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Interest Rate Pass-through and pricing behaviour of financial products in UK financial industry and Interest Margin Determinants in EU countrie

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Interest Rate Pass-through and pricing behaviour of financial products in UK financial industry and Interest Margin Determinants in EU countries.

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A Thesis Submitted in Fulfilment of The Requirements for the Degree of Doctor of Philosophy

Supervised by

Professor John Goddard

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Declaration and Consent

Yr wyf drwy hyn yn datgan mai canlyniad fy ymchwil fy hun yw'r thesis hwn, ac eithrio lle nodir yn wahanol. Caiff ffynonellau eraill eu cydnabod gan droednodiadau yn rhoi cyfeiriadau eglur. Nid yw sylwedd y gwaith hwn wedi cael ei dderbyn o'r blaen ar gyfer unrhyw radd, ac nid yw'n cael ei gyflwyno ar yr un pryd mewn ymgeisiaeth am unrhyw radd oni bai ei fod, fel y cytunwyd gan y Brifysgol, am gymwysterau deuol cymeradwy.

I hereby declare that this thesis is the results of my own investigations, except where otherwise stated. All other sources are acknowledged by bibliographic references. This work has not previously been accepted in substance for any degree and is not being concurrently submitted in candidature for any degree unless, as agreed by the University, for approved dual awards.

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Abstract

The banking sector of the financial system plays an important role in an economy in transmitting the central bank's monetary policy stance. This thesis presents three papers that examine the importance of the IRPT mechanism, the validity of The Law of One Price and investigates the determinants of the interest rate margins.

First study uses a large sample of aggregated data to shed light on how bank retail rates for deposit, lending and mortgage products respond to changes in policy rates. The main goal of the study is to analyse the dynamic adjustment of UK bank and building society interest rates in response to policy rate changes. The study finds a very slow adjustment speed pre-crisis for both deposit and lending products but marginally complete for mortgage products, and it is heterogeneous across products. Long run pass through is incomplete for most products. Post-crisis, short sun adjustment Speed on all lending, mortgage and deposit products increases significantly. Average short run adjustment speed on deposit products is higher than on lending products.

Second paper investigates the stickiness of interest rate pass-through, level of competition, and the Law of One Price for three types of Financial Institutions (High street banks, building societies and Small banks) offering the same instant access savings and mid tier savings products. The average short run adjustment speed for the industry as a whole shows sluggish and sticky behaviour for low tier, mid tier and high tier instant access savings and mid tier savings accounts. The results verify that that price setting behaviour in the UK banking industry is not only sticky but also that inter-bank and intra-bank heterogeneities exist in the short- and long-run variables. Results show that heterogeneities for short run adjustment speed not only exist within different types of firm offering the same products, but also within the same firm offering different products.

Third paper investigates the determinants of lending margins for products for the five EU countries least affected and 4 EU countries most effected by the financial crisis,

pre and post-crisis. Focusing on bank structural factors, country level bank-specific characteristics, macroeconomic and monetary factors, the study considers whether there are differences in the determinants of lending margins before and after the crisis period. Study finds evidence that the lending margins have changed considerably post-crisis; unconventional monetary policy has been successful in kick starting the financial system; and the pass-through has improved in least affected countries post-crisis.

List of Abbreviations

2-YEAR FIXED RATE MORTGAGE	**2Y-FIX**
2-YEAR VARIABLE MORTGAGE	**2Y-VR**
3-YEAR FIXED RATE MORTGAGE	**3Y-FIX**
5-YEAR FIXED RATE MORTGAGE	**5Y-FIX**
AKAIKE INFORMATION CRITERIA	**AIC**
AUGMENTED DICKEY FULLER	**ADF**
AUTOREGRESSIVE DERIVATIVE LAGGED MODEL	**ARDL**
BANK OF ENGLAND	**BOE**
BANK OF ENGLAND RATE	**BOE RATE**
BUILDING SOCIETIES	**BS**
CASH ISA ACCOUNT	**ISA**
CENTRAL AFRICAN ECONOMIC AND MONETARY COMMUNITY	**CAEMC**
CENTRAL EAST EUROPEAN COUNTRIES	**CEE**
COMMON MONETARY AREA	**CMA**
COMPOSITE INDEX OF SYSTEM STRESS	**CISS**
CREDIT CARD LENDING	**CCL**
DIFFERENCE IN DIFFERENCE	**DID**
ERROR CORRECTION MODEL	**ECM**

EURO INTERBANK OFFERED RATE	**EURIBOR**
EUROPEAN CENTRAL BANK	**ECB**
EUROPEAN MONETARY UNION	**EMU**
EUROPEAN UNION	**EU**
FINANCIAL INSTITUTIONS	**FIs**
FIXED RATE BOND	**BOND**
GROSS DOMESTIC PRODUCT	**GDP**
HIGH STREET BANKS	**HSB**
HIGH TIER	**HT**
HOUSE HOLDS	**HHs**
INDUSTRY	**IND**
INSTAN ACCESS SAVINGS	**IAS**
INSTANT ACCESS ACCOUNT	**INSTANT**
IRPT	**IRPT**
LONDON INTERBANK OFFER RATE	**LIBOR**
LONG RUN EQUILIBRIUM RATE	**LRER**
LONG RUN PASS-THROUGH	**LRPT**
LOW TIER	**LT**
MARGINAL COST	**MC**
MARGINAL REVENUE	**MR**

MEDIUM TERM SAVINGS	**MTS**
MID TIER	**MT**
MONETARY FINANCIAL INSTITUTIONS	**MFIs**
MONETARY POLICY COMMITTEE	**MPC**
OVERDRAFT	**OD**
PERSONAL LOAN 10K	**10K**
POLICY RATE	**PR**
QUANTITATIVE EASING	**QE**
RETAIL PRICE INDEX	**RPI**
SCHWARTZ INFORMATION CRITERIA	**SIC**
SHORT RUN ADJUSTMENT SPEED	**SRAS**
SMALL BANKS	**SB**
SOUTHERN AFRICAN CUSTOMS UNION	**SACU**
SOUTHERN AFRICAN DEVELOPING COUNTRIES	**SADC**
STANDARD VARIABLE RATE MORTGAGE	**ST-VR**
STATISTICAL DATA WAREHOUSE	**SDW**
THE CONSUMER PRICE INDEX	**CPI**
TIME DEPOSITS	**TIME**
TRACKER MORTGAGE	**TR**
UNRESTRICTED ERROR CORRECTION METHOD	**UECM**

