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The Influence of Banking Centralisation on Depositors: Regional Heterogeneities in the Transmission of Monetary Policy

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Abstract

This study examines whether regionally and nationally branching banks set deposits interest rates differently. This assessment of the UK retail deposit market between 1992 and 2008 indicates regional banks set deposit interest rates in a manner distinct to nationally branching banks. This deviation between changes in the market interest to retail interest rates is characterised by a non-linear mean reverting process. Deposit interest rates offered by regional banks also display lower levels, a slower response to wholesale interest rate increases and a swifter response to wholesale interest rate falls, relative to national banks. It is concluded this evidence is consistent with distinct monetary conditions existing in the UK regions.

Key Words: Interest rate transmission, Market definition, Bank Branching.

JEL Classification: G21 - Banks; Other Depository Institutions; Micro Finance Institutions; Mortgages

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1. Introduction

Do regionally and nationally branching banks set interest rates differently? This study empirically examines such regional heterogeneity in interest rate setting, by examining the transmission of wholesale interest rate changes to interest rates on deposit accounts issued by regional and nationally branching UK banks. The central hypothesis underlying this assessment is that deposit interest rate deviations are mean reverting, so that bank deposit interest rates do not drift far away from the London Interbank Offered Rate (hereafter LIBOR). In other words, given mean reversion, individual bank interest on deposit accounts will fall if they are high as compared with the LIBOR, and vice versa.

Such evidence matters as the regions which may spark a monetary policy action may or may not be the regions' most sensitive to monetary policy actions (FRATANTONI and SCHUH 2003). This concern has resonance for many nations with centralised banking systems, and particularly the focus of the study, the UK. Within this nation, South East England is home to most national bank headquarters, which has had, for many years, significantly higher property values and appreciated higher levels of borrowing relative to other UK regions (MACKAY, 2003). Subsequently every recent UK house price 'boom' has begun in South East England before moving out unevenly through other parts of the UK (MARTIN 2011). Describing this process, DOW and MONTAGNOLI (2007) report higher interest rates employed to choke off higher mortgage lending demand in South East England has forced other parts of the UK to

adopt more conservative attitudes to growth and asset values. If we accept this hypothesis, it is pertinent to enquire are these distinct monetary policy demands are reflected in different forms of interest rate setting by nationally and regionally branching banks.

In light of the foregoing it is proposed nationally branching banks require relatively tighter monetary policy to regional banks. Subsequently regional banks should reduce interest rates more swiftly within periods of interest rate decline and increase interest rates more slowly when interest rates are rising. Alternatively, if regional banks do pass on market interest rate changes to retail rates in a manner similar to nationally branching banks, regional heterogeneities within the UK banking system are overstated, at least in their influence on retail banking.

This hypothesis is examined through investigation of the misalignment of bank specific deposit interest rates relative to the LIBOR over time. This examination uses bank specific interest rate data for deposits below and at or above £25,000 drawn from the wider population of UK retail depository institutions between 1992 and 2008, including both nationally and regionally focused banks and building societies (hereafter collectively termed banks). We start our empirical investigation by utilizing standard linear unit root tests to test mean reversion for national and regional banks using unit root tests. This process may exhibit near unit root behaviour in a specific range, so that bank deposit interest rate deviations from LIBOR may appear non stationary from the perspective of test procedures, which specify a linear nonstationary process as the null hypothesis. Second, we examine the possibility that deposit interest rate misalignments from the LIBOR can be characterized by a smooth non linear mean reverting process, captured by the non linear unit root test of

Kapetanios et al (2003). Lastly, we examine interest rate asymmetries which may exist in periods of rising and falling interest rates.

It is reported that within a linear model, convergence between bank specific deposit interest rates and LIBOR occurs for all banks, both national and regional, with an adjustment process more pronounced for larger deposits. The nonlinear unit root test results are more favourable for stationarity since in all cases where nonlinearity is present, the unit root null hypothesis can be rejected. Hence, bank deposit interest rate deviations from LIBOR follow a nonlinear mean reverting process. It is shown that these nonlinear dynamics are genuine, because they are not merely capturing the effects of non-normal deviations in an otherwise linear data generating process. This non-linear adjustment rate is far more variable between regions for relatively smaller deposits, with banks predominately locating branches within Northern Ireland, the Midlands and Scotland displaying lower interest rates than nationally branching banks. For deposits of £25,000 or greater similar rates of adjustment to LIBOR are recorded for all types of banks indicating the deposit market may be more integrated for larger deposits. We also report an asymmetry is present for deposit accounts of less than £25,000. Specifically negative interest rate changes have a faster speed of adjustment, than positive interest rate changes. For deposit accounts with £25,000 or greater deposited these asymmetries in interest rates are not observed.

The study is divided into five sections. In section 2, the research background will be outlined. The data and the model adopted in the study will be discussed in section 3. In section 4, the results will be discussed. Lastly, in section 5, conclusions will be drawn.

2. Literature review

This brief review examines why intra-national differences could arise in interest rate setting by national and regional banks. This examination is informed by literatures on regional economics and banking, bank branching and interest rate transmission. This review is not comprehensive yet attempts to map the contours of these different yet interconnected literatures, specifically examining two questions: a) why would regional monetary policy conditions vary and distinct interest rates arise, and b) Is there past evidence of distinct interest setting by regionally and nationally branching banks?

2.1 Why would regional monetary policy conditions vary and distinct interest rates arise?

There is a strong theoretical argument as to why monetary policy conditions would be uniform within nations. Standard neoclassical theory indicates capital is perfectly mobile and should flow from rich to poor regions due to higher marginal capital productivity. Indeed as financial markets integrate, firms and individuals will be able to free themselves of local financial constraints and capital will flow to the regions with the highest productivity.

Despite the persuasiveness of this argument, evidence of capital flows from rich to poor regions are illusive (LUCAS, 1990); an outcome attributed to market failures and information asymmetries (CARREIRA and SILVA, 2010). At the national level, if informational imperfections exist, capital flows can be reversed leading to a transfer of funds from poor to rich nations, permanent income inequality and enhanced cyclical fluctuations (BOYD and SMITH, 1997). Similarly when assumptions of perfectly informed markets and rational behaviour are relaxed within nations, capital may flow from peripheral to core regions. Therefore within a spatially centralised financial system, capital may

flow disproportionately to some rather than all regions with differential interest rate setting by banks emerging as an outcome of this process.

Alternatively within the extensive literature examining monetary policy transmission, distinct industrial profiles of regions are identified as a significant influence on the effectiveness of monetary policies. For example, CARLINO and DEFINA (1999) report that a percentage change in the official interest rate influences US states differently, where states with a high proportion of manufacturing industry and reliance on investment are influenced far more by monetary policy changes relative to other states. This influence has also been observed in European nations. Within Spain, RODRIGUEZ-FUENTES and PADRÓN-MARRERO (2008) report monetary policy changes have regional effects due to geographical industrial specialisation. Across the entire EURO area, PEERSMAN and SMETS (2005) observe the impact of monetary policy on durable goods industries is three times greater than occurs for non-durable goods industries.

Different monetary policy conditions may also arise within nations as regional firms face difficulties in raising bank finance. As regional firms are geographically and often functionally (ALESSANDRINI *et al.* 2009a) distant from national financial institutions' head offices information asymmetry and uncertainty can influence bank lending decisions and restrict access to lending (DOW and MONTAGNOLI, 2007; KLAGGE and MARTIN, 2005). Conversely when firms are physically and culturally closer to the banks headquarters, senior managers, local stakeholders (ALESSANDRINI *et al.* 2009a) and personal contacts (ENGLEBERG *et al.* 2012) greater incentives exist for banks to lend. This outcome can be exaggerated as small and medium sized firms are often dependent on bank financing and are disproportionately represented within many regional economies.

Differences may also exist in the form of lending decision making employed by larger and smaller banks. Banks of different sizes have access to distinct endowments of resources and face dissimilar distances between decision making and authority. This leads to divergent methods of undertaking business and activities undertaken (BERGER *et al.* 2005) with larger, multimarket banks relatively more diversified and less focused on the retail sector. Subsequently, it has been argued larger banks often employ transactional type lending decision making techniques requiring more hard quantitative information and information technology. Similarly smaller banks are believed to make greater use of 'soft' information developed through loan officer contacts (BERGER *et al.* 2005, 2007).

