

# Interest Rate Pass-Through in the UK: Has the Transmission Mechanism Changed During the Financial Crisis?

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## ABSTRACT

*Interest rate has been the monetary policy tool used by the modern central banks. For monetary policy to be effective, changes in the policy rate should influence the short-term money market rate and retail rates. Using an error correction methodology, this paper examines the short-run and long-run dynamics of interest rate pass through from the LIBOR to four different UK retail rates. The results indicate that interest rate pass-through in the UK is incomplete in the short run, but fairly complete in the long-run and the adjustment of retail rates depend on whether they are below or above their respective long-run values. The results also indicate a temporary, but statistically significant change in the interest rate pass-through since the beginning of the financial crisis in 2007.*

## 1. INTRODUCTION

CENTRAL BANKS IN THE INDUSTRIALIZED COUNTRIES, including the Bank of England (BoE), conduct their monetary policy through the interest rate channel. The central bank's official rate is set with the aim of influencing prices and aggregate demand in the economy. The interest-rate pass-through (IRPT) is defined as the degree and speed of adjustment of retail interest rates due to changes in the monetary authority's policy rate (Aydin, 2007). Monetary policy is considered to be effective if changes in the policy rates are completely passed through to retail interest rates over a reasonably short period (Hofmann and Mizen, 2004). Generally, studies suggest that interest rate pass-through has been both small in degree and slow in adjustment in response to changes in the official rate. Moreover, monetary policy easing in contrast to a tightening one could lead to asymmetric adjustment in retail rates such that output and prices would be affected differently. It is therefore important to know how much (the degree of pass-through), how fast (the speed of pass-through) and how symmetrically or otherwise retail interest rates adjust to a change in the policy rate.

The recent global financial crisis has thrown further challenges to the monetary authorities. The crisis has forced the Monetary Policy Committee (MPC) to cut the policy rate to 0.5 per cent and unconventional monetary policy in terms of quantitative easing was adopted. It is, therefore, important to investigate the behaviour of the transmission mechanism of the interest rate during the period.

The BoE has officially been using interest rate as its main monetary policy tool based on inflation targeting rule as defined by the government since the late 1990s, but studies on the IRPT in the UK have generally concentrated on one or two retail rates. For example, Becker *et al.*'s (2012) analysis was limited to mortgage rate, Fuertes *et al.* (2010) and Panagopoulos *et al.* (2010) considered deposit and loan rates while Hofmann and Mizen (2004) covered deposit and mortgage rates. The UK financial sector has undergone some changes in the last fifteen years in terms of competition and ownership. There were a number of mergers and acquisitions as well as entry of foreign banks into the sector. These will have impact on competition, which will invariably affect the IRPT.<sup>2</sup>

In light of the above, this paper extends the previous work in three aspects. First, it examines the short-run and long-run dynamics of adjustment of four retail rates to changes in the policy rate thereby extending the number of retail rates covered in the previous studies. Second, the paper seeks to identify changes in the behaviour of UK banks in setting their retail rates since the beginning of the financial crisis in summer 2007. Third, as the paper uses a sample of data-set that covers longer period of time, it will be able to capture structural changes that took place in the UK financial sector.

The rest of the paper is organized as follows. The next section reviews the theoretical and empirical foundations of the interest rate pass-through. Section 3 explains the methodology used in this paper. Section 4 discusses the data and the estimated results while Section 5 concludes.

## 2. INTEREST RATE PASS-THROUGH

Cottarelli and Kourelis (1994), using a panel sample of 31 countries that consisted of both developed and developing countries found that short-run pass-through is slower than long-run pass-through (for details see Espinosa-Vega and Rebucci, 2003). Specifically, they reported that the lending rate adjusts by about 67 per cent after 3 months of the policy rate changes and by 97 per cent in the long run. The study also shows that the degree of stickiness of the lending rate differ across the countries, especially in the short run. This could be due to the differences in the structure of the countries' financial systems. Other studies on interest rate pass-through point to the fact that loan and deposit rates respond to changes in the policy rate with a lag. For example, Heffernan (1993) finds a sluggish adjustment of loan and deposit rate to changes in the LIBOR. However, Hofmann and Mizen (2004) who use monthly data of 90-day time deposits and mortgages over the period 1985-2001

reported a complete pass-through of the policy rate changes into the retail rates in the long-run. These results contrast with the findings of Paisley (1994) who finds that mortgage rates were not responsive to changes in the market rates in the 1970s.

Studies on IRPT in the Euro Area countries generally, used annual data with a notable exception of Mojon (2000) and Kaufmann and Schaler (2006) that used quarterly data. They found considerable differences of pass-through across the Euro-area countries. Most of the studies on the IRPT in the area found that immediate pass through in terms of both deposit and lending rates appear to be smaller than the long-run pass through.<sup>3</sup> The long-term pass-through is evidently larger, but remains incomplete in the area.

Another strand of the literature attributes differences in pass-through according to the type of financial products. For example, Mojon (2000), de Bondt (2002) and Sander and Kleimeier (2004) conclude that rates on household loans, savings and overnight deposits are stickier than the rates on corporate loans and time deposits.

In the light of the above, there is an indication that the IRPT is generally incomplete, particularly, in the short-run. However, there is much debate on causes of incomplete pass-through. Gropp, Kok Sorensen and Lichtenberger (2007) identify the degree of competitiveness among financial institutions as a key determinant of the IRPT. They show that the adjustment of loan rates to changes in market rates would be larger if financial markets became more competitive. Hannan and Berger (1991) and Hofmann and Mizen (2004) provide evidence that limited pass-through could be due to the existence of adjustment costs. Similarly, Fuertes and Heffernan (2008) explain sluggish retail market responses could be due to sunk costs, price discrimination relying on consumer habit and collusions between financial institutions which undermine competition in the financial markets. Consequently, Cottareli and Kourelis (1994) suggest that removal of constraints on capital movements, getting rid of constraints on bank competition such as barriers to entry, ownership of banks by the private sector and the existence of a competitive market for short-term monetary instruments will enhance IRPT.