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1 INTRODUCTION

1.1 Background and Motivation for the Study

Monetary policy transmission has several channels: interest rate, bank lending, balance sheet, asset pricing, exchange rate, and expectation. Through these channels, the monetary policy stance of the central bank is transmitted to the rest of the economy. While research theory offers a wide range of channels, this study considers the traditional interest rate channel, which is considered the first stage in the transmission process and the most important channel (Baugnet et al., 2007: p2; Ozdemir, 2009: p8; Wang and Lee, 2009; Samba and Yan, 2010).

The banking sector of the financial system plays an important role in an economy in transmitting the central bank's monetary policy stance. A well-functioning and healthy banking sector contributes to the growth of the economy, welfare provision and smooth business cycles. Commercial Banks act as intermediaries, through which changes in monetary policy are transmitted from the central bank to the rest of the economy. This process is called the *Interest Rate Pass-Through* (IRPT). By implication, banks' activities and their position as intermediaries make them vital in the IRPT transmission process (Fuentes and Ahumada, 2003: p1).

IRPT can have short- and long-run dynamics. Short-run dynamics are also known as the short-run adjustment speed (SRAS); a slower speed means that retail rates are sticky to respond to a change in the policy rate. Long-run pass-through (LRPT) represents the degree of competition in financial markets. *LRPT* should ideally be equal to 1, which represents an efficient monetary policy system and perfect competition. Greater competition leads to greater integration in the market. Most of the studies of IRPT find a complete *LRPT* and a faster adjustment speed in the short-term in advanced economies. However, IRPT in the short-run is sticky and *LRPT* incomplete in the majority of emerging and developing economies, as well as some developed economies. In general, the developed countries have higher and relatively complete pass-through compared to developing and emerging economies in the short-

and long-run. The stickiness of retail interest rates with respect to changes in the policy interest rate has been a serious impediment to the smooth transmission of monetary policy impulses to the rest of the economy. Therefore, it is important for central banks and policy makers to have a comprehensive understanding of the nature of the of IRPT and the determinants of the interest rate price settings of financial products, since this can have important implications, not only for monetary policy, but to keep track of the level of competition and soundness of the financial system (Aydin, 2007: p1; Aziakpono and Wilson, 2010: p3).

As mentioned above, the key aspect of the success of the monetary policy interest rate channel is the speed at which changes in policy rate (PR) are transmitted to the retail deposit and lending rates of commercial banks. Hence, the effectiveness of the monetary policy largely depends on how commercial banks change their lending and deposit rates following changes in the central bank's PR. Effective monetary policy is crucial for the stabilization of inflation and other economic activities. If it is to be effective, changes in the PR should be transmitted to other interest rates quickly, and the magnitude of the change in the short term should be large enough to influence investment, consumption and aggregate demand in the economy (Aziakpono and Wilson, 2010, p. 3). According to Fuentes and Ahumada (2003: p1), monetary policy is effective through the interest rate channel when the central bank's adjustments to short-term interest rates have an impact on the retail interest rates that commercial banks charge their customers. The changes in retail rates ultimately affect investment and consumption in the economy. The interest rate channel is effective if commercial banks quickly transmit PR changes to their customers. However, if transmission is not immediate, the channel is ineffective. This scenario is also referred sometimes as the lag or stickiness in retail rate responses to a change in base rate. Overall, the effectiveness of monetary policy largely depends on the speed of transfer following a change in PR and the magnitude of the adjustment applied by commercial banks to their deposit and lending rates.

It is also important to understand whether the pass-through dynamics for different types of financial products are different or the same. Ideally, banks should make the

adjustment to all their financial products at the same time. It is also necessary to understand whether different types of institution make price adjustments at the same time or whether the retail rate adjustment is different in different types of firm. If there are signs of convergence in the pricing behaviour of different banks for the same product, it suggests the existence of *The Law of One Price* and integration in the financial market. These are relevant questions for the monetary policy perspective. Understanding the behaviour of different types of firm is important for successful monetary policy transmission.

Another key question concerns the determinants that affect the pricing of financial products. According to Bernanke and Gertler (1995), these are still a black box, meaning the transmission process and the determinants of pricing remain unclear. If the factors that determine the price settings can be identified, it could help facilitate and strengthen the monetary policy process. Although literature in this area is limited, studies have suggested several different factors that may affect commercial banks' pricing decisions. Among these are: the degree of competition amongst financial intermediaries (Cottarelli and Kourelis, 1994); stages of financial market development, concentration within the banking sector, and the degree of financial market openness (Cottarelli and Kourelis, 1994; Borio and Fritz, 1995; Mojon, 2000; Weth, 2002); asymmetric information (Stiglitz and Weiss, 1981); menu cost (Rotemberg and Saloner, 1987; Hannan and Berger, 1991; Hofman and Mizen, 2004); switching cost (Fried and Howitt, 1980; Ausubel, 1991; Cottarelli, Ferri and Generale,1995; Angeloni et al., 1995; Berlin and Mester, 1997); adverse selection (Lowe and Rohling, 1992).

1.2 Research Questions

This thesis presents three papers that examine the importance of the IRPT mechanism, the validity of *The Law of One Price* and investigates the determinants of the interest rate margins.

In first paper a large sample of aggregated data is used to shed light on how bank retail rates for deposits, lending and mortgage products respond to changes in PR. The main goal of the study is to analyse the dynamic adjustment of UK banks' and building societies' interest rates in response to PR changes.

The specific research questions addressed in this paper are as follows:

- How complete and homogeneous is the UK monetary policy transmission mechanism before and after the financial crisis for deposit, lending and mortgage products?
- How long does it take for the changes to be transmitted to deposit, lending and mortgage rates following a change in the PR?
- How complete and homogeneous is the competition prevailing in the financial market for different types of financial products?
- How do banks price different financial products in the markets by examining the mark-up/-down?