This internationally observed difference in lending decision making, while not clear cut (ALESSANDRINI *et al.* 2009a), could result in the reluctance of larger banks to make small loans in distant regions due to due diligence and administration costs. Smaller regional or community banks are therefore viewed to be an important conduit for lending to regional small and medium sized firms within regions. Indeed the level of local financial development is viewed to be critical for regional economic growth irrespective of the level of financial integration (GUISO *et al.* 2004). This process has been linked with sharply different levels of lending within UK and European regions (MACKAY and MOLYNEUX, 1996) and also different forms of lending within more remote regions (ÖZYILDIRIM and ÖNDER 2008).

Notwithstanding the importance of lending, the supply of deposits is also important in this discussion. Nationally branching banks have operational benefits in the deposit market, deriving economies of scale in many administrative functions from the national collection of deposits (KLAGGE and MARTIN, 2005). This enables lower cost provision of depository services and

facilitates the intermediation of locally obtained deposits beyond the region (ÖZYILDIRIM and ÖNDER 2008) providing a wider range of investment opportunities and potentially higher returns. Subsequently, the geographical expansion of bank branching has been linked with improved bank efficiency (BERGER *et al.* 2007), profitability and competition (HANNAN and PRAGER, 2009) and financial management (CARLSON and MITCHENER, 2009) in the USA. Distinctly, within regionally segmented banking markets it is expected that regional banks will transform locally obtained deposits into loans for local productive investment opportunities.

Despite this potential benefit accorded to regional banks, in many economies the number of these institutions has reduced within an accelerating process of banking consolidation and centralisation (DeYOUNG *et al.* 2009). This process is viewed to have had a real impact on lending and economic development on non-core regions (KLAGG and MARTIN, 2005) with benefits accorded by smaller regional banks diminished to a degree which more than off-sets the benefits arising from improved information and communication technologies in banking (ALESSANDRINI *et al.* 2009b). Responding to these concerns there have been calls to retain and establish regional banks and regional banking centres (ALESSANDRINI *et al.* 2009a, KLAGG and MARTIN, 2005) or even return to an '*originate and hold*' finance model (MARTIN, 2011) to alleviate wider frustrations with the inability of larger national or multimarket banks to lend (BERGER *et al.* 2005).

Overall we can conclude that theoretically distinct monetary conditions can arise in different regions. These differences in monetary conditions may, in turn, be reflected in interest rates of banks operating regionally as the real effects of monetary policy are transmitted through interest rates (BERNANKE and BLINDER 1992).

2.2 Is there past evidence of distinct interest setting by regionally and nationally branching banks?

Evidence of differential regional and national interest rate setting has been linked with a range of literatures considering the transmission of monetary policy, market definition for competition assessment, the size and location of banks, as well forms of lending decision making.

Past assessments of deposit interest rate setting reports infrequent and sluggish interest rate movement is a common response to official or wholesale interest rate changes. This slow adjustment of retail interest rates to official or market rates is attributed to a number of possible factors, including the competitiveness of retail financial services markets (CALEM and MESTER, 1995; HEFFERNAN, 1997; PAISLEY, 1994); interest rate asymmetry (De HAAN and STERKEN, 2004; LIM, 2001), the structure of the banking industry, both in the US and Europe (ADAMS AND AMEL, 2011; CALEM and CARLINO, 1991; CORVOISIER and GROOP, 2001; De GRAEVE *et al.* 2007; HANNAN and BERGER, 1991; JACKSON, 1997), lending channel effects (De GRAEVE *et al.* 2007), credit risk premium, (MARTIN-OLIVER, 2007), bank efficiency (FUERTES and HEFFERNAN, 2009), macroeconomic changes (GAMBACORTA, 2008), regulation (CHONG, 2010) and the scale of base rate changes (FUERTES *et al.* 2010). MAROTTA (2009) and De BONDT (2005) both provide extensive reviews of this literature.

There is also limited evidence that differential interest rates provided by regional and nationally branching banks exists. Within the UK, McKILLOP and HUTCHINSON (1990) and ENNEW and BINKS (1993) identified higher costs of business borrowing in Northern Ireland. Similarly ASHTON (2001, 2009a) rejected the presence of a unified economic market for retail deposits and

reported deposit interest rates vary significantly between regionally based and nationally based UK banks, respectively.

Distinct interest rate setting within regional banking markets has also been examined in the USA, often in the context of market definition for competition assessment. High levels of market integration or rejection of local markets are reported for studies employing co-integration methods (e.g. COOPERMAN *et al.* 1991; JACKSON, 1997; JACKSON and EISENBEIS, 1997). Regression and correlation based methods provide results indicating local markets are influential. More recently BECKER (2007) used demographic data to indicate the local scope of deposit markets, assuming the use of deposits by older persons is a key indicator of banking markets. Other international evidence for regional and national interest rate differentials have been reported. For example KANO and TSUTSUI (2003) indicated lending costs of lending for regionally located Shinkin banks vary across Japan.

3. Empirical Design, Data and Analysis

This section outlines the data employed and econometric methods used in the study. These choices are guided by reference to previous studies, and particularly concerns with sample selection, the use of deposits to consider interest rate transmission, the form of branching, linear or nonlinear forms of interest rate change and concerns with the aggregation of data.

3.1. Rational for the empirical design

In earlier studies of regional bank interest rate setting, the reported findings, the sample area, institutions, methods of analysis and aggregation of data examined have all varied. Many earlier studies focused entirely on depository

institutions operating only within metropolitan areas (e.g. AMEL and HANNAN, 1999; BIEHL, 2002; COOPERMAN *et al.* 1991; HANNAN, 1991; JACKSON and EISENBEIS, 1997) while other studies considered institutions which operate across an entire regions (e.g. BILLINGSLEY *et al.* 1994; HEITFELT and PRAGER, 2004; HYMEL, 1994; OSBORNE, 1988). Similarly many market integration or segmentation studies examined different types of institutions such as just larger institutions (e.g. JACKSON and EISENBEIS 1997) or a certain type of depository institution (e.g. AMEL and HANNAN, 1999; BIEHL, 2002; HANNAN, 1991).

Such selective sample selection may bias results. Banking customers communicate with their banks with distinct media and over different distances in urban and rural markets (PETERSEN and RAJAN, 2002). Therefore just considering larger urban banks could provide "*... an inaccurate picture of inter-regional price differences if locally-based banks behave differently from other banks, or if consumers view their services as qualitatively different from those provided by larger, more diversified, banks*" (HEITFIELD and PRAGER, 2004). To accommodate this concern both large and small and mutual and proprietary retail banks supplying retail deposits consistently over the sample period are examined.

Secondly, we employ deposits to assess the transmission of monetary policy. The role of locally sourced deposits in the intermediation process and interest rate formation is essential for regionally based financial institutions. While larger banks are able to borrow internationally reducing their dependence on deposits (PARK and PENNACCHI, 2009), deposits remain a relatively cheap source of bank funding and are particularly important for smaller banks (BERNANKE and GERTLER, 1995). Indeed the wider benefits of deposit financing for banks is increasing recognised, to both navigate challenging

financial environments (HUANG and RATNOVSKI, 2011, SHIN, 2009) and in limiting contraction of credit provision (CORNETT *et al.* 2011). Further, deposits are expected to reflect the influence of monetary policy far more quickly than some other financial services. Loans, for example, are contractually constrained commitments and while these will eventually change in response to monetary policy (and often coincide with changes in unemployment, a feature helpful when assessing economic growth), this process is highly lagged when assessing the transmission of monetary policy (BERNANKE and BLINDER 1992). In addition to the relative immediacy of deposit interest rate changes, the collection of deposits through bank branches often retains a local character whilst loan financing has become increasingly national and global in form (AALBERS 2009).

A third concern raised in past examinations of regional banking is that bank branching will only influence interest rate setting behaviours when both national and regional institutions are operating in the same market (CARLSON and MITCHENER, 2009). The UK has both established national and regional banks and has not recently faced regulatory restrictions on bank branching, such as the Riegal-Neal Act in the USA, which would distort such an examination. To further emphasise the regional and national form of banking distribution only branch distributed deposit accounts are considered. This approach is justified as many retail customers' use branches and many financial services transactions are undertaken through a physical outlet, even if just for advice on how to proceed with a telephone or internet application (COMPETITON COMMISSION, 2001).