Part of the literature focuses mainly on the differences between upward and downward responsiveness of retail rates to the official rate and they find that there is asymmetric adjustment. It is observed that loans rates are rigid to increases while deposit rates are rigid to decreases. Explanations for such rigidities lie in the customers' unfavourable reactions to unstable rates and the unwillingness of the banks to break collusive price arrangements. Such responses of retail rates to changes in the policy rates have been looked into by Hannan and Berger (1991) and by Neumark and Sharpe (1992) who find asymmetrical rigidities in lending and deposit rates. In the same vein, Sander and Kleimeier (2004) and Hofmann and Mizen (2004) conclude that 'the speed of adjustment in retail rates depend on whether the perceived gap between the retail and the base rates is widening or narrowing'.

### 3. METHODOLOGY

The methodology used in this paper to investigate the IRPT in the UK is the Error Correction Mechanism (ECM). The advantage of the methodology lies in its ability to quantify both the degree and speed of adjustment of retail bank rates sequel to a change in the policy rate. It also allows a distinction between the long-run relationship of two variables and the short-run adjustment towards their long-run equilibrium. An ECM which captures both the short-run and the long-run dynamics of retail rates,  $x_t$ , and the policy rate,  $y_t$ , can be written as:

$$\Delta x_{it} = \beta \Delta y_t + \gamma_i (x_{i,t-j} - x_{i,t-j}^*) + \sum_{l=1}^{k_1} \mu_{i,l} \Delta x_{i,t-l} + \sum_{l=1}^{k_2} \phi_{i,l} \Delta y_{t-l} + \varepsilon_{i,t} \quad (1)$$

where,  $\varepsilon_{i,t} \sim iid(0, \sigma_i^2)$   $t=1, \dots, T$  (which is monthly; 1999M01 to 2009M06),  $i=1, \dots, N$  (each of the retail interest rate like deposit rate, lending rate, etc). The errors  $\varepsilon_{i,t}$  are assumed to be identically distributed and follow a normal distribution. The term in equation (1),  $(x_{i,t-j} - x_{i,t-j}^*)$  represents the deviation of the retail bank rate  $x_{i,t-j}$  from its long-run value, which is given by  $x_{i,t-j}^*$ ; where,

$$x_{it}^* = A_i + C_i y_{it} \quad (2)$$

Equation (2) defines the retail interest rate on a product as a linear function of the official rate. This is based on the fact that the retail rate cannot drift too far from the official rate over a long period, implying that there should be a long-run relationship between the two variables (Fuertes and Heffernan, 2008). The lag  $j$  is the short term lag representing the delay in the error correction.

Equation (1) identifies four aspects of the transmission mechanism of interest rates. First, the immediate pass-through is given by  $\beta$ . Second, the parameter  $\gamma_i$ , measures the *adjustment speed*. To expect a return to equilibrium, the growth,  $x_{i,t}$  should be negatively related to the error  $(x_{i,t-j} - x_{i,t-j}^*)$ , such that the parameter  $\gamma_i$  will be negative.  $\gamma_i$  in absolute term, represents how much of the error or gap  $(x_{i,t-j} - x_{i,t-j}^*)$  prevailing at month  $t-j$  is corrected during month  $t$ . Third,  $A_i$  is defined as the long-run mark-up, representing how much the retail rate for a particular banking product is marked above ( $A_i > 0$ ) or below ( $A_i < 0$ ) the official rate in the long run. Fourth the parameter  $C_i$  represents the long-run pass-through. It measures the degree of the policy rate that is passed into the retail rates in the long-run. A complete long-run pass-through means  $C_i = 1$ . This refers to a banking sector which is perfectly competitive and characterized with no market imperfections like banking costs or

credit rationing. If the long-run multiplier is less than unity ( $C_i < 1$ ), it means that there is limited (partial) pass-through in the long-run. A long-run pass-through larger than unity would be translated as a kind of overshooting, which Kok and Werner (2006) suggest that it may be due to asymmetry information between bankers and borrowers and hence credit risk for bankers.

To avoid problems of endogeneity and estimated long-run coefficients' biasedness as argued by Warner (2006) and Banerjee *et al.* (1986), the ECM in equation (1) can be reparametrised to a dynamic model given by:

$$\Delta x_{it} = \alpha_i + \beta \Delta y_t + \gamma_i x_{i,t-j} + \delta_i y_{t-j} + \sum_{l_1=1}^{k_1} \mu_{l_1} \Delta x_{t+l_1} + \sum_{l_2=1}^{k_2} \theta_{l_2} \Delta y_{t+l_2} + \varepsilon_{it}, \quad (3)$$

where  $\varepsilon_{i,t} \sim iid(0, \sigma_i^2)$ . As a result, equation (3) yields unbiased and consistent measures of the long-run mark-up  $A_i$  and pass-through  $C_i$  (Fuetes and Heffernan, 2008). In the long-run steady-state,  $\Delta x_{it} = \Delta y_t = 0$  such that:

$$-\gamma_i x_{i,t-j} = \alpha_i + \delta_i y_{t-j} \quad (4)$$

and therefore,  $A_i = -\frac{\alpha_i}{\gamma_i}$  and  $C_i = -\frac{\delta_i}{\gamma_i}$ . This gives (in the long-run):  $x_{it}^* = A_i + C_i y_{it}$

In order to identify the appropriate lag length  $j$ ,  $k_1$  and  $k_2$  and getting rid of the possibility of having autocorrelation, a one-step approach to determine the appropriate lag terms  $j$ ,  $k_1$  and  $k_2$  simultaneously through the estimation of model (3). Maximum number of lags is allowed for both the level and the difference terms. The optimum lag determined by the Akaike Information Criteria (AIC) was 6.