In the second paper, a large sample of disaggregated data is used to analyse the dynamic adjustment of savings interest rates by different types of UK firm (high street banks, building societies and small banks) in response to changes in the PR. It also investigates the existence of heterogeneous behaviour in interest rate settings among different types of firm to discover whether the Law of One Price exists in the UK Saving accounts market.

The research questions of this paper are as follows:

- Do inter-bank heterogeneities in SRAS and competition exist for IAS and MTS accounts exist among firms (which type of firm is more efficient; which firm has the highest competition for IAS and MTS accounts?)?
- Do inter-bank heterogeneities exist among firms for mark-up/down for IAS and MTS accounts? (Does the *Law of One Price* exists in UK market)
- Do intra-bank heterogeneities exist for *SRAS* and competition (tier effect) exist within firm itself for adjustment speed for IAS and MTS accounts? (Difference in adjustment speed and competition in the same firm type and product, but among different deposit tiers?)

Finally, the third uses a large sample of data for MFIs for the nine EU countries; five least affected and four most affected by the financial crisis to investigate the determinants of lending margins for Households. The main research question is: *What are the determinants of bank lending margins?* Accordingly, the study explores the following questions:

- How do various market structure, macroeconomic, monetary and bank-specific variables at country level impact lending margins?
- Have the determinants changed post-crisis?
- Are the determinants of lending margins for the least stressed and most stressed countries different?

1.3 Main contributions

Past studies conducted on the UK banking market on the interest rate pass-through mostly used one or two products only. For example, study of Becker et al. (2012) analyses only mortgage rates, and Panagopoulos, Reziti, & Spiliotis (2007) consider only deposit and loan rates ; similarly Hofmann & Mizen (2004) cover deposit and mortgage rates only. In terms of structure, the UK financial sector has undergone major changes in terms of competition and ownership, including entry of foreign banks and a large number of mergers and acquisitions. It is expected that these changes will have impact on competition, which will in turn affect the IRPT.

In light of the above, the first study extends the previous work in three aspects. First, it examines the short-run and long-run dynamics of adjustment of 13 retail rates for mortgage, lending and deposit products (6 mortgage, 3 lending and 4 deposit products) to changes in the official rate, thereby extending the number of retail rates covered in previous studies. Second, the study seeks to identify changes in the behaviour of UK banks in setting their retail rates—because the study uses a sample of data set that covers longer period of time (1999:M01—2012:M04). Third, the present study includes data since the financial crisis, and this helps analyse any changes in retail rate pass-through arising from the MPC's lowering of the official rate to 0.5 percent.

The second study uses disaggregated interest rate data at the bank level for UK savings accounts. There are very few studies conducted on interest rate transmission in the UK financial market that use disaggregated data. Those studies that use this type of data are also confined to very few firms, products and cover a very small observation period. To the author's best knowledge, only four studies have been conducted using disaggregated data for the UK (namely: Hefferman, 1997; Hofmann & Mizen, 2004; Ashton, 2007; Fuertes & Heffernan, 2009). The current study is, therefore, the first to cover an extended period and a wider range of products.

This study contributes to the literature in three ways. First, by using a large sample of disaggregated data it identifies how individual financial institutions react to changes in the Bank of England (BoE) PR, in contrast to previous studies that rely on

aggregated data. Second, using disaggregated data, the study analyses short- and long-run dynamics for retail rates. Third, by grouping the individual estimates by Financial Institution (FI) type (high street bank, building society and small bank) this study is the first to formally test the inter-bank (among different firms) and intra-bank (within the same firm) heterogeneities in the short- and long-run dynamics for savings accounts.

In the third study uses a large sample of aggregated data for MFIs for the nine EU countries; five least affected and four most affected by the financial crisis to investigate the determinants of lending margins pre- and post-crisis. In the aftermath of financial crisis the EU banking sector has gone through several structural, macroeconomic and monetary policy changes.

The study adds to the literature in following ways: First, we use a large sample harmonised data set for the period of 2003 to 2017. Second, we deepen the understanding of the determinants by looking at the two groups of countries; least affected and most affected by crisis. Third, our study deepens our understanding the differences in determinants in post crisis period for the least affected and most affected countries of EU. If we know the factors that determine or influence the pricing of the interest rate price settings, it can help smoothen and strengthen the monetary policy process.

1.4 Data collection and Methodology

For the three studies undertaken three different methodological approaches were used to answer the research questions.

For the first study, aggregated monthly data for banks and building societies is collected from the BoE website for the period January1999 to April 2012 for 13 mortgage, lending and deposit products. These comprise four deposit, six mortgage, and three lending products. The six mortgage products are Tracker Mortgage to

Household (TR), 2-Year Fixed Rate Mortgage (2Y-FIX), 3-Year Fixed Rate Mortgage (3Y-FIX), 5-Year Fixed Rate Mortgage (5Y-FIX), 2-Year Variable Mortgage (2Y-VR), and Standard Variable Rate Mortgage (ST-VR). The three lending products are Credit Card Lending (CCL), Personal Loan 10K (10K) and Overdraft (OD). The four deposit products are Instant Access Accounts (INSTANT), fixed rate bond deposit (BOND), Cash ISA Account (ISA) and Time Deposits (TIME).

The second study uses disaggregated UK savings data offered by UK financial institutions for the period of January 1999 to December 2011. Data is collected from Moneyfacts, a company that collects and publishes interest rate data for UK financial institutions. Unbalanced panel bank level data is collected on a monthly basis. Using disaggregated data allows its classification into three groups on the basis of the type of firm: high street bank (HSB), building society (BS) and small bank (SB). The sample consists of a total of 78 banks and building societies: 9 HSBs, 52 BSs and 17 SBs.