It is also assumed each region is treated as independent in the analysis. While we do acknowledge that costumers are able to move their bank and shop around for the best deal, the degree of switching deposit accounts is very low

both in the UK and internationally (KISER, 2002; CRUICKSHANK, 2000). For example, the UK Independent Commission on Banking (2011) reports the percentage of customers who switched deposit accounts in the previous 12 months was 6% in 2009 and under 6% in 2010. Further information technology has been previously viewed not to alter the pricing (ASHTON, 2002) or local nature of deposit provision significantly (BECKER, 2007; PETERSEN and RAJAN, 2002). Deposit account features such as access to a cash card are not included in the assessment. While these features have a real interest rate value (ASHTON and LETZA, 2003; HEFFERNAN, 1992) their measurement is problematic (HEFFERNAN, 2002).

A fourth and wider concern in considering the relationship between branching location and interest rate setting is the wide range of macroeconomic variables and relationships which can display nonlinear aspects of change, not least in the relationship between UK interest rates and economic growth (e.g. SENSIER *et al.* 2002). Nonlinear asymmetric reactions to monetary policy can emerge for a host of reasons affecting both individual regions and the operation of monetary at national level resulting in dynamic responses to monetary policy actions varying in magnitude and duration (FRATANTONI and SCHUH 2003). These nonlinear influences arise from regional causes such as the differing levels of wage rigidity and national sources such as political factors (e.g. DOLADO et al, 2005; MILAS AND NARAIDOO, 2012; PEERSMAN and SMETS, 2005). Within the study, these influences are accommodated through the use of both linear and nonlinear econometric techniques.

Lastly, FUERTES and HEFFERNAN (2009) report the use of aggregate data in transmission and integration studies can distort results. The use of aggregated data is therefore avoided and disaggregated bank level data is employed.

3.2 Data

Acknowledging the concerns of selective data coverage, the use of deposits, the scope of branching, nonlinearities and aggregation we examine branching retail banks for the UK operating continually over the sample period 1992-2008. The coverage of this data considers all English regions, Wales, Scotland and Northern Ireland. The interest rate data used in this study was developed from issues of the MONEYFACTS magazine, which provides a detailed monthly survey of UK monthly retail banking interest rates prices and charges for the near population of UK retail depository institutions. This data has been previously used in both regulatory (e.g. COMPETITION COMMISSION 2001; 2002) and academic investigations (e.g. ASHTON and HUDSON 2008; FUERTES and HEFFERNAN 2009; HEFFERNAN, 2002) and covers around 95% of the UK deposit market incumbents excluding only very small institutions. The data sets are contiguous yet unbalanced due the entry and exit of deposit services and banks. In a limited number of cases banks considered have been subject to takeover or merger within another institution; in cases where banks have continued to operate as subsidiary banks with distinct deposit accounts, these observations are considered in this analysis. Further, a number of banks also operate separate subsidiaries which operate in different areas of the UK. These banks are also considered in this analysis as separate banks when these institutions offer distinct deposit products, to their parent companies.

Bank specific interest rate data used in the study are provided from January 1992 to December 2008. This data is recorded over a range of different interest rate tiers for in total 719 deposit products offered by 92 banks and building societies, reflecting the different levels of interest paid for different sums deposited. For the purpose of brevity and the changing real values of

these interest rate tiers[1] we do not estimate findings for each of these interest rate tiers, yet estimate the average interest rate for deposits below £25,000 (the average of interest rates for £1,000, £5,000 and £10,000 deposited) and at or above £25,000 deposited (the average interest rate for £25,000, £50,000 and £100,000 deposited). We acknowledge that this approach, to reduce complexity of this assessment involves the aggregation of data which we have acknowledged is problematic in such an assessment and may obscure some of the relationships between LIBOR and bank specific rates particularly for interest rates provided for the smallest and largest deposits.

Interest rate change in this market has been previously examined (ASHTON 2009b). This study reports interest rates on retail deposits change with a periodic frequency for most banks, with a minority of larger retail banks and converted building societies changing deposit interest rates simultaneously. Distinctly, all individual banks which have a number of deposit accounts tend to change the interest rates of their own deposit accounts simultaneously.

The geographical dispersion of depository institutions offering banking services is made with reference to the distribution of bank branches in 1999, roughly halfway through the sample period. The branch location data was collated both with reference to individual banks and the BUILDINGS SOCIETIES ASSOCIATION year book (2000). The definition of a banks' regional focus is made by selecting all banks which have 75% or more of their branches located within a particular region. The definition of banks with a scope beyond individual regions or nationally branching banks is made by considering, those banks without 75% of branches located in any single region of the UK. While it is conceded that the scale of individual branch networks has

[1] Values of £1,000, £5,000, £10,000 and £25,000 in 1992 would be £673, £3,365, £6,730 and £16,827 when deflated by the UK Annual Retail Price Index over this time period.

altered over the sample period 1992-2008, and particularly branch closure has focused on lower income areas, the geographical coverage by individual institutions in terms of entire regional areas is not thought to have shifted significantly over the sample (see LEYSHON *et al*, 2008; MARSHALL *et al*, 2000, for further discussion). It is also acknowledged that the decision to define a regional bank in this way as arbitrary, and indeed it would be possible to alternatively consider only 25% and 50% of branches located in an individual region as a definition of a regional bank. A drawback of such 'wider' definitions of a regional bank is that some banks would be classified has having multiple regions. The 92 banks considered and the 75%, 50% and 25% classification of the regional focus of banks are reported in Appendix 1. Further the different descriptive statistics formed through the use of these alternative classifications of a regional orientation are also considered in the descriptive statistics, to reflect the influence of these alternative definitions. In total, 9 regional areas are defined including the English regions (Northern England and Yorkshire, including North East England, Eastern England, South East England, South West England, the Midlands and North West England), Scotland, Wales and Northern Ireland.

LIBOR is used as a measure to quantify the market interest rate. While this measure has the statistical advantage of providing high levels of interest rate change we do acknowledge problems can arise with this choice. FUERTES and HEFFERNAN (2009) correctly indicate the choice of the Bank of England base rate is preferable as LIBOR and official rates do diverge at times and the Bank of England base rate gives the official policy stance of the central bank rather than the cost of funds in the short term money market.

3.3 The Econometric Methods and Hypothesises

Reflecting the methodological concerns raised in the preceding section we adopt three forms of econometric analysis considering both linear and non-linear methods which are conducted after a descriptive assessment of the data. Initially, the unit roots of the time series deposit data are considered. Secondly, the non-linear aspects of the time series data are assessed. This procedure is undertaken as if the speed of adjustment of bank specific deposit interest rates to the market costs of individual deposit accounts rises as the deviation between the bank specific rate and market costs of funds increases, the non-linear mean reverting model is more appropriate, because it captures this behaviour. Lastly, interest rate asymmetry is considered for periods when the wholesale costs of funds are increasing and declining.

This form of time series econometrics has been widely used in regional economics to assess cases of convergence. For example stochastic and non-linear unit root tests have been employed to assess the convergence of Mexican regional GDP (CARRION-I-SILVESTRE and GERMAN-SOTO, 2007) and income within US regions respectively (CHRISTOPOULOS and TSIONAS, 2007). At the time of writing this is the first study to our knowledge to apply non-linear approaches to the transmission of interest rates on a regional basis.

3.21 ADF unit root test

The standard linear ADF test (DICKEY and FULLER, 1979; SAID and DICKEY, 1984) uses the following regression model to test the stationarity of the deviation between national and regional banks:

$$\Delta ILIBOR_t = \gamma_0 + \gamma ILIBOR_{t-1} + \sum_{i=1}^{k} \gamma_i \Delta LIBOR_{t-i} + \varepsilon_t \qquad (1)$$

where $ILBOR_t$ denotes the deviation between individual interest rates on deposit accounts to the LIBOR interest rate ratio at time period *t*, the $\gamma's$ are constants and ε_t is a random disturbance term: $\{\varepsilon_t\} \sim iid(0,\sigma_\varepsilon^2)$. The terms in $\Delta ILIBOR_{t-i}$ are included to remove any serial correlation in ε_t. Rejecting the null of unit root requires the estimates of γ to be negative and significantly different from zero; the greater the negative result the stronger the rejection of the hypothesis that there is a unit root at some level of confidence. Both deterministic and stochastic convergence between bank specific interest rates and LIBOR are reported when the testing procedure contains a constant, or a constant and a time trend respectively.