The ECM in equation (1) implicitly assumes that the adjustment of retail interest rates  $x_{it}$  to the deviation from the long-run value given by  $(x_{i,t-j} - x_{i,t-j}^*)$  is the same for positive and negative gaps. However, it is interesting to investigate whether interest rates adjust differently depending on whether they are above or below their equilibrium levels. Based on Kleimeier and Sander (2008) and Ozdemir (2009), an asymmetric error correction framework could be defined by introducing dummy variables to take into account possibility of asymmetric adjustment. Dummy variables, which take the following values are generated:

$$\begin{aligned} V=1 & \text{ if } (x_{i,t-j} - x_{i,t-j}^*) > 0 & W=1 & \text{ if } (x_{i,t-j} - x_{i,t-j}^*) < 0 \\ V=0 & \text{ if } (x_{i,t-j} - x_{i,t-j}^*) < 0 & W=0 & \text{ if } (x_{i,t-j} - x_{i,t-j}^*) > 0 \end{aligned}$$

The coefficients associated with the dummy variables will indicate how the retail interest rate adjusts when the retail interest rate observed ( $x_t$ ) is above its equilibrium value ( $x_t^*$ ), following a change in the policy rate. When asym-

metric adjustment is taken into account, the specification of the short-run dynamic equation takes the following form:

$$\begin{aligned} \Delta x_{it} = & \beta \Delta y_t + \alpha_1 * V * (x_{(t-j)} - x_{(t-j)}^*) + \alpha_2 * W * (x_{(t-j)} - x_{(t-j)}^*) \\ & + \sum_{l=1}^k \mu_{i,l} \Delta x_{i,t-l} + \sum_{l=1}^k \theta_{i,l} \Delta y_{i,t-l} + \varepsilon_{(t)} \end{aligned} \quad (5)$$

where  $\varepsilon_{i,t} \sim iid(0, \sigma_i^2)$ . The estimated coefficient  $\alpha_1$  measures the speed of adjustment in response to a disequilibrium in the past period when  $x_{it} > x_{it}^*$  while the estimated coefficient  $\alpha_2$  measures the speed of adjustment in the case of past period disequilibrium when  $x_{it} < x_{it}^*$ . To account for asymmetric adjustment,  $\alpha_1$  should be significantly different from  $\alpha_2$ .

As the sample used in this paper includes the financial crisis period, there is a likelihood of break of cointegration during the period. Therefore, structural break tests of Bai and Perron (2003) were used to determine the break dates. The Bai-Perron tests consider the multiple linear regression with  $m$  breaks, which gives  $m+1$  regimes represented as:

$$y_t = x_t \hat{\alpha} + z_t \hat{\delta}_j + e_t \quad (6)$$

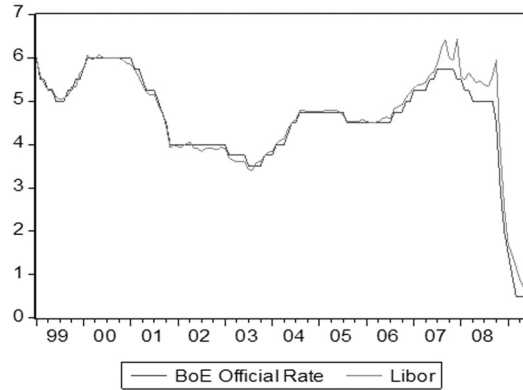
where  $y_t$  is the dependent variable,  $x_t$  and  $z_t$  are vectors of covariates.  $\beta$  and  $\delta$  are vectors of coefficients while  $t$  is the time period with  $j=1, \dots, m+1$  regimes. The number of breaks is decided based on the Bayesian Information Criteria, BIC and its modified version proposed by Liu *et al* (1997), LWZ.<sup>4</sup>

#### 4. DATA AND THE ESTIMATED RESULTS

The data-set used for this study was sourced from Datastream. A sample of 126 observations, consisting of monthly variables of four retail interest rates, covering the period 1999:01 - 2009:06 are used. The rates are instant deposit rate, time deposit rate, secured lending rate and mortgage rate. Instant deposit rate is the average rate set by UK banks and building societies on instant access deposits from the household sector. Time deposit rate is the average interest rate quoted on time deposit for households and lending rate is the average rates quoted on secured loans for consumption made to individuals from £1000 to £10000 while mortgage rate is the average rates quoted on loans to households for house purchase. The London Interbank Offered Rate, LIBOR is used as the exogenous interest rate as it is the rate at which banks quote each other in the UK for overnight deposits and loans. It also represents the opportunity cost of the total asset of a bank. It is justifiable to use the LIBOR in place of policy rate since it is the market rate used by the sector. The LIBOR also serves as a benchmark to determine the marginal revenue

of assets and the marginal cost of liabilities. Moreover, it normally moves with the policy rate (Fuertes and Heffernan, 2008). A comparison of both rates is shown in Figure 1. Except for the period of mid 2007 where there was a temporary divergence between the two rates, it could be observed that the LIBOR is generally in line with the BoE policy rate for the whole period. Using the LIBOR as a proxy for the stance of the BoE's monetary policy is well established in the literature.<sup>5</sup> For example, in a recently published paper, Hussain (2011) used the LIBOR as a proxy for the monetary policy rate.

**Figure 1: The BoE's Policy Rate and LIBOR**



Literature on interest rates has generally identified interest rates as a non-stationary series (Kok and Werner, 2006; Fuertes and Heffernan, 2008). It is therefore imperative to ascertain the level of integration of the series used. The Augmented Dickey Fuller Test (Dickey and Fuller, 1979) and the Phillips-Perron Test (Phillips and Perron, 1988) are used to that end. The results of the two tests are reported in Table 1. It is evident from the results that the null of a unit root cannot be rejected for all the variables. It could be, therefore, concluded that all the series are integrated of order one, I(1) on levels and stationary I(0) on first difference.