For savings accounts, there are two main product categories: Instant Access Savings (IAS) and Mid-Term Savings (MTS). IAS accounts are those for which no notice period is required to withdraw savings. The IAS product is further classified into seven tiers, according to deposit levels: 1K, 2.5K, 5K, 10K, 25K, 50K and 100K. In total, therefore, seven IAS accounts are used in the analysis, namely: 1K-IAS, 2.5K-IAS, 5K-IAS, 10K-IAS, 25K-IAS, 50K-IAS and 100K-IAS.

MTS accounts are those for which 30 to 90 days of notice are required to withdraw money. As the interest rate paid on savings accounts changes with the amount of funds deposited, MTS accounts are classified into seven representative deposit levels:1K, 2.5K, 5K, 10K, 25K, 50K and 100K. This gives rise to a total of seven deposit tiers for MTS accounts, namely: 1K-MTS, 2.5K-MTS, 5K-MTS, 10K-MTS, 25K-MTS, 50K-MTS and 100K-MTS. These tiers are grouped into three main deposit levels; Low-tier (LT), Mid-tier (MT) and High-tier (HT). We class 1K-IAS and 2.5K-IAS as Low-tier accounts, 5K-IAS and 10K-IAS as Mid-tier and 25K-IAS, 50K-IAS AND 100K-IAS as High-tier accounts in order to investigate any associated tier effects.

The third study uses aggregated monthly lending margin data for Monetary Financial Institutions (MFIs) for the period January 2003 to October 2017 for nine EU countries. Data comprises two dependant variables: lending margins for households *(HHs*). In total, we collect data for 12 independent variables: *diversification, capitalization, liquidity risk, credit risk, interest-rate risk, market share, Herfisham Herfindahl Index (HHI), inflation, GDP, financial deepening, Euro Interbank Offered Rate (Euribor) and base money.*

The first two studies use the autoregressive derivative lagged (ARDL) testing approach to co-integration, also known as the Bounds approach (Pesaran, Shin, and Smith, 2001). This involves an autoregressive distributed lagged model, which analyses the short- and long-run dynamics of retail rate pass-through. The Wald Bounds test is used to find the long-run equilibrium rate and co-integration.

This methodology is used for the following reasons. First, the use of the ARDL approach to co-integration allows for dealing with the presence of I (0), I (1) or mutually co-integrated regressors. This is in contrast to Engle and Granger's (1987) and Johansen's (1988) procedures, which require the presence of I (1) series. The ARDL approach has the advantage of avoiding the pre-testing problems linked to the performance of unit root tests (Pesaran et al., 2001). Thus, there is no need to run unit root tests on all of the series individually before testing the series for co-integration. Second, in contrast to the two-step Engle and Granger approach, the Bounds approach relies on a single equation, the *unrestricted error-correction model* (UECM, Pesaran et al., 2001). Another reason for using this approach is that it is more appropriate for small samples than Engle and Granger's and Johansen's co-integration techniques (Pattichis 1999; Narayan and Peng 2007; Ozturk and Acarav 2010). Finally, the ARDL approach allows the selection of the lag structure of the UECM, thus enabling the choice of a different number of lags for the variables of the model. This is in contrast with other econometric procedures (Ozturk and Acarav 2010), and facilitates the capture of the short- and long-run dynamics of interest rates. It is useful for estimating the short- and long-term effects of one series on another time series. Using these models, it is possible to evaluate the short-term effects of changes in PR on retail

interest rates, long-term effects of changes in PR on retail rates (that is, the long-run multiplier), and the speed at which retail rates return to equilibrium after any deviation has occurred.

In the first paper, homogeneity and integration among different financial products are investigated, using aggregated data for the UK banking industry. We derive further measures of competition and mark-up to shed light on the type of competition for different products and the pricing pattern of different financial products.

In the second paper, the same methodology is applied to capture the short- and long-run parameters for the same deposit products offered by small banks, building societies and the high street banks. However, mean difference t-tests are used to identify homogeneities in the *SRAS*, competition and mark-up prices for all three types of firm.

In the third paper, difference in difference regression model is employed to identify the determinants of interest rate margins for household lending products offered by the 4 most stressed and five least stressed EU countries. This model has been employed to see the difference pre- and post-crisis for in lending margins determinants. Macro-economic s, structural, monetary and variables and country level bank specific are selected as potential determinants. The data has been collected from the ECB website.

1.5 Key Findings

In first paper, the key findings are as follows. First, there is a very slow adjustment speed pre-crisis for both deposit and lending products, and the speed is heterogeneous across products. While *LRPT* is incomplete for most of the products, it is partially higher for TR, 2Y-VR and ST-VR products. Moreover, it is higher than expected for CCL, 10K and OD, which could be explained by asymmetric information costs without rationing (de Bondt, 2005). Pass-through is complete for TIME, however, suggesting perfect competition. It is also higher than expected for ISA, suggesting the availability of substitute products and indicating a high level of competition in the market.

Post-crisis, it appears that the adjustment speed for all lending and deposit products increases significantly, with average speeds for deposit products higher than lending products. In addition, post-crisis the pass-through for lending products decreases, whereas it increases significantly for deposit products. We also conclude that margins on lending products increase post-crisis. Traditionally banks pay lower interest rates on deposit products, but post-crisis banks pay higher interest rates than LIBORs.

The key findings from the second paper are as follows. The average *SRAS* on industry, for Low-tier, Mid-tier and High-tier accounts is sluggish and sticky for IAS and MTS accounts. The results verify that price setting behavior in the UK banking industry is not only sticky, but also inter-bank and intra-bank heterogeneities exist for short- as well as long-run variables. In addition, heterogeneities for γ not only exist within different types of firm offering the same products, but also within the same firm offering different products. Moreover, the results of t-tests for intra-bank heterogeneities find that γ is significantly lower for Low-tier products compared to High-tier products in the industry for IAS and MTS accounts. This is known as the *tier effect*. The results also suggest that *SRAS* for HSB is above the industry average for IAS and MTS on all deposit tiers. On the other hand, *SRAS* is lowest for SB on both products. Results for *LRPT* for all IAS deposit tiers reveal that the accounts which have higher Ci also have higher Ai and γ. An increasing trend is found for Ci in the

industry with increase in tier size on both products. The study finds that SB have the highest Ci on both products and HSB the lowest. Results indicate an increasing trend in mark-up for HSB, BS and SB and the industry with increases in tier size for both IAS and MTS products. Ai is found to be different on all deposit tiers within the same type of firm. However, t-test results for intra-bank heterogeneity do not detect any significant differences among tiers within the same firm type. The inter-bank results for mark-up shows clearly that HSB charge significantly higher mark-ups on low-, mid- and high tier IAS and MTS which, also significant differences in mark-up exist between SBs and BSs which implies that the Law of One Price does not exist in the UK market for IAS and MTS products.