This procedure allows examination of convergence between bank specific and the market cost of funds. If unit roots are reported, convergence between the bank specific interest rates and LIBOR is not observed indicating the data is non-stationary and changes in the market costs of funds permanently influence market interest rates. As the linear test is a partial adjustment model we cannot capture the speed of this adjustment process as the linear ADF model assumes the speed of transmission to be constant. The ADF results can be seen in Table 2.

3.22 Alternative Linear Unit Root Tests

For robustness we also computed three other linear unit root tests. First we implement the NG and PERRON (2001) test, which ensures that non-rejections of the null-unit root are not due to a low probability of rejecting a false null hypothesis, while rejections are not related to size distortions. Second, we estimate the PHILLIPS and PERRON (1988) unit root test, which gives more

robust estimates than the ADF test when the series has serial correlation and time dependent heteroscedasticity. Finally, we estimate the KWIATKOWSKI *et al*, (1992) KPSS test, which constructs a component representation in which the time series under study is written as the sum of a deterministic trend, a random walk and a stationary error. The null hypothesis of trend stationarity corresponds to the hypothesis that the variance of the random walk equals zero.

3.23 Non-linear unit root test

If non-stationarity in the linear model is reported, we estimate a non-linear mean reverting unit root test. A failure to reject non-stationarity using the ADF test may result from a lack of power of linear unit root tests if the true data generating process is non-linear. Such non-linearity in the data may affect the stationarity properties of the data seriously. For example if the speed for bank specific interest rates adjustment back to LIBOR increases as the deviation between the bank specific interest rate and LIBOR rises, a non-linear model is more appropriate. Methodologically, this approach examines how individual banks react to changes in the market cost of funds by allowing for the speed of adaptation to vary with the magnitude of the change in LIBOR.

The initial testing for the presence of non-linearities in $ILIBOR_t$ is based on three stages. First, a linear autoregressive model for $ILIBOR$ is specified in order to determine the lag length k. The lag length selection is based on the Schwarz information criteria and the Ljung-Box statistic for serial correlation. The residuals are saved from the chosen autoregressive model and denoted as w. Second, having determined k, the next stage is to test for the presence of non-linearities. This is done through the estimation of

$$G_t = \beta_0 + \beta_1 ' x_t + \beta_2 ' x_t ILIBOR_{t-d} + \beta_3 ' x_t ILIBOR^2_{t-d} + \beta_4 ' x_t ILIBOR^3_{t-d} + f_t \qquad (2)$$

where the linearity test is on the null hypothesis $H_0 : \beta_2 ' = \beta_3 ' = \beta_4 ' = 0$. The final stage of the non-linearity test is to determine which smooth transition model, LSTAR or ESTAR, is appropriate for the data. This is done by running the following sequence of nested tests.

$$H_{04} : \beta_4 ' = 0 \qquad (3)$$

$$H_{03} : \beta_3 ' = 0 / \beta_4 ' = 0 \qquad (4)$$

$$H_{02} : \beta_2 ' = 0 / \beta_4 ' = \beta_3 ' = 0 \qquad (5)$$

Rejection of (3) implies selecting the LSTAR model. If we accept (3) and (4) we choose the ESTAR model. Accepting (3) and (4) and rejecting (5) leads to an LSTAR model. However, Terasvirta (1994) show that application of this sequence of tests may lead to incorrect conclusions, because the higher order terms of the Taylor expansion used in deriving these tests are disregarded (for more details see Terasvirta (1994) pp. 211-212.). They therefore recommend that we should compute the p-values of all the F tests of (3)-(5) and make the choice of STAR model on the basis of the lowest p-value.

Following this procedure we capture the non-linear nature of the adaptation process by using an Exponential Smooth Transition Autoregressive (ESTAR) model. The ESTAR model assumes that the adjustment of the ILIBOR towards its average value is characterized by a symmetric non-linear process:

$$ILIBOR_t = \beta ILIBOR_{t-1} + \delta ILIBOR_{t-1}\left(1 - \exp[-\alpha ILIBOR_{t-1}{}^2]\right) + u_t \qquad (6)$$

KAPETANIOS *et al.* (2003) developed a test where the null hypothesis of a unit root is tested against an alternative of non-linear ESTAR process, which is globally mean reverting. In order to implement the KAPETANIOS *et al.* (2003) unit root test on our dataset the non-linearity testing procedure formulated by TERERASVIRTA (1994) is used to determine whether the ILIBORs follow a non-linear mean reverting process. Under the null hypothesis of non-stationarity, $\beta = 1$ and $a = 0$, the ILIBOR follows a random walk. Computing a first-order Taylor series approximation to (1) under the null and allowing for serial correlation in u_t, the following auxiliary regression model can be obtained (see KAPETANIOS *et al.* 2003):

$$\Delta ILIBOR_t = \gamma_0 + \gamma ILIBOR_{t-1}{}^3 + \sum_{i=1}^{k} \gamma_i \Delta ILIBOR_{t-i} + v_t \qquad (7)$$

where v_t is the error term and the other variables are defined as previously. The null hypothesis in equation (7) is that $\gamma = 0$. Equation (7) does not provide a direct method to test the statistical significance of γ. This is because the cubic term embedded in γ is a non-linear function of the underlying parameter estimate resulting in the distribution of γ being unknown. Therefore, a bootstrap technique is used to obtain an asymptotic *t* statistic to test the significance of γ. Given that the data exhibits non-normal residuals in equation (7), the wild bootstrap technique employed previously by ARGHYROU and GREGORIOU (2008) is a suitable method to derive the appropriate critical

values for γ. It entails estimating equation (7) by OLS, obtaining the estimated v_t series and generating a new residuals series given by

$$v_t^* = v_t \varepsilon_t \tag{8}$$

where ε_t is drawn from the two-point distribution

$$\varepsilon_t \sim \begin{cases} -(5^{0.5}-1)/2 \text{ with probability } p=\dfrac{\left(1+5^{0.5}\right)}{2(5^{0.5})} \\ (5^{0.5}+1)/2 \text{ with probability } (1-p) \end{cases} \tag{9}$$

The ε_t terms are mutually independent drawings from a distribution independent of the original data characterised by the properties $E(\varepsilon_t) = 0$, $E(\varepsilon^2_t) = 1$ and $E(\varepsilon^3_t) = 1$. Hence, any non-normality in the estimated residuals v_t of equation (6) is preserved in the created residuals v^*_t. To examine this 10,000 sets of v_t^* residuals are generated and for each bootstrap iteration a series of ADF tests is constructed under the null hypothesis $\gamma = 0$, therefore the generated sequence of artificial data has a true γ coefficient of zero. However, when we regress the artificial ADF test for a given bootstrap sample $0t$, estimated values of γ that differ from zero will result. This procedure provides an empirical distribution for γ and their associated standard errors based

exclusively on the re-sampling of the residuals from the original regression (6). Therefore appropriate critical values are obtained for the null hypothesis of non-stationarity $\hat{\gamma} = 0$ in equation (6). Jacque Bera normality test results indicating non-normal residuals for equation (6) for all regions are also estimated and are reported in Table 2.