**Table 1: Augmented Dickey Fuller (ADF) and Phillips-Perron (PP) Unit Root Tests**

Variable	ADF		PP	
	Level	First Difference	Level	First Difference
Time Deposit	-0.796 (0.369)	-4.442 (0.00*)	-1.217 (0.204)	-6.404 (0.00*)
Instant Deposit	-1.077 (0.253)	-5.669 (0.00*)	-1.245 (0.194)	-5.700 (0.00*)
Lending Rate	-0.946 (0.305)	-5.791 (0.00*)	-1.176 (0.218)	-5.851 (0.00*)
Mortgage Rate	-0.952 (0.303)	-5.849 (0.00*)	-1.184 (0.215)	-5.929 (0.00*)
LIBOR	-1.105 (0.243)	-7.493 (0.00*)	-1.261 (0.190)	-7.614 (0.00*)
BoE Office Rate	-1.017 (0.277)	-5.999 (0.00*)	-1.300 (0.178)	-6.156 (0.00*)

Note: P-value is given in parenthesis; \*denotes the rejection of the existence of unit

The results of the Johansen Test for the whole period, January 1999 to June 2009 fail to reject the null of no cointegration at 5% level of significance. Since the sample used for this analysis includes the financial crisis period, and in line with sudden interest cuts by the BoE at the onset of the financial crisis, structural break tests based on Bai and Perron (2003) were carried out to statistically investigate structural change of the series. Table 2 reports the Bai-Perron structural break tests. Both coefficients are significant at the conventional level of significance and the BIC as well as LWZ suggest the existence of one break. The suggested break date is 2007:08 with Confidence interval between 2006:12 and 2008:08.

**Table 2: Bai-Perron Structural Break Tests**

<i>Coefficients</i>	<i>Break Date</i>	<i>95% CI</i>	<i>Breaks Selected</i>	
$\beta_1$ 4.88** (0.09)	2007:09	2006:12 - 2008:08	BIC	1
$\beta_2$ 2.65** (0.31)			LWZ	1

\*\*Significant at 5%.  $\beta_1$  and  $\beta_2$  are mean prior to and after the break, respectively.

Consequently, cointegration tests using data for the period of January 1999 to July 2007 were carried out. The results are reported in Table 3, from which it is observable that the existence of a co-integrating relationship between each retail rate and the LIBOR is confirmed at 5% level for the period 1999:01 to 2007:07. Consequently, an ECM as discussed in Section 3 was estimated.

**Table 3: Johansen Cointegration Tests for 1999:01 - 2007:07**

<i>Variable (lag)</i>	<i>Adjusted Sample Size</i>	<i>Cointegration Test Rank</i>	<i>Trace Statistic</i>	<i>Prob.</i>
Instant Deposit (2)	100	$r=0$ $r \leq 1$	26.854 1.890	0.0007* 0.169
Time Deposit (3)	99	$r=0$ $r \leq 1$	23.718 3.575	0.002* 0.059
Lending Rate (4)	98	$r=0$ $r \leq 1$	15.218 2.087	0.005* 0.149
Mortgage Rate (2)	100	$r=0$ $r \leq 1$	15.983 1.411	0.042* 0.235

Notes \*denotes the rejection of the null hypothesis of no co-integrating vector at the 5 % level; r is the number of co-integrating vectors.



For each retail rate, the ECM given by equation (3) was estimated and the results are reported in Table 4. It is clear that the explanatory power of the model across different retail rates is quite strong and similar, except for the time deposit rate where it is roughly 10 per cent lower at 67 per cent.

**Table 4: Results for Dynamic ECM**

	<i>Instant deposit</i>	<i>Time deposit</i>	<i>Lending rate</i>	<i>Mortgage rate</i>
$\alpha_i$	-0.153**	-0.069*	0.540**	0.567**
$\Delta y_t$	0.055*	0.123**	0.142**	0.137**
$x_{i,t-1}$	-0.235**	-0.142**	-0.257**	-0.276**
$y_{t-1}$	0.207**	0.146**	0.239**	0.259**
$\Delta x_{i,t-1}$	-0.094	-0.252**	-0.342**	-0.328**
$\Delta y_{t-1}$	0.383**	0.383	0.504**	0.501**
$\Delta x_{i,t-2}$	-0.032	-0.007	-0.092**	-0.063
$\Delta y_{t-2}$	0.156*	0.048	0.336	0.322*
$\Delta x_{i,t-3}$	0.033	na	0.113**	0.095
$\Delta y_{t-3}$	-0.003	na	0.112*	0.087
R <sup>2</sup>	0.76	0.67	0.78	0.77
DW	2.037	1.987	2.039	2.046
SC LM Test	0.652	0.181	0.515	0.652
(P-value)	(0.529)	(0.835)	(0.599)	(0.421)
ARCH-LM Test	0.399	0.512	0.477	0.652
(P-value)	(0.529)	(0.476)	(0.491)	(0.421)
JB Test	3.96	3.170	0.795	3.58
(P-value)	(0.138)	(0.205)	(0.672)	(0.166)
T	99	100	99	99

Note: \*\* and \* denote that the coefficient is significant at 5% and 10% levels, respectively. DW is Durbin Watson Statistic; JB is Jarque Bera test; T is number of observations; na: error message if more lags are added.