Key findings for the third paper are as follows: Results conclude that post crisis determinants of lending margins have changed.The study finds that least affected countries follow Euro Interbank Offered Rate (*Euribor*) more closely and we find that the pass-through is almost complete and evidence of improved pass-though is found for lending margins during 2008-2017. However, results indicate that the most affected countries don't really follow *Euribor* rate strictly and we found pass-through coefficients insignificant. Evidence is found for both least and most affected countries that unconventional monetary policy is successful in increasing the demands of lending activities; as a result raising the lending margins. We find, therefore, that post-crisis the ECBs non-conventional monetary policy does have a positive effect on lending margins for *HHs*. Study also finds that in the case of least affected countries macroeconomic variables (*inflation*, *GDP*) are insignificant but highly significant post-crisis. Increase in the effectiveness of structural, macroeconomic and monetary policy variable is noted. Similar results are found for most affected countries that the effect size of coefficients for macroeconomic and structural variables have increased post-crisis.

1.6 Structure of the study

The thesis is divided into six chapters. Chapter 1 is the Introduction, which presents the motivation, objectives, data and methodology, key findings, and structure of the

thesis. Chapter 2 reviews the relevant literature, including theoretical perspectives and the mechanics of the tests used in the study. Chapters 3, 4 and 5 present the first, second and third papers, respectively. Finally, Chapter 6, the Conclusion, presents the key findings, contributions and limitations of the study.

2 REVIEW OF THE RELEVENT THEORIES AND LITERATURE

2.1 Introduction

Due to the importance of IRPT and the determinants of price setting for monetary policy, many studies have attempted to investigate, understand and answer questions related to the mechanism and its determinants. This chapter presents a review of the relevant theories and literature on IRPT. It also presents the mechanics of the tests used in the study's papers. The rest of the chapter is structured as follows: Section 2.2 describes the evolution of the Mark-up Pricing Theory. Section 2.3 presents a brief overview of theories on interest rate stickiness and the determinants of the IRPT. Section 2.4 provides the variable definitions of IRPT. Section 2.5.1 presents introduction to relevant literature, while Section 2.5.2 presents literature on IRPT rigidity, stickiness and heterogeneities. Section 2.5.3 examines studies that investigate integration, competition and the Law of One Price in the market. Section **Error! Reference source not found.** presents the studies on the determinants on of price settings of financial products offered by the commercial banks.

2.2 Evolution of Mark-up Pricing Theory

This section aims to critically assess various theories and models of how banks set their retail rates.

2.2.1 Rousseas's (1985) Mark-up Pricing Theory (Market Power)

One of the main formal theories of how banks set their retail rates was developed by Rousseas (1985). The author developed a mark-up pricing model for a non-perfect competitive banking sector, since it is argued that banks exhibit some degree of market power (oligopolist market) because the typical retail market is "...dominated by a few large banks of national and international character" (Rousseas, 1985, p.136). Hence, a starting argument of Rousseas is that banks in the loan market are price setters that set their retail interest rates as a mark-up (profit margin) over their prime costs, expressed as follows:

$$i = k\ (u)$$

where, i is the interest rate on loans, u represents the unit prime or variable costs and k is the mark-up or the profit margin over the variable costs. The profit margin is determined by the market power acquired by the bank(s) such that in less competitive markets, where banks exhibit greater market power, the mark-up (profit margin) will be higher. The prime or variable costs are composed of labour costs and "raw materials". In the case of the banking sector, according to Rousseas (1985), labour costs are taken as fixed because, unlike manufacturing firms, the number of employees does not vary much with the level of financial activities. Therefore, banks' variations in prime costs are mainly due to the variations in the "raw material" component, which represents the cost of funding their lending activities (cost of funds). This comprises the interest rates that banks pay on deposits, interest rates on their borrowing in the money market, and other costs. For example, in the case of the US, those other costs partly reflect the costs arising from the required reserves that banks must hold at the Federal Reserve and the insurance fees on deposits that they are obliged to pay to the Federal Deposit Insurance Corporation.

Rousseas's (1985) model assumes that the cost of funds rates, represented mainly by the funds raised in the money market, are exogenously determined because banks in these market segments are price takers due to the relatively high level of competitiveness. However, this is not the case for the retail market. Thus, Rousseas argues that changes in the lending rates are mainly determined by changes in the 'cost of funds' because the profit margin is taken to be constant over the business cycle. However, this assumption may not always coincide with reality because the model assumes that the banking environment and banks' financial characteristics are static over time. According to other modifications of the model (Allen, 1988; Angbazo, 1997), it is argued that some of these factors may affect the mark-up margin.

Rousseas's (1985) argument for constant mark-up pricing over time is empirically supported in the paper. The main hypothesis is that changes in the representative loan interest rate (in this case, the prime rate) should follow the changes in the 'cost of funds' rate (proxied by the Federal Funds Rate (FFR), while the interest rate margin, indicating the mark-up between the two, should be constant. By analysing the interest rate fluctuations and spreads during the period 1955 to 1984, Rousseas's (1985) found that changes in the prime rate coincide with the changes in the FFR and, in general, the interest rate spread was constant with small fluctuations, except for the periods of 1955-64, 1973-76 and 1982-83. The reasons for the fluctuations in the first two periods are interpreted as a consequence of exogenous factors, such as post-war recovery and oil shocks.

