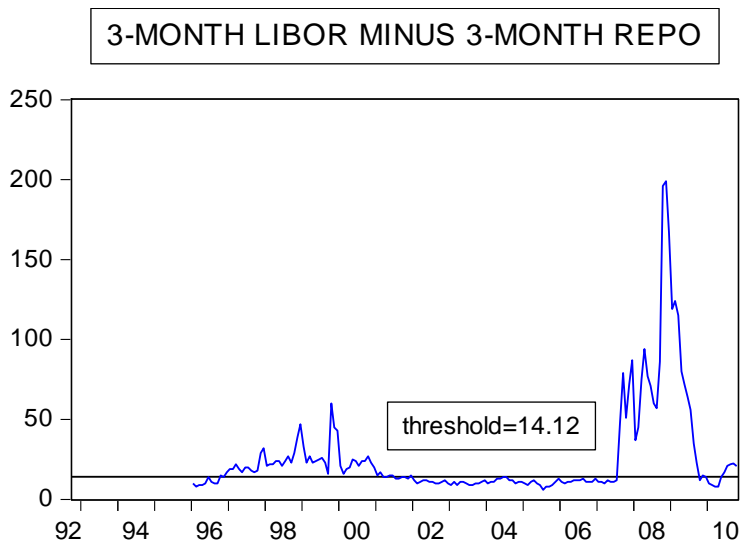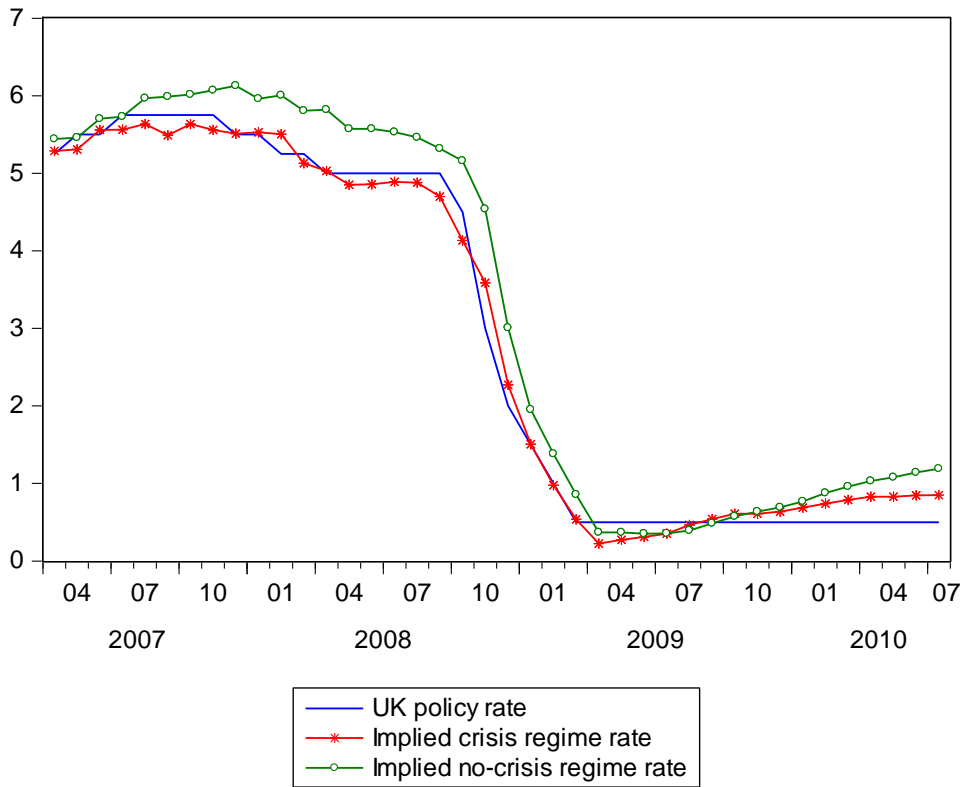3-MONTH LIBOR MINUS 3-MONTH REPO