#### 4.1 Pass-Through in The Long-Run

The Delta Method is employed to find the long-run coefficients and the standard errors. The results are presented in Table 5. To test for the significance of the long-run coefficients of the retail rate, Wald Test proposed by Pesaran, Shin and Smith (2001) was used to test for the significance of the coefficients  $A_i$  and  $C_i$  of each retail rate. The null hypothesis of no long-run pass-through,  $A_i = -\frac{\alpha_i}{\gamma_i} = 0$  and  $C_i = -\frac{\delta_i}{\gamma_i} = 0$  in equation (3) for each of the four retail rates against the alternative was tested. In all the four cases the null hypotheses was rejected in favour of the alternative. In order to check whether it is appropriate and essential to include the long-run value of the retail rate given by  $x_{it}^*$

in the ECM model (equation 1), the following regression was estimated:

$$\Delta x_{it} = \alpha_i + \beta \Delta y_t + \gamma_i x_{i,t-1} + \varphi x_{i,t-1}^* + \sum_{l=1}^{k_1} \mu_l \Delta x_{i,t-l} + \sum_{l=1}^{k_2} \theta_{i,l} \Delta y_{t-l} + \varepsilon_{i,t} \tag{7}$$

and the significance of  $x_{it}^*$  from the results was tested using the Wald Test. The null that the coefficient associated to  $x_{it}^*$ ,  $\varphi=0$ , as reported in Table 5, was rejected for all the retail rates, at 5 % level of significance. It is therefore relevant to include  $x_{it}^*$  in the model in all cases.

**Table 5: Estimated Long-Run Coefficients**

<i>Variable</i>	<i>Long run</i> $x_{it} = A_i + C_i y_{it}$
Instant deposit rate	$x_{it}^* = - 0.650 + 0.880y_{it}$ (0.162) (0.034)
Time deposit rate	$x_{it}^* = - 0.486 + 1.027y_{it}$ (0.338) (0.070)
Lending rate	$x_{it}^* = 2.100 + 0.929y_{it}$ (0.153) (0.032)
Mortgage rate	$x_{it}^* = 2.057 + 0.938y_{it}$ (0.153) (0.032)

Note: Standard errors are given in parentheses

**4.2 Short- and Long-Run Dynamics**

Table 6 reports the estimates of the ECM as represented by equation (1). The results indicate that the explanatory power of the model is similar to that of model (3) across the retail rates, suggesting strong statistical fitness of the models. The short-run and the long-run estimates are presented in Table 7. The coefficient  $\beta$  gives the immediate (short-run) pass-through. It represents the reaction of retail rates to a change in the LIBOR within the same month. Only 5.5 per cent of the change in the LIBOR during a particular month is reflected in the change in instant deposit rate in the same month. A change in the LIBOR by 100 basis points leads to a 12.7 per cent change in the time deposit rate, 14.2 per cent in the lending rate and 13.7 per cent in the mortgage rate in the same month. So, it is clear that immediate pass-through is incomplete in all the cases.

Table 6: Results for ECM

	<i>Instant deposit</i>	<i>Time deposit</i>	<i>Lending rate</i>	<i>Mortgage rate</i>
$\Delta y_t$	0.055*	0.127**	0.142**	0.137**
$(x_{i,t-j} - x_{i,t-j}^*)$	-0.235**	-0.146**	-0.257**	-0.276**
$\Delta x_{i,t-1}$	-0.094	-0.250**	-0.342**	-0.328**
$\Delta y_{t-1}$	0.383**	0.383**	0.504**	0.501**
$\Delta x_{i,t-2}$	-0.032	0.022	-0.092	-0.063
$\Delta y_{t-2}$	0.156	0.041	0.336**	0.322**
$\Delta x_{i,t-3}$	0.033	0.010	0.113*	0.095
$\Delta y_{t-3}$	-0.003	-0.044	0.112	0.087
R <sup>2</sup>	0.76	0.67	0.78	0.77
DW#	2.037	1.978	2.039	2.044
SC LM test	0.652	0.083	0.519	0.854
(P-value)	0.421	0.920	0.597	0.429
ARCH-LM Test	0.399	0.268	0.477	0.512
(P-value)	0.529	0.623	0.492	0.476
Jarque Bera	3.958	3.556	0.795	3.167
(P-value)	0.138	0.193	0.672	0.205
T	99	99	99	99

Note: \*\* and \* denote that the coefficient is significant at 5% and 10% levels, respectively.

# To have absence of autocorrelation between the residuals, the DW statistic has to lie between 1.78 and 2.22. The values of DW lie within the range.

The speed of adjustment,  $|\gamma|$  in absolute terms has a sensible economic interpretation if it is significant. It indicates how much of the error/shock occurring this month will be corrected in the next month in order to get the system back to its long-run value. As indicated in Table 7,  $\gamma$  is significant and negative in all the four cases. When the retail rate deviates from its equilibrium value, about 22.8 per cent of the divergence is eliminated during the following period. The speed of adjustment is more or less similar to the other three of the retail rates: 23.5 per cent, 25.7 per cent and 27.6 per cent for the instant deposit, the lending rate and the mortgage rate, respectively. In the case of time deposit, speed of adjustment was roughly 8 per cent lower, at 14.5 per cent. This implies that the customers holding instant deposits would benefit more than those holding time deposit accounts when the LIBOR is rising. Indeed, the holders of instant deposit accounts would benefit from 23.5 per cent of the rise of the LIBOR in the next period as compared to holders of time deposit who would benefit from only 14.5 per cent from the rise. However, the former would be worse off if the LIBOR is falling.

Table 7: Short-Run and Long-Run Summary

Variable	Short-run			Long-run		
	Immediate adjustment ( $\beta$ )	Speed of adjustment $ \gamma  * 100$	Adjustment delay (j)	Mark up (A)	Pass-through (C)	Complete Passthrough (C=1)
Instant Deposit Rate	0.055*	23.5%	1 month	-0.65	0.88	No
Time Deposit Rate	0.127**	14.5%	1 month	-0.49	1.03	Yes
Lending Rate	0.142**	25.7%	1 month	2.10	0.93	Yes
Mortgage Rate	0.137**	27.6%	1 month	2.05	0.94	Yes

Note: \*\* and \* indicates the significance at 5% and 10% levels, respectively.