The fluctuations in the last period are attributed to changes in the US monetary policy, such as the shift from interest rate to money supply targeting and the abandonment of the Regulation Q. An additional reason proposed for the sharp increase in the spread in the last period is the tendency for increased loan riskiness, in response to which banks increased their profit margins in order to compensate for the increased probability of borrowers defaulting. With this explanation, Rousseas implicitly introduces another factor that may affect the mark-up margin, that is the riskiness of loans. However, these interpretations of variations in the spread are mainly based on

descriptive statistics and not on more sophisticated statistical methods that may provide different conclusions.

A direct criticism of Rousseas's (1985) empirical work is provided by Niggle (1987), who argues that the selection of both representative rates, the prime rate and the FFR, as representative of loan and cost of funds rates respectively, may not be appropriate, especially after the late 1970s. The reason why the prime rate may not be taken as the representative loan rate is that interest rates on small loans in the US (up $1 million), as well as rates on loans higher than 1 million US Dollars, have been set on a prime-plus basis, mainly based on short-term money market rates, such as 90-day Certificate of Deposits (CDs), the London Interbank Offer Rate, or prime commercial paper rate. Therefore, the loan rates on small and large loans have almost always been below the prime rate. On that basis, Niggle (1987) also argues that the FFR is no longer the best representative cost of funds rate because banks use various money market rates with different maturities as the 'cost of funds' rates when setting their loan rates. Consequently, Roussea's conclusions of a constant mark-up over the business cycle may be misleading because they are based on inappropriate representative loan and 'cost of funds' rates.

In addition, Laudadio (1987) criticises Rousseas's view on the basis that not all loan markets are oligopolistic, and thus the mark-up may not be stable in various segments on the loan market. For example, Laudadio argues that the market for large short-term loans in the USA is highly competitive because the demand side is dominated by large well-known corporations with large assets which have other available options for external finance, while the supply side is represented by a large number of domestic and international banks. This leads to competitive pricing by the banks, which set the mark-up as low as possible in order to attract more borrowers. In contrast, the loan market for small short-term loans in the USA is characterised by an oligopolistic structure because on the supply side there are small local banks whose number is limited and thus have relatively high market power. The demand side is dominated by small firms with limited assets whose banks' loans are their major source of external finance. Hence, due to their acquired market power, local banks may set a higher mark-

up. However, even in this case, Laudadio argues that the mark-up is not seen as stable because it may be determined by other factors such as switching costs and the existence of customer relations with banks.

The main weakness of Rousseas's (1985) theory is related to the argument that variations in banks' retail interest rates are mainly determined by the variations in the 'cost of funds' rate, without specifying the extent to which those variations are transmitted. Another possible weakness of this model is that it lacks consistency in explaining how the mark-up margin is set and whether it can be defined as a constant proportion of the 'cost of funds' rate or, as Rousseas argues in his empirical work, it is a constant in absolute terms.

2.2.2 Ho and Saunders' (1981) Dealership Model

Ho and Saunders (1981) present a comprehensive model known as the Dealership Model. The main contribution of this model, known as a static one-period decision model, is that it clearly defines how the mark-up margin is determined. In this model, the loans and deposits are taken as a single product with the same maturity. The hypothesis presented by the authors is that banks exhibit some kind of market power and act as risk averse intermediaries (dealers) between the suppliers of funds (depositors) and those who require funds (borrowers). The model works under the two assumptions: first, loan demand and deposit supply are exogenously determined; second, changes in these quantities are not synchronised. Thus, new deposit arrivals and/or new loan demands are unforeseen by banks, which try to match the new deposits with the new loan demands by lending and/or borrowing on the money market. This incurs interest rate risk, arising from reinvestment and refinancing.

Banks borrow in the money market when they have a higher loan demand compared to the deposit supply. This borrowing addresses the insufficient deposit supply but increases their refinancing risk. In the case where banks have a new deposit supply but insufficient new loan demand, they have to place their deposits in the money market. This increases their reinvestment risk. Due to these risks, banks adjust their mark-up

margin as a hedging instrument against the interest rate risks they face in the money market in order to maximise their utility.

According to this model, the prices of loans (P_l) and deposits (P_d) are inversely related to loan and deposit retail interest rates.

According to this model, the prices of loans (P_l) and deposits (P_d) are inversely related to loan and deposit retail interest rates. p_l and p_d are defined as follows:

Equation 2-1

$$p_l = p - b$$

Equation 2-2

$$p_d = p + a$$

where p_l and p_d are the prices of loan and deposits, and *xl* and *xd* are the retail rates on loans and deposits. *p* is the so-called "true" or "pure" price of loans and deposits; *b* and *a* are fees charged by the bank for the provision of their financial services to the borrowers and depositors, respectively. It is assumed that p_l and p_d are set at the beginning of the period and remain unchanged over the rest of the period. Consequently, the interest rate spread (the mark-up margin = *s*) between the loan and deposit rate is a sum of the two fees ($s = a + b$). By manipulating these fees, banks may actually affect the loan demand λ_b and deposit supply λ_a, and consequently may establish mark-up margins that will protect them from the interest rate risks they face on financial markets. For example, in the case where banks face higher deposit inflow than loan demand, then they may increase fee *a*, which will increase the price of deposits which reduces the deposit interest rate and discourage further new deposit supply. On the other hand, banks may also react by reducing fee *b, which* will increase the price of loans which decreases loan interest rates and stimulate new borrowing on the loan market.

The new deposit supply λ_a and a new loan demand λ_b depends on the respective sizes of the two fees, *a* and *b*. Ho and Saunders (1981) assume a symmetric and linear supply of deposit and demand for the loan functions, giving Equation 2-3.

$$\lambda_a = \alpha + \beta a \qquad \text{Equation 2-3}$$

$$\lambda_b = \alpha + \beta b \qquad \text{Equation 2-4}$$

where a and b are the fees on deposits and loans. Ho and Saunders (1981) argue that banks simultaneously change the two fees, depending on the supply and demand of funds on the loan market. Similar to Rousseas (1985), they argue that banks set their lending rates on a mark-up margin higher than the 'cost of funds' rate (the money market rate), where the mark-up margin is determined in absolute terms by the banks.