There is also an alternative literature that attempts to capture the non-linear unit root behavior by implementing the two structural break unit root test established by LEE and STRAZICICH (2003). The linear unit root test results are robust to these structural breaks because the LEE and STRAZICICH test requires that the breaks, captured through the use of time dummies, are very sharp. This approach is adopted as the standard no-breaks unit root tests are subject to the drawbacks of low-power and biases in the presence of structural breaks (see PERRON, 1989). Subsequent literature has emphasized the need to determine the breaks endogenously (see e.g. PERRON, 1997). More recently, the endogenous two-break minimum LM unit-root test of LEE AND STRAZICICH (2003) counterbalances the potential loss of power of tests that ignore more than one break. The Lee and Strazicich test includes breaks under both the null and the alternative hypotheses, with rejections of the null unambiguously implying trend stationarity[2]. Allowing for breaks in the form of two shifts in the level of ILIBOR, the null and alternative hypotheses are:

$$ILIBOR_t = \mu_0 + d_1 B_{1t} + d_2 B_{2t} + ILIBOR_{t-1} + \upsilon_{1t} \qquad \textit{Null} \quad (10)$$

$$ILIBOR_t = \mu_1 + \gamma t + d_1 D_{1t} + d_2 D_{2t} + \upsilon_{2t} \qquad \textit{Alternative} \quad (11)$$

[2] Lee and Strazicich (2003) point out that structural breaks under the unit root null can be interpreted as large permanent shocks or outliers.

where the error terms ($\upsilon_{1t}, \upsilon_{2t}$) are stationary processes; $B_{jt} = 1$ for $t = T_{bj} + 1$ ($j = 1,2$) and 0 otherwise; $D_{jt} = 1$ for $t \geq T_{bj} + 1$ ($j = 1,2$) and 0 otherwise. An LM score principle is used to compute the LEE AND STRAZICICH (2003) unit root test statistic based on the following regression model:

$$\Delta ILIBOR_t = \delta' \Delta Z_t + \varphi \tilde{S}_{t-1} + \sum_{i=1}^{k} \gamma_i \Delta \tilde{S}_{t-i} + u_t \qquad (12)$$

where $Z_t = [1, t, D_{1t}, D_{2t}]'$, $\tilde{S}_t = ILIBOR_t - \tilde{\psi}_x - Z_t \tilde{\delta}$; $t = 2,\ldots,T$; $\tilde{\delta}$ are coefficients in the regression of $\Delta ILIBOR_t$ on ΔZ_t; $\tilde{\psi}_x = ILIBOR_1 - Z_1 \tilde{\delta}$, where $ILIBOR_1$ and Z_1 denote the first observations of $ILIBOR_t$ and Z_t, respectively, and $\Delta \tilde{S}_{t-i}$ terms ($i = 1,\ldots,k$) are included to account for serial correlation. We can consequently test the unit root null hypothesis by examining the t-statistic ($\tilde{\tau}$) associated with $\phi = 0$.

3.23 Interest Rate Asymmetry

Interest rate asymmetry is examined by considering two distinct subsamples of the data set, where a) LIBOR is rising and b) where LIBOR is declining for bank specific average interest rates for deposits above and below £25,000. This procedure allows examination whether regional banks reduce interest rates more swiftly than national banks within periods of interest rate decline, and increase interest rates more slowly when interest rates are rising.

Asymmetry is assessed through considering if the non-linear test changes the linear result from non-stationary to stationary. This implies that the speed

of adjustment increases the greater the gap between the two deposit rates. While we cannot compare the speed of adjustment across different regions we may assess if it is increasing as the deviation between bank specific deposit rates and the market costs of funds rises.

4. Results

The results are provided in three groups considering the research questions and the associated three forms of econometric assessment.

4.1 *Descriptive Statistics*

Different definitions of regional and national banks are reported in Table 1, including banks defined as regionally orientated when 25%, 50% and 75% of branches are located in an single region; national banks are defined when no regional orientation is identified. Within Table 1 it is observed that while Wales, Eastern England and North East have relatively few banks viewed to be regional for all such definitions, the Midlands and South East England have a far greater number of banks with a strong branching presence, particularly when the criteria for regional orientation is weaker (i.e. when only 25% and 50% of branches need to located in a single region to determine a regional orientation).

Table 1 also indicates that a relatively high level of dispersion is observed in average interest rates in each region. T Tests for the differences between average deposit interest rates for under £25,000 and £25,000 and greater are undertaken between national and regional averages. It is reported that in over ¾ of cases significant differences between average interest rates of regionally orientated banks and nationally branching banks are reported. Of these 41 significant cases, only five represent regionally orientated banks having higher

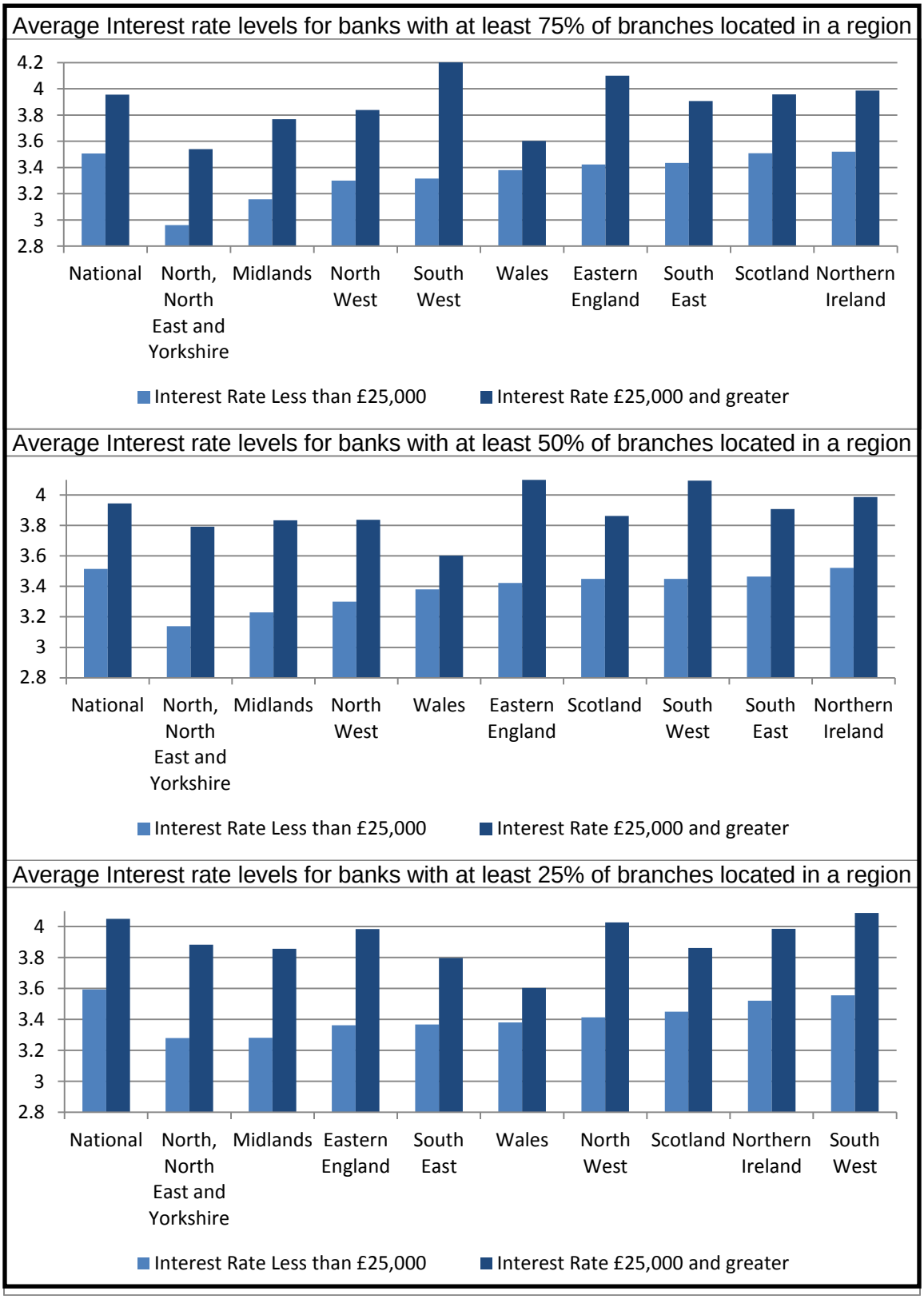
interest rates than offered by national banks. Therefore average interest rates of banks predominantly operating in Wales, the Midlands, North West England and Northern England and Yorkshire offer consistently lower average levels of interest on their deposits, than nationally branching banks. Banks from Northern Ireland and in some cases Eastern England have similar or higher average deposit interest rates than nationally branching banks. These differences are reported in Figure 1, which displays differences in the average levels of interest paid on deposits under and over £25,000 for regionally orientated and nationally branching banks defined with the three forms of regional orientation classification (25%, 50% and 75%).