To see the impact of this difference on borrowing and lending rates, think of a customer who holds a time deposit account and a repayment mortgage in the same bank in the UK. If the LIBOR is rising then the customer will find that 14 per cent of the error is corrected in one month while 27.6 per cent is corrected for his mortgage. Hence, the customer will find a faster adjustment for his mortgage than his deposit rate. This result might be due to the fact that financial institutions, especially building societies in the UK have a tendency to subsidise borrowers in cases where rates are rising (see, also Heffernan, 1997). The relationship between each retail rate and the LIBOR is given by the 'long-run' column in Table 7. A long-run pass-through,  $C$  is close to unity ( $C=1$ ) together with a small mark-up,  $A$  implies that the retail rate equals the LIBOR in the long-run. For deposit accounts, it is expected that the long-run pass through would be less than unity in markets characterised by imperfect competition. This is because the rate paid on deposit accounts represents a cost for banks and it is advantageous for the banks not to raise the deposit rate up to the full amount of the change in the LIBOR. However the long-run pass-through would be close to unity if the market is highly competitive because depositors are in a position to search for more attractive rates hence prompting banks to adjust their deposit rates fully. The long-run mark-up represented by the coefficient  $A$ , exhibits a negative sign in the case of the deposit rates (implying a mark-down), and a positive sign for the lending and mortgage rate (implying a mark-up). These signs are in line with the theoretical expectations. One would expect a mark-down in the price of deposits since it represents a cost to the banks and a mark-up in the lending rate since it represents revenue to the banks. Long-run pass-through for the instant deposit rate is not complete but is relatively high at 88 per cent, with a small constant term of -0.49. The time deposit rate recorded a complete long run pass-through. The estimates for the lending rate and the mortgage rate yield

a long-run complete pass-through. The mark-up coefficient is large and positive in both cases, suggesting that two retail rates are marked up well above the LIBOR rate. Based on these findings, it can be argued that the pricing of deposit, lending and mortgage accounts in the UK follows a competitive structure where a change in the LIBOR is reflected in the deposit rate in the long-run.

The findings reveal that deviation of each retail rate from its long run value does persist after one month. On average, only about 22.8 per cent of the deviation is corrected within one month. That is, 77.2 per cent of the error persists after one month. It means that, it takes about 4 months and 12 days for the whole deviation to be completely corrected. This can be regarded as a fairly quick adjustment. It, therefore, suggests that the retail rates react fully to a change in the LIBOR but with a time lag. Similar results were reported by Heffernan (1997).

The findings reveal that deviation of each retail rate from its long run value ( $x_{i,t-j} - x^*_{i,t-j}$ ) does persist after one month. On average, only about 22.8 per cent of the deviation is corrected within one month. That is, 77.2 per cent of the error persists after one month. It means that, it takes about 4 months and 12 days for the whole deviation to be completely corrected. This can be regarded as a fairly quick adjustment. It, therefore, suggests that the retail rates react fully to a change in the LIBOR but with a time lag. Similar results were reported by Heffernan (1997).

The immediate adjustment given by  $\beta$  is very slow, with the highest adjustment of 14.2 per cent in the lending rate. It is reasonable to argue that the interest rate pass through in the UK is slow and incomplete in the short-run, but complete in the long-run, probably due to the competitive structure of the banking sector in the UK. This finding compares very well with previous ones, particularly, Cottarelli and Koureli (1994), Borio and Fritz (1995) which reported 'complete' long-run but 'incomplete' short-run pass-through.

Existence of collusion in the retail banking sector might incite each bank to try to guess the price setting behaviour of others. This might slow down the adjustment process to new equilibrium. Similarly, presence of consumer inertia such that the customers do not possess all up-to-date information about price setting of banks and are generally perceived to be reluctant to change banks, which gives opportunity to the banks to practise price discrimination. Banks would find frequent re-pricing of products in response to changes in the policy rate expensive. This will encourages the banks to stick to the rate already set to avoid menu or sunk costs, thus leading to incomplete pass-through.

#### *4.3 Tests for asymmetry adjustments*

The asymmetric correction model described by equation (5) was estimated to investigate if retail rates adjust differently depending on whether they are below or above their long-run equilibrium level. The results for this model are reported in Table 8.

Table 8: Estimation for Asymmetric Adjustment

	<i>Instant deposit</i>	<i>Time deposit</i>	<i>Lending rate</i>	<i>Mortgage rate</i>
$\Delta y_t$	0.056	0.126**	0.146**	0.141**
$V(x_{i,t-j} - x_{i,t-j}^*)$	-0.327**	-0.143**	-0.319**	-0.329**
$W(x_{i,t-j} - x_{i,t-j}^*)$	-0.215**	-0.147**	-0.242**	-0.261**
$\Delta x_{i,t-1}$	-0.086	-0.250**	-0.329**	-0.320**
$\Delta y_{t-1}$	0.349**	0.383**	0.490**	0.490**
$\Delta x_{i,t-2}$	-0.031	0.025	-0.091	-0.064
$\Delta y_{t-2}$	0.142*	0.041	0.324**	0.313**
$\Delta x_{i,t-3}$	0.035	0.011	0.116**	0.098*
$\Delta y_{t-3}$	-0.004	-0.044	0.109	0.087
R <sup>2</sup>	0.762	0.668	0.777	0.771
DW#	2.037	1.977	2.030	2.038
SC LM test	0.652	0.124	0.353	0.662
(P-value)	0.421	0.884	0.704	0.519
ARCH-LM Test	0.258	0.450	0.249	0.389
(P-value)	(0.613)	(0.529)	(0.619)	(0.534)
Jarque Bera	3.512	3.968	0.616	2.739
(P-value)	(0.172)	(0.138)	(0.735)	(0.254)
Wald Test Statistic	2.446	0.011	0.553	0.414
(P-value)	(0.122)	(0.919)	(0.459)	(0.521)
T	99	99	99	99

Note: \*\* and \* denotes the significance level at 5% and 10% , respectively.