The equilibrium bank interest margin can be specified by Equation 2-5.

$$s = a + b = \frac{\alpha}{\beta} + \frac{1}{2} R \sigma_1^2 Q \qquad \text{Equation 2-5}$$

The first term $\frac{\alpha}{\beta}$ is a measure of the "risk neutral spread", the spread that would be chosen by a risk neutral bank. It is the ratio of the intercept α to slope β of the symmetric deposit and loan arrival probability functions. Ho and Saunders (1981) interpret this first term as a measure of market power, since if a bank faces relatively inelastic demand and supply functions in the two markets, it exercises market power by charging a greater spread. The second term is a measure of risk premium and reflects three elements, namely the coefficient of absolute risk aversion R, the variance of the interest rate on net credit inventories σ_1^2, and the size of the deposit/loan transaction Q. This implies that, all things being equal, the higher the degree of risk aversion, the larger the size of transactions and greater the variances of interest rates and bank margins.

To control for the effects of these factors, Ho and Saunders (1981) develop a two- step regression model. In the first regression, a "pure interest margin" is derived by controlling for the factors that influence the net interest margins of an individual bank. The size of this margin, which is assumed to be universal across banks, is found to be a function of four variables: the degree of managerial risk aversion, average transaction size, competition within the banking market, and variability of interest rates. They argue that positive margins will tend to exist, even in a world of highly competitive banking markets, as long as transaction uncertainty is present.

Ho and Saunders (1981) further identify the size of this pure margin using quarterly income and balance sheet data for a sample of large commercial banks. They estimate the pure transaction margin or spread for this group of banks for each quarter. Using these estimated spreads as a time series, the validity of the theoretical model is tested by examining the empirical relationship between the derived pure spreads and measures of interest rate volatility and market structure. They find that the spread is positively related to the variance in the rate on bonds. The study also finds that smaller banks have an average spread of approximately 0.33% more than larger banks. Statistical tests conclude that this difference is largely due to market structure rather than risk aversion and transaction size.

There are two main empirical approaches used to estimate the theoretical model of Ho and Saunders (1981) and its subsequent extensions. First, in Ho and Saunders (1981) and Saunders and Schumacher (2000) the empirical estimation of the determinants of interest margins follows a two-stage process. In the first step, a regression of net interest margin is estimated for a cross-section of banks on bank specific variables, such as the ratio of non-interest bearing assets to total assets, the ratio of non-performing loans to total loans, and capital asset ratios. The constant term in these regressions is a measure of the "pure" spread for the country's financial system; that is, the portion of the spread that cannot be explained by bank-specific characteristics. In a second step, the constant term captures the effect of market structure on the determination of the "pure" spread; that is, the portion of the spread that cannot be attributed either to bank-specific characteristics or macroeconomic factors.

The alternative approach to estimating the model, as outlined in McShane and Sharpe (1985), Allen (1988), Angbazo (1997), and Guevara et al. (2005), involves a single stage. The net interest margins are nested within an empirical specification that also includes bank-specific characteristics as determinants of observed net interest margins. Other studies extend this by including the explanation interest margins, both variables derived from the theoretical model and additional variables (or imperfections) that reflect other aspects not incorporated into the modeling the "pure margin".

Ho and Saunders (1981) mark-up pricing model was amended by Allen (1988) and Angbazo (1997), who consider some additional important factors that affect the mark-up margin. Allen (1988) abandons the assumption of equal maturity of loans and deposits (the single product assumption), and argues that another important factor in setting the mark-up margin is the cross-product diversification of loans and deposits in respect to their maturity. According to Allen (1988), banks actually try to match deposits and loans with similar maturities in order to minimise the interest-rate risk. For example, when the coverage ratio of long-term loans to long-term deposits is higher, then interest rate risks and thus the mark-up margin will be lower. The reason for this is that banks are less likely to have to borrow more money in the money market in order to satisfy the long-term loan demand.

Angbazo (1997) considers another additional factor that may affect the mark-up margin: the borrowers' default risk. Accordingly, those banks that have a higher default risk set a higher mark-up margin in order to compensate for the expected higher default losses.

Overall, within the mark-up margin theory there is inconsistency in specifying whether the margin is constant through time and, if so, whether it is constant in absolute or in relative terms. For example, Rousseas's (1985) empirical findings suggest that banks keep their mark-up margin constant in absolute terms over time. However, he also argues that it may vary in some periods due to the increased riskiness of bank loans and/or disturbances by some regulatory requirement changes. In contrast, Laudadio

(1987) argues that the mark-up margin varies according to the market segment in which banks operate and the level of market power that banks have. Ho and Saunders (1985) argue that banks adjust their mark-up margin according to the interest risk they face and that the macroeconomic environment (aggregate demand) may affect the size of adjustment. In their empirical examination, they argue that the risk neutral mark-up margin (when there are no interest rate risks on the financial market) is constant in absolute terms. As the mark-up pricing model, has been modified through time, Allen (1988) suggests that the bank mark-up margin is determined by the stability of the sources of financing loans, that is, their coverage of long-term loans with long-term deposits, and is also seen to vary through time in relative terms. Angbazo (1997) argues that the mark-up margin is additionally determined by the level of riskiness of the loan portfolio, which may also affect the size of the pass-through.

2.2.3 De Bondt (2005) Mark-up pricing Model

Based on the mark-up pricing models of Ho and Saunders (1981) and Rousseas (1985), de Bondt (2005) defines retail rate setting using the following equation:

$$i = \beta_1 + \beta_2 u$$ Equation 2-6

where *i* is bank retail rate (deposit or loan rate), β_1 is the constant mark-up in absolute terms, *u* is the cost of funds rate, and β_2 represents the demand elasticity of deposits or loans, in respect of deposit (loan) interest rates, respectively; that is, the size of the pass-through coefficient. According to this equation, variations in retail rates are determined by variations in the cost of funds rate, but the extent to which those variations are transmitted to bank retail rates depends upon the size of the β_2 coefficient, which may vary. It can be less than one, implying an incomplete pass-through from the cost of funds rate to bank retail rates; if it is equal to one, this represents complete pass-through.