Table 1: Descriptive Statistics

Regions	No. of banks	No. Deposit Accounts	Obs.	Deposit Rate <£25,000			Deposit Rate =>£25,000		
				Mean	St. Dev.	T Test	Mean	St. Dev.	T Test
Overall	92	719	42254	3.318	2.006	n/a	3.875	1.703	n/a
At least 75% of branches located in a region									
National	30	356	19057	3.506	2.113	n/a	3.955	1.759	n/a
Wales	2	8	585	3.380	2.343	-1.479	3.603	1.878	-4.603**
Northern Ireland	6	40	2724	3.521	2.150	21.241**	3.986	1.775	9.946**
Scotland	4	26	1791	3.509	2.0826	0.055	3.958	1.716	0.063
North, North East and Yorkshire	8	32	2299	2.960	1.881	-11.810**	3.540	1.729	-9.230**
North West	6	37	2228	3.300	1.855	-4.402**	3.838	1.621	-2.916**
Midlands	21	149	9485	3.158	1.805	-13.676**	3.769	1.611	-8.272**
South East	8	29	1619	3.435	2.042	-1.310	3.906	1.672	-0.999
South West	3	28	1441	3.316	1.749	-3.336**	4.289	1.542	6.837**
Eastern England	3	17	1234	3.422	2.101	1.348	4.099	1.690	-2.490*
At least 50% of branches located in a region									
National	18	194	11550	3.5145	2.117	n/a	3.9440	1.748	n/a
Wales	2	8	585	3.3799	2.343	-0.946	3.6028	1.878	-3.791**
Northern Ireland	6	40	2724	3.5213	2.150	21.498**	3.986	1.775	9.747**
Scotland	5	35	2322	3.4485	2.118	-1.982*	3.862	1.720	-2.310*
North, North East and Yorkshire	12	90	5368	3.1393	1.976	-11.785**	3.7926	1.822	-5.257**
North West	6	37	2228	3.300	1.855	-5.071**	3.838	1.621	-2.898**
Midlands	22	182	10426	3.230	1.854	-11.6078**	3.834	1.649	-5.124**
South East	11	58	3053	3.465	2.054	-1.848*	3.907	1.606	-1.364
South West	5	58	2763	3.450	2.009	-2.106**	4.095	1.671	3.599**
Eastern England	3	17	1234	3.422	2.101	-1.909*	4.099	1.690	2.433*
At least 25% of branches located in a region									
National	7	74	3580	3.594	2.265	n/a	4.050	1.858	n/a
Wales	2	8	585	3.380	2.343	-2.113*	3.603	1.878	-5.165**
Northern Ireland	6	40	2724	3.521	2.150	-18.848**	3.986	1.775	-10.027**
Scotland	5	35	2322	3.449	2.118	-2.480*	3.862	1.720	-3.738**
North, North East and Yorkshire	14	123	7082	3.280	1.968	-7.375**	3.882	1.772	-4.294**
North West	7	54	2880	3.414	1.912	-3.405	4.027	1.615	-0.495
Midlands	23	200	11312	3.282	1.875	-8.230**	3.856	1.655	-5.643**
South East	19	143	8544	3.367	2.053	-5.376**	3.797	1.682	-6.967**
South West	8	88	4595	3.555	2.093	-0.807	4.088	1.667	0.936
Eastern England	4	42	2127	3.362	2.178	-3.770**	3.984	1.893	-1.210

** indicates significant at 1%, * indicates significant at 5%

Figure 1: Distribution of Average Interest Rates (%) by Region.



4.2 *Linear unit root tests*

The linear unit root tests were undertaken over the time periods 1992 to 2008 and 1999-2008 and are reported in Panels A and B of Table 2 respectively. The unit root null hypothesis is not rejected in all cases providing strong evidence for non stationary behaviour in the regional UK ILIBORs. This indicates that within a linear model convergence between bank specific deposit interest rates and LIBOR does not occur for national and regional banks. This finding is consistent for all the unit root tests that were estimated.[3] The adjustment process is clearly far more pronounced for larger deposits of £25,000 and more deposited, than smaller deposits, of less than £25,000 deposited, in all cases. This potentially indicates depositors of larger deposits have greater incentives to ensure they are receiving a competitive interest rate.

The decision to break the sample at 1999 follows assessment of structural breaks using Lee and Strazicich's two-break unit root test. The results from these tests, displayed in Table 3, indicate there is a structural break in the ILIBOR rate at the cut-off point between the two periods, justifying the use of the sub-samples. The estimated break dates suggest that both breaks took place around 1999-2000, justifying our sample split at 1999. The unit root null hypothesis is accepted (rejected) in all cases when bank deposits are greater (less) than £25,000. The results from the two break tests are in complete agreement with the linear unit root tests that do not encapsulate structural breaks, suggesting that the LEE and STRAZICICH test requires that the breaks, captured through the use of time dummies, are very sharp.

[3] Note we estimate all our linear unit root tests with a constant and a trend, for robustness we also estimate them for a constant and trend in isolation. The results do not change and are available from the authors upon request.

Table 2: Linear unit root test results (1992-2008)

	Linear unit root test results				Linear Results overall	
Panel A 1992-2008						
Region	ADF test	NG Perron test	PP test	KPSS test	Linear ADF t-test statistic	
					Deposit Rate <£25,000	Deposit Rate =>£25,000
UK National	-1.47	-1.15	-2.00	0.99**	-8.77**	-2.11
Wales	-2.22	-2.00	-2.32	1.11**	-9.19**	-2.17
Northern Ireland	-1.74	-1.55	-2.24	1.00**	-9.99**	-0.92
Scotland	-1.85	-1.33	-1.77	1.32**	-9.77**	-1.80
North and Yorkshire	-1.09	-1.00	-1.99	1.23**	-9.99**	-1.84
North West	-2.15	-1.97	-2.43	1.33**	-8.10**	-2.10
Midlands	-1.79	-1.22	-2.10	1.05**	-9.88**	-1.60
South East	-1.94	-1.77	-1.45	0.88**	-9.33**	-2.11
South West	-2.07	-2.23	-2.50	1.04**	9.44**	-1.84
Eastern England	-1.87	-1.77	-1.66	1.11**	-9.00**	-2.19
Panel B 1999-2008						
Region	ADF test	NG Perron test	PP test	KPSS test	Linear ADF t-test statistic	
					Deposit Rate <£25,000	Deposit Rate =>£25,000
UK National	-1.40	-1.21	-1.90	1.44**	-8.55**	-2.00
Wales	-2.30	-2.34	-2.00	0.88**	-9.87**	-2.02
Northern Ireland	-1.60	-1.96	-1.66	1.10**	-9.32**	-0.98
Scotland	-1.82	-2.44	-2.22	1.04**	-10.54**	-1.85
North and Yorkshire	-1.19	-1.66	-1.50	1.66**	-10.23**	-1.89
North West	-2.44	-1.32	-1.44	1.50**	-8.18**	-2.00
Midlands	-1.61	-1.21	-1.04	1.03**	-9.33**	-1.69
South East	-1.88	-2.11	-2.24	1.11**	-9.50**	-2.00
South West	-2.15	-2.00	-2.18	1.77**	9.88**	-1.99
Eastern England	-1.72	-1.53	-0.98	1.59**	-9.11**	-2.45

Note: **, * indicate rejection of the null hypothesis at the 1%, 5% level of significance, respectively. The reported ADF, NG and Perron and PP t statistic tests the null hypothesis that the ILIBOR contains a unit root. The KPSS test statistic tests the null that the ILIBOR follows a stationary process. **, * indicate rejection of the null hypothesis at the 1%, 5% level of significance, respectively. We also did a robustness test with constant and a trend, and none results robust and available upon request.

Table 3: Two-break unit root test results

Region	Lee and Strazicich test statistic					
	Deposit Rate <£25,000			Deposit Rate =>£25,000		
	$\tilde{\tau}$ -stat	Break dates		$\tilde{\tau}$ -stat	Break dates	
UK National	-8.48**	1999	2000	-4.84	1999	2000
Wales	-7.80**	1999	2000	-3.25	1999	2000
Northern Ireland	-8.30**	1999	2000	-5.04	1999	2000
Scotland	-8.84**	1999	2000	-5.39	1999	2000
North and Yorkshire	-9.07**	1999	2000	-5.00	1999	2000
North West	-8.11**	1999	2000	-4.70	1999	2000
Midlands	-7.79**	1999	2000	-4.32	1999	2000
South East	-8.82**	1999	2000	-4.41	1999	2000
South West	-8.33**	1999	2000	-4.72	1999	2000
Eastern England	-7.50**	1999	2000	-4.31	1999	2000
Scotland	-8.15**	1999	2000	-4.72	1999	2000
Northern Ireland	-7.57**	1999	2000	-4.59	1999	2000

Note: The two-break unit root test was undertaken over the time period 1992-2008. The reported Lee and Strazicich statistic tests the null hypothesis that ILIBOR contains a unit root. **, indicate rejection of the null hypothesis at the 1% level of significance.