threshold=14.12

CDS

threshold=15.62

IMF FINANCIAL INDEX

threshold=1.270
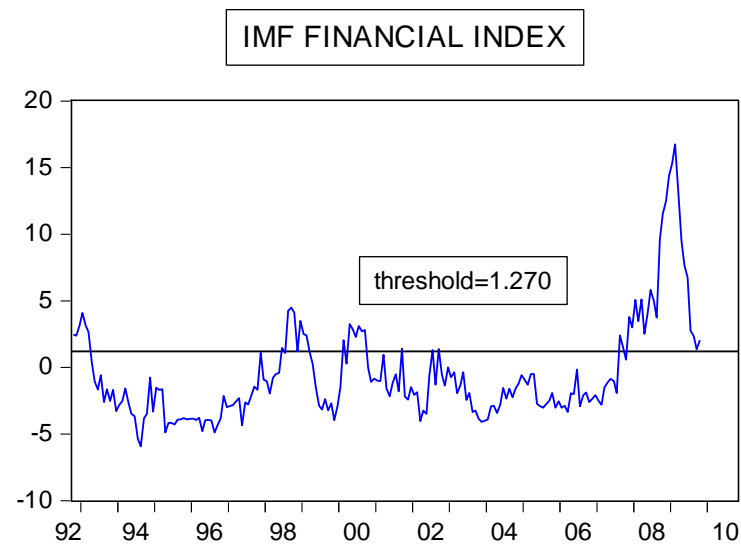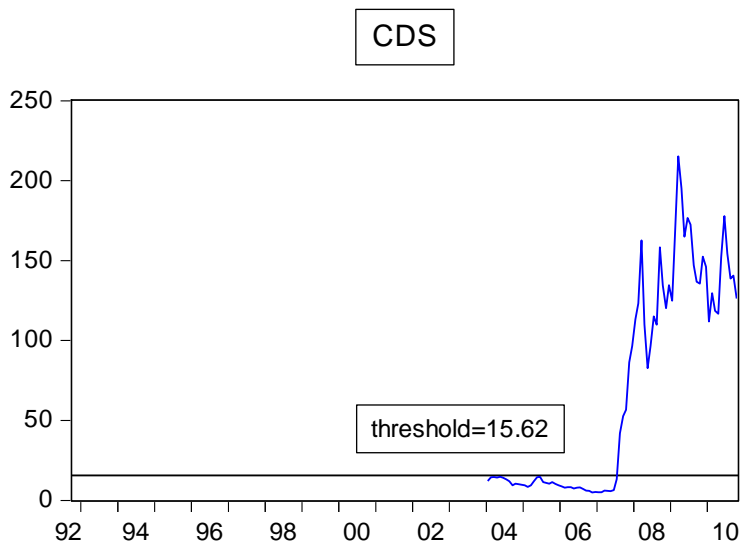
Figure 3: Actual and implied regime-specific policy rates

Note: Figure is based on estimates reported in Table 3i) (model with spread between 3-month LIBOR and 3-month Repo).
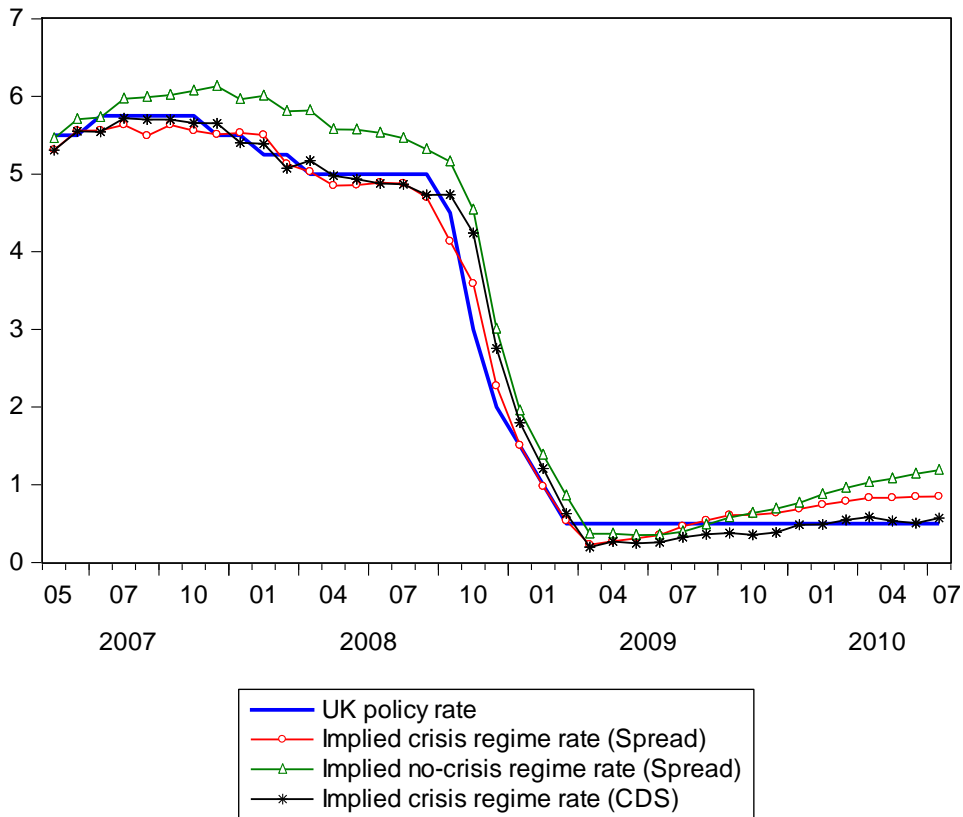
Figure 4: Actual and implied regime-specific policy rates

Note: Figure is based on estimates reported in Table 3i) (model with spread between 3-month LIBOR and 3-month Repo) and estimates reported in Table 3ii) (model with CDS premia).