The asymmetric response of retail rates to the changes in the LIBOR could be discerned by observing the coefficients  $\alpha_1$  and  $\alpha_2$ . As reported in the table, both coefficients are negative and significant in all cases. That is when the instant deposit rate is higher than the LIBOR in the previous period, it adjusts downward by 0.33 in the current period. On the other hand, it adjusts upward only by 0.21 when it is higher than the LIBOR in the previous period. Therefore, downward adjustment for instant deposit rate is 12 per cent higher than the upward adjustment. This shows that instant deposit rate is rigid upward — a result which is valid in concentrated market, where banks are in a better position to avoid a price increase on deposits to minimise the cost of their funds. However, adjustment in time deposit rate to changes in the LIBOR appears to be symmetrical, where  $\alpha_1 = \alpha_2 = 14$  per cent meaning that upward adjustment is equal to downward adjustment.

The downward adjustment of 0.32 takes place in the next period when the lending rate is higher than the LIBOR in the previous period. The upward

adjustment is of 0.24 where the lending rate is lower than the LIBOR in the previous period. The results are similar to that of the mortgage rate. These are indicative that lending rates can also be characterised by upward rigidity, which might appear counter intuitive. One would think that banks would like to benefit from the rise in lending rate to maximise their revenue. But a plausible explanation could be found in Stiglitz and Weiss (1981), where it was shown that banks are reluctant to adjust their loan rates upwards, but not downwards. This reluctance in raising rates is due to the risk of losing safe borrowers and attracting those who are riskier.

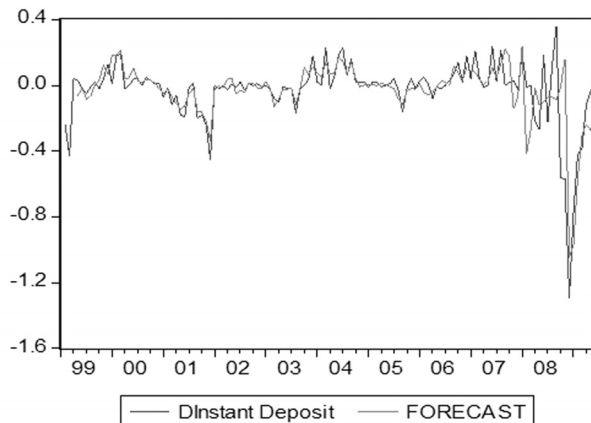
#### *4.4 Effect of the financial crisis on the IRPT*

Based on the structural break results of Bai and Perron (2003) presented above, August 2007 was taken to be the date marking the structural break in interest-rate pass-through. The rise in the LIBOR from 5.86 per cent in July 2007 to 6.22 per cent in August 2007 gave the first signal for the initial effect of the credit crunch.<sup>7</sup> This marks the date which breaks the cointegrating relationship between each retail rate and the LIBOR. The procedure of Jobst and Kwapil (2008) was adopted to test for the effect of the financial crisis on the IRPT. The idea is to use the estimations of 1999:01-2007:07 which give relationships between each retail rate and the LIBOR for 8½ years as the historical basis to forecast the evolution of each retail rate for the second half of 2007 up to July 2009.<sup>8</sup> This forecast is then compared with the actual movement of the retail rates. The result of this comparison is reported in Figure 2. It could be observe that the evolution of the change in instant deposit rate after August 2008 seems to follow the historical pattern. This, therefore, indicate that the credit crunch has not impacted on the banks' behaviour in setting the instant deposit rate. However, in the case of other retail rates, it is observed that they were not reduced as much as the historical patterns suggest as shown in Figures 3, 4 and 5. It is evident from the figures that the change in time deposit rate was higher than the forecast value as from the mid-2008. The LIBOR, which was about 6.22 per cent in August, 2007, declined to about 0.5 per cent by June, 2009, representing a loss of 90 per cent of its value. The time deposit rate however, was reduced from 5.09 per cent in August 2007 to 2.74 per cent in June 2009, a decrease of only 46.1 per cent over the whole period. A plausible argument for this behaviour is the willingness of the UK banks to keep existing savers and even attract new ones in face of the shortage of liquidity due to the credit crunch. In the case of the lending and mortgage rates, the respective forecast rates seem to diverge from the actual rate for the period starting from August 2007. It is relevant to note that two major UK banks, Halifax and Abbey had raised their mortgage rates for new borrowers by 2% during this period (Walayat, 2007). Other financial institutions also followed by raising their interest rates by the end of 2007. The likely reason being rise in bad debt due to the credit crunch, which prompted banks to tighten their lending criteria despite the fall

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**Figure 2: Relationship between Actual Instant Deposit Rate and the Forecast Rate**

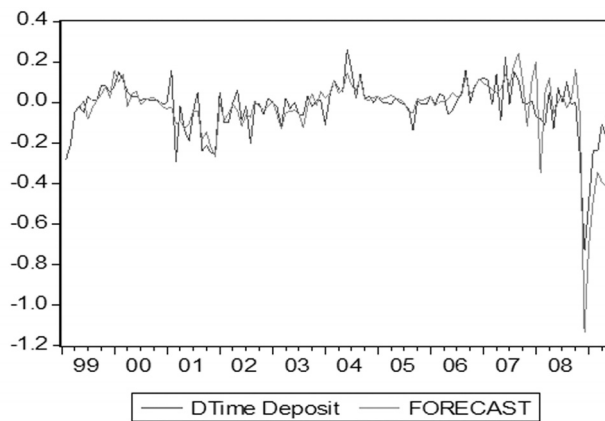
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**Figure 3: Relationship between Actual Time Deposit Rate and the Forecast Rate**

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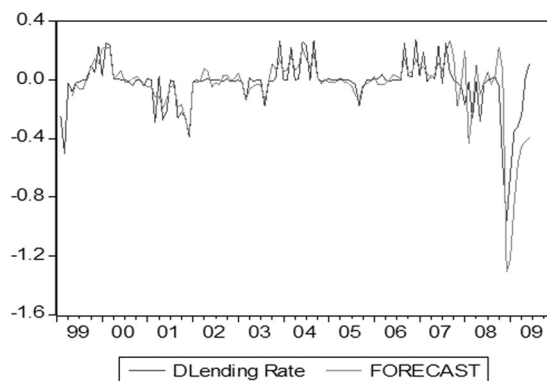
in the LIBOR. But Alliance and Leicester and the Bank of Scotland had left their rates unchanged till December 2007.<sup>9</sup> This reflects the observation of Skenfield (2009):<sup>10</sup> 'Despite this low rate environment, there is a significant disparity in the amount of this saving being passed on to mortgage borrowers by the main UK lenders.'