4.3 *Non-linear unit root test*

The non-linear unit root test was undertaken over the time period 1992-2008 and is reported in Table 4. The non-linear unit root test were applied in all cases since using the TERASVIRTA (1994) non-linearity tests we cannot reject the null hypothesis of linearity at the 5% level of significance. The reported 1% level of significance critical values were obtained from the wild bootstrap simulation with replacement in 10,000 replications. A robustness test with constant and a trend was also undertaken, yet as none of these results were significantly different, they are not reported and are available upon request.

Applying the TERASVIRTA (1994) non-linearity tests it is found that the null of linearity can be rejected in all cases, and that the ESTAR specification was preferred to the Logistic STAR (LSTAR) specification in all the non-linear cases.

Table 5: Non-Linear Results (1992-2008)

Panel A					
	Deposit Rate <£25,000		Deposit Rate =>£25,000		
Region	Non-linear ADF t-test statistic Constant	Wild Bootstrap 1% Critical Value	Non-linear ADF t-test statistic Constant	Wild Bootstrap 1% Critical Value	Jacque-Berra test statistic
UK National	-9.74 **	-3.95	-4.77 **	-3.99	11.51** [0.00]
Wales	-6.04**	-3.70	-4.11**	-3.66	24.76** [0.00]
Northern Ireland	-4.08**	-3.70	-4.33 **	-3.74	14.42** [0.00]
Scotland	-4.23 **	-3.87	-4.07 **	-3.80	14.91** [0.00]
North and Yorkshire	-7.99 **	-3.80	-3.99 **	-3.90	13.24** [0.00]
North West	-7.33 **	-3.88	-4.70 **	-3.98	13.48** [0.00]
Midlands	-5.17 **	-3.77	-4.11 **	-3.70	24.57** [0.00]
South East	-5.99 **	-3.80	-4.69 **	-3.87	9.96** [0.01]
South West	-8.29 **	-3.66	-4.33 **	-3.80	5.27** [0.07]
Eastern England	-6.34 **	-3.79	-4.88 **	-3.89	6.29** [0.04]

Panel B. Table Y Non Linear Tests and Econometric Specification of the Model					
Region	H_{04}	H_{03}	H_{02}	p-value	Type of Model
UK National	0.231	0.002#	0.541	0	ESTAR
Wales	0.321	0.004#	0.431	0	ESTAR
Northern Ireland	0.265	0.006#	0.476	0	ESTAR
Scotland	0.252	0.005#	0.501	0	ESTAR
North and Yorkshire	0.332	0.004#	0.431	0	ESTAR
North West	0.112	0.001#	0.221	0	ESTAR
Midlands	0.338	0.002#	0.723	0	ESTAR
South East	0.441	0.001#	0.111	0	ESTAR
South West	0.139	0.000#	0.066	0	ESTAR
Eastern England	0.326	0.006#	0.555	0	ESTAR
Scotland	0.222	0.003#	0.400	0	ESTAR
Northern Ireland	0.118	0.001#	0.444	0	ESTAR

Note: The reported non-linear ADF *t*-statistic tests the null hypothesis that the ILIBOR contains a unit root. **, indicate rejection of the null hypothesis at the 1%, level of significance. We also did a robustness test with constant and a trend, and none results robust and available upon request. Note: The number in the square bracket shows the *p*-value from the Jacque-Bera test for the null hypothesis of normality, and ** indicate rejection of the null hypothesis at the 1% level of significance. Panel B reports non linearity results and the specification of the econometric model. The null of non linearity is based on equation (1). The column headed 'p-value' corresponds to the test H_0 where the null is linearity. The variable deletion tests portrayed in equations (3), (4) and (5). # denotes the lowest p-value associated with the variable-deletion tests and therefore the determination of the relevant STAR model.

This indicates the level of convergence between bank specific deposit interest rates and LIBOR may be inaccurate when considering a linear model alone. Overall for all values the adjustment rate is more variable between different regions, with banks located predominantly located in Northern Ireland, the Midlands and Scotland displaying lower deposit interest rates than deposit interest rates offered by national banks. For interest rates for deposits of £25,000 or more, similar levels of adjustment are recorded for all types of banks indicating the deposit market may be more integrated for larger deposits[4].

4.4 *Interest Rate Asymmetry*

Table 5 reports unit root tests for interest rates during periods of increasing and declining interest rates. We observe that for positive (negative) interest rate changes for deposit accounts with less than £25,000 invested, the non-linear model reports stationary in 40% (60%) of cases. For deposits with more than £25,000 invested, stationarity is present in all cases regardless of the direction of change in interest rates. These results show that an asymmetry is present for interest rates offered on deposit accounts with less than £25,000 invested between positive and negative interest rate changes, given that negative interest rate responses have a faster speed of adjustment. In addition, for deposit accounts with £25,000 and over invested an asymmetry is not present given that the non-linear model reports stationarity behaviour for both positive

[4] Note we do not report the lag structure of the various unit root tests (linear and non linear) that we estimate. This is because the results remain intact regardless of the lag structure of the unit root tests. The results of the unit root tests with lag structures from one to twelve are available from the authors upon request.

and negative interest rate changes.[5] Table 6 includes the unit root assessment of this data.

Table 5: Asymmetry Changes in Deposit Interest Rates.

Panel A Positive Changes in Libor					
Region	Linear ADF t-test statistic			Non-Linear unit root test results	
	Constant	Constant and Trend	None	Deposit Rate <£25,000	Deposit Rate =>£25,000
UK National	-1.89	-1.92	-1.87	-9.23**	-2.19
Wales	-5.17**	-6.22**	-6.43 **	-9.19**	-5.62**
Northern Ireland	-0.92	-1.79	0.66	-9.99**	-0.82
Scotland	-1.82	-1.93	-0.86	-9.77**	-1.73
Yorkshire and North	-5.72**	-6.12**	-6.36 **	-7.83**	-6.83**
North West	-6.15**	-6.33**	-6.72 **	-8.10**	-7.10**
Midlands	-5.79**	-6.02**	-6.33 **	-9.00**	-6.67**
South East	-2.04	-1.86	-1.23	-8.23**	-2.12
South West	-1.32	-2.12	0.76	9.99**	-1.80
Eastern England	-1.36	-1.56	-1.67	-7.23**	-2.00
Panel B Negative Changes in Libor					
Region	Linear ADF t-test statistic			Non-Linear unit root test results	
	Constant	Constant and Trend	None	Deposit Rate <£25,000	Deposit Rate =>£25,000
UK National	-5.63**	-5.99**	-6.03**	-8.36**	-6.23**
Wales	-1.22	-1.34	-1.42	-8.12**	-1.53
Northern Ireland	-5.94**	-5.89**	-6.02**	-8.32**	-7.44**
Scotland	-5.83**	-5.96**	-5.44**	-5.97**	-5.99**
Yorkshire and North	-1.72	-1.33	-1.44	-6.23**	-1.92
North West	-2.01	-2.12	-2.23	-7.65**	-2.10
Midlands	-1.36	-1.33	-1.73**	-9.65**	-2.00
South East	-7.32**	-7.24**	-6.33**	-7.00**	-6.12**
South West	-5.65**	-6.00**	5.73**	7.42**	-5.85**
Eastern England	-6.66**	-6.88**	-7.23**	-8.45**	-8.03**

Note: The p-value of the t-statistic are obtained through bootstrap simulations and are available from the authors upon request. **, indicate rejection of the null hypothesis at the 1%, level of significance.

[5] For further robustness we repeated the entire econometric analysis by defining regional banks as institutions with 50% or more of their branches located within a particular region. The results reported in this paper remain intact and are available from the authors upon request.

It is also observed that the results for deposits of £25,000 or more, when positive and negative changes in LIBOR are considered are complimentary. During periods of increase in the LIBOR, significant results are reported for Yorkshire and Northern England, North West England, the Midlands and Wales, and during periods of LIBOR decline significant results are recorded for National banks, South East England, South West England, Eastern England, Scotland and Northern Ireland. This indicates that lower synchronization with the UK business cycle may exist for the former regions.