Figures 4 and 5 indicate that the actual lending and mortgage rates since 2008 were indeed higher than those predicted by the historical pattern.

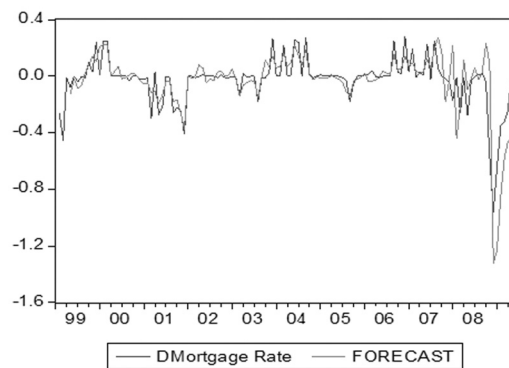
Overall, the results show that the pass-through of the LIBOR rate to the retail rates became weaker since the beginning of the financial crisis in August 2007. Banks seem to adopt a safer approach to preserve liquidity from depositors and avoid default from borrowers.



**Figure 4. Relationship between Actual Lending Rate and the Forecast Rate**



**Figure 5. Relationship between Actual Mortgage Rate and the Forecast Rate**



#### 4.5 Robustness checks

To check for the robustness of the estimated results, the residuals of the models were subjected to homoscedasticity, normality and autocorrelation tests. Homoscedasticity is verified through the ARCH LM Test of Engle (1982) where the null cannot be rejected at 5% level for all the four retail rates. Thus, the residuals are homoscedastic. The normality of errors is checked through the Jarque Bera Test where the null hypothesis is the normality of the errors cannot be rejected for all the retail rates. Durbin-Watson (DW) statistic has suggested that the residuals have no autocorrelation. However, the DW statistic has some limitations, especially when there are lagged dependent variables on the right hand-side of the regression. As a result, the Breusch-Godfrey Serial

Correlation LM Test was used and the results indicate that the null of no serial correlation cannot be rejected in either case.

## 5. CONCLUSION

This paper analysed the transmission mechanism of interest rates in the UK using monthly data from 1999:01 to 2009:06. The LIBOR was used as a proxy for the policy rate and the study examined how changes in the LIBOR are passed-through to four retail rates. For each retail rate, an ECM was utilised to identify the immediate adjustment and the speed of adjustment. The long-run pass-through, the long-run mark-up which determine the long-run equilibrium was also estimated. The empirical results revealed that the UK banking system adjusts its retail interest rates in response to the changes in the LIBOR completely in the long-run, while adjustment in the short-run is found to be incomplete. This result is consistent with the findings of Cottarelli and Koureli (1994) and Borio and Fritz (1995), but contrasts with most of the literature on the IRPT where pass-through is found to be generally incomplete even in the long-run.

It is argued in the literature that monetary policy will be more effective, particularly, in controlling inflation, if immediate pass-through is complete (see for example, Fuertes and Heffernan, 2009). But this study reveals that the maximum immediate adjustment stands only at 14.2%. This incomplete short-run pass-through might hinder the potency of the monetary policy. However, the results indicate that it takes not more than four months for the whole transmission to complete. It could be, therefore, argued that if this period is predictable by the economic agents, it can act as a signal to them for the formulation of their savings and investment decisions and hence improve the short-run effectiveness of the monetary policy.

It is also found that asymmetric behaviour across the different retail rates is apparent. The results suggest that interest rates on deposit, lending and mortgage adjust asymmetrically depending on whether the retail rates are above or below their long-run equilibrium value. However, time rate did not exhibit asymmetric adjustment.

The analysis also contributed to the existing literature by analysing the impact of the credit crunch on the IRPT in the UK. It was found that the retail rates deviated from their historical pattern suggesting that the financial crisis has impacted on the financial institutions' behaviour in setting retail rates. This is particularly with deposit, lending and mortgage rates.

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## ENDNOTES

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2. For full discussion on the evolution of the UK banking system, see Davies et al. (2010).
3. For full detailed survey, see de Bondt, Mojon, and Valla (2005) and Kok Sorensen and Werner (2006).
4. For full discussion of the model, see Bai and Perron (2003).
5. Heffernan (1997) provides econometric justification for choosing the LIBOR as a proxy for the policy rate (see Heffernan, 1997, p.223). Instead of pass-through from the policy rate, we will therefore focus on the pass-through from a short term money market rate. But as observed on figure 1, the LIBOR adjusts quickly to the BoE's official rate, which will enable us to extend our findings to changes in the policy rate. The use of the LIBOR will also enable us to study the potential impact of the credit crunch on the IRPT.
6. Calculated as a mean of the 4 coefficients of speed of adjustment:  $(23.5+14.5+25.7+27.6)/4=22.8$ .
7. Conway (2007), 'Libor soars as credit crunch returns', [www.telegraph.co.uk/finance/economics/](http://www.telegraph.co.uk/finance/economics/).
8. The forecast is based on h-step ahead, which is more relevant in this case.
9. MSN Money Consumer Champion (2007).
10. Myfinances.co.uk (2009), <http://www.myfinances.co.uk/mortgages/2009/8/20/mortgage-lenders-fail-to-pass-on-interest-rate>.

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