Table 6: Unit Root Results (1992-2008)

	Non-Linear Deposit Rate <£25,000		Non-Linear Deposit Rate =>£25,000	
Region	Non-linear ADF t-test statistic Constant	Linear ADF t-test statistic	Non-linear ADF t-test statistic Constant	Linear ADF t-test statistic
UK National	-9.74 **	-7.95**	-8.77 **	-1.99
Wales	-7.07**	-7.70**	-8.00**	-1.66
Northern Ireland	-6.11**	-8.70**	-6.30 **	-1.74
Scotland	-6.89 **	-5.87**	-6.19 **	-1.80
North and Yorkshire	-8.99 **	-5.65**	-6.00 **	-1.90
North West	-7.00 **	-5.93**	-5.86 **	-2.00
Midlands	-6.20 **	-5.77**	-6.88 **	-1.74
South East	-7.25 **	-6.89**	-5.99 **	-1.87
South West	-8.01 **	-7.66**	-7.44 **	-1.82
Eastern England	-6.77 **	-5.79**	-6.77 **	-1.56

Note: The reported linear and non-linear ADF *t*-statistic tests the null hypothesis that the ILIBOR contains a unit root. **, indicate rejection of the null hypothesis at the 1%, level of significance. For the non linear unit root test the critical values were obtained from a wild bootstrap simulation with 10,000 replications, which are available from the authors upon request. We also did a robustness test with constant and a trend, and none results robust and available upon request.

5. Conclusions

This study examines whether regional and nationally branching banks set retail interest rates distinctly? This question is examined for the UK which has regions which vary their industrial profiles, has established national and regional banks and faces distinct regional monetary policy challenges (DOW and MONTAGNOLI, 2007). It is reported that the transmission process from wholesale interest rates to retail interest rates is significantly slower for regionally branching banks relative to nationally branching banks. The mean reverting transmission process is encapsulated with the use of an ESTAR unit root test and displays interest rate asymmetry, where the speed of pass through is distinct during periods of whole rate decline and increase; an outcome consistent with regional banks operating under relatively distinct monetary policy conditions. The implication of this finding is consistent with the conjecture from DOW (1992), DOW and MONTAGNOLI (2007) and MACKAY (2003) that monetary policy requirements differ between regions.

The implications of this finding include depositors with regional banks will receive interest rates which are less responsive to wholesale interest rate changes. Therefore policy shifts encouraging the development of regional banking will come at a cost to depositors. More widely while we acknowledge it may be impossible to enact monetary policy to accommodate the demands of different regions (FRATANTONI and SCHUH 2003), it is important to both identify and quantify the degree of these regional disparities in monetary conditions, as these influence the aggregate outcome of monetary policy and need to be accommodated in policy making.

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Appendix 1: Banks used in the study

At least 25% of branches located in a region		
Wales	**Midlands**	**South East England**
Monmouthshire	Birmingham Midshires	Abbey National
Principality	Britannia	Bank of Cyprus
Northern Ireland	Buckinghamshire	Bank of Ireland (UK)
Bank of Ireland (NI)	Chesham	Barclays
City of Derry	Clay Cross	Bristol and West
First Trust bank	Coventry	Catholic
Northern Bank	Derbyshire	Chelsea
Progressive	Dudley	Coutts
Ulster bank	Earl Shilton	Halifax
Scotland	Hanley Economic	Harpenden
Bank of Scotland	Hinckley and Rugby	Holmesdale
Clydesdale	Leek United	Kent Reliance
Dunfermline	Loughborough	Lambeth
Royal Bank of Scotland	Mansfield	National Countries
Scottish	Market Harborough	Nationwide
Northern England and Yorkshire	Melton Mowbray	Natwest
Barnsley	Nottingham	Newbury
Beverly	Nottingham Imperial	Saffron Walden, Herts and Essex
Cumberland	Shepstead	Woolwich
Darlington	Stafford Railway	**National**
Ecology	Staffordshire	Alliance and Leicester
Leeds and Holbeck	Tipton and Cosely	Bradford and Bingley
Mercantile	West Bromwich	Co-operative
Newcastle	**South West England**	HFC
Northern Rock	Bath	HSBC
Scarborough	Bristol and West	Lloyds TSB
Skipton	Chelsea	Post Office
Universal	Cheltenham and Gloucester	
Yorkshire BS	Newbury	
Yorkshire bank	Portman	
North West England	Stroud and Swindon	
Cheshire	Teachers	
Chorley and district	**Eastern England**	
Furness	Cambridge	
Manchester	Ipswich	
Marsden	Norwich and Peterborough	
Vernon	Scarborough	
Skipton		

At least 50% of branches located in a region		
Wales	**Midlands**	**South East England**
Monmouthshire	Birmingham Midshires	Bank of Cyprus
Principality	Buckinghamshire	Bank of Ireland (UK)
Northern Ireland	Chesham	Catholic
Bank of Ireland (NI)	Clay Cross	Chelsea
City of Derry	Coventry	Harpenden
First Trust bank	Derbyshire	Holmesdale
Northern Bank	Dudley	Kent Reliance
Progressive	Earl Shilton	Lambeth
Ulster bank	Hanley Economic	National Countries
Scotland	Hinckley and Rugby	Saffron Walden, Herts and Essex
Bank of Scotland	Leek United	Woolwich
Clydesdale	Loughborough	**National**
Dunfermline	Mansfield	Abbey National
Royal Bank of Scotland	Market Harborough	Alliance and Leicester
Scottish	Melton Mowbray	Barclays
Northern England and Yorkshire	Nottingham	Bradford and Bingley
Barnsley	Nottingham Imperial	Britannia
Beverly	Shepstead	Cheltenham and Gloucester
Cumberland	Stafford Railway	Co-operative
Darlington	Staffordshire	Coutts
Ecology	Tipton and Cosely	Halifax
Leeds and Holbeck	West Bromwich	HFC
Mercantile	**South West England**	HSBC
Newcastle	Bath	Lloyds TSB
Northern Rock	Bristol and West	Natwest
Scarborough	Chelsea	Newbury
Skipton	Cheltenham and Gloucester	Post Office
Universal	Newbury	Yorkshire BS
Yorkshire bank	Portman	
North West England	Stroud and Swindon	
Cheshire	Teachers	
Chorley and district	**Eastern England**	
Furness	Cambridge	
Manchester	Ipswich	
Marsden	Norwich and Peterborough	
Vernon		

At least 75% of branches located in a region		
Wales	**Midlands**	**National**
Monmouthshire	Buckinghamshire	Abbey National
Principality	Chesham	Alliance and Leicester
Northern Ireland	Clay Cross	Bank of Ireland (UK)
Bank of Ireland (NI)	Coventry	Barclays
City of Derry	Derbyshire	Birmingham Midshires
First Trust bank	Dudley	Bradford and Bingley
Northern Bank	Earl Shilton	Bristol and West
Progressive	Hanley Economic	Britannia
Ulster bank	Hinckley and Rugby	Chelsea
Scotland	Leek United	Cheltenham and Gloucester
Bank of Scotland	Loughborough	Co-operative
Clydesdale	Mansfield	Coutts
Dunfermline	Market Harborough	Halifax
Scottish	Melton Mowbray	HFC
Northern England and Yorkshire	Nottingham	HSBC
Barnsley	Nottingham Imperial	Leeds and Holbeck
Beverly	Shepstead	Lloyds TSB
Cumberland	Stafford Railway	Nationwide
Darlington	Staffordshire	Natwest
Ecology	Tipton and Cosely	Newbury
Mercantile	West Bromwich	Northern Rock
Newcastle	**South East England**	Portman
Universal	Bank of Cyprus	Post Office
North West England	Catholic	RBOS
Cheshire	Harpenden	Scarborough
Chorley and district	Holmesdale	Skipton
Furness	Kent Reliance	Woolwich
Manchester	Lambeth	Yorkshire BS
Marsden	National Countries	Yorkshire bank
Vernon	Saffron Walden, Herts and Essex	
South West England	**Eastern England**	
Bath	Cambridge	
Stroud and Swindon	Ipswich	
Teachers	Norwich and Peterborough	