After Ho and Saunders (1981) and Rousseas (1985) established the mark-up pricing theory of bank retail rates setting, the main field of interest turned to exploring what factors affect the β_2 coefficient. In the theoretical literature, various explanations are provided. For example, Niggle (1987) argues that the size of the loan demand elasticity may be an important factor for the banks in setting their loan interest rates, especially for those borrowers who have access to other external sources of finance. Other authors, such as Ho and Saunders (1981), Rousseas (1985) and Angbazo (1997), provide indications that the size of the β_2 coefficient may depend on general macroeconomic factors, market structure in the banking sector, and bank-specific characteristics, but do not clearly specify which. Explanation of theories that examine the factors that affect the size of the β_2 coefficient, shown in Equation 2-6, are presented in the following sub-sections.

2.3 Theories on Interest Rate Stickiness and Determinants of Interest Rate Pass-Through

Among studies of IRPT determinants, a number of theories have been proposed to explain the stickiness of interest rate adjustment speed, while other studies focus on the determinants of asymmetric adjustment speed.

One of the first theories related to the determinants of interest rate stickiness is developed by Stiglitz and Weiss (1981). Their theory, known as asymmetric information and credit rationing, utilizes a credit rationing model to clarify stickiness in retail lending rates. Klemperer (1987) presents the switching costs hypothesis, with the aim of clarifying the sticky nature in adjustment speed. Fried and Howitt (1980), applying the implicit labor contract model of Azariadis (1976), present their theory, known as risk sharing theory. An alternative hypothesis tries to clarify risk sharing, as per this hypothesis, if borrowers are more risk averse than the shareholders of the banks; there exists an understood risk insurance argument for the stickiness of interest rates. Later, Hannan and Berger (1991), using Rotemberg and Saloner's (1987) model to explain the determinants of stickiness, presented their theory of menu costs. Ausuel (1991) proposed the consumer irrationality theory.

On the other hand, Neumark and Sharpe (1992) found that in the US there are two sources of asymmetries in interest rates, and presented two theories: collusive pricing arrangements and adverse customer reaction. Another noteworthy contribution is from Lowe and Rohling (1992), who argue that theories used to explain price stickiness in the goods and labour markets can also be applied in financial markets to explain stickiness in retail interest rates. Consequently, they propose four theoretical explanations, which are based on adverse selection, switching costs, risk sharing and consumer irrationality.

2.3.1 Informations Asymmetry, Adverse Selection, Moral Hazard and Credit Rationing

Asymmetric information, also known as "information failure," occurs when one party to an economic transaction possesses greater material knowledge than the other party. This typically manifests when the seller of a good or service possesses greater knowledge than the buyer; however, the reverse dynamic is also possible. Almost all economic transactions involve information asymmetries.

One of the most cited theories of the determinants of pass-through is the theory of asymmetric information and lending rate stickiness proposed by Stiglitz and Weiss (1981). According to these authors, asymmetric information introduces the problems of adverse selection and moral hazard (adverse incentive) with regard to setting lending rates.

Their model is based on the simple assumption that there are only two groups of borrowers in the market: risk averse and risk seekers. They also assume that there is high demand in the market for loans, and equilibrium is not achieved via price increase but through credit rationing. Based on these assumptions, in a situation of excess demand for loans, or when the cost of funds increases, it may not be in the best interest of banks to increase their lending prices as a response to an increase in the cost of funds rate, or to offset excess demand for loans because it can lead to Adverse Selection and Moral Hazard.

In a high demand situation, if banks decide to increase prices on their lending rate to offset demand, riskier borrowers, who want to invest in riskier projects, will be disproportionately attracted, causing adverse selection. On the other hand, if banks increase their interest rates following an increase in the cost of funds, there is a high likelihood that customers with lower risk and good credit rating might be pushed to invest in riskier projects to compensate for the high price. This can cause moral hazard and may also decrease bank returns. Both of these outcomes, due to an increase in the interest rates, are unfavourable to banks, as they decrease overall returns.

This theory assumes that by increasing the loan interest rate beyond the level of r*, safe borrowers start to withdraw from the loan market and mainly the riskier borrowers apply. For this reason, banks may refrain from increasing interest rates beyond a certain point and decide to ration credit. Figure 2-1 below represents this scenario.

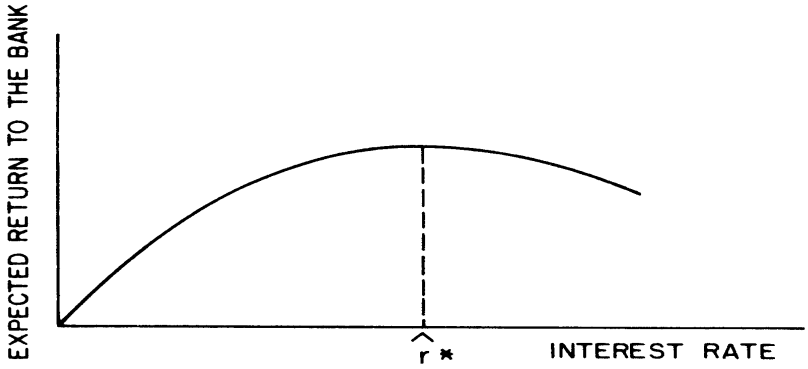

Figure 2-1: Source: Stiglitz and Weiss (1981, p.394).

Here the optimal level of return is at r* interest rate. If banks increase the rate beyond that point, the expected return will decrease due to adverse selection and moral hazard, introduced above. In other words, until the interest rate reaches r*, a mix of both risky and safe borrowers will apply for loans but, after that point, safe borrowers will withdraw from the market and only risky borrowers will apply for loans, resulting in an overall decrease in the bank returns.

De Bondt (2005) argues that if banks do not ration credit, the theory does not hold. It is assumed that banks can distinguish between the two types of borrower, banks are risk neutral. The assumption made here is that there are only two types of borrower to which banks can lend to: one is risk free and the other is risky. Increase in interest rates may lead to adverse selection and moral hazard. Given the scenario of perfect competition, banks must earn the same amount of revenue on the returns from both classes of borrower.

For the loans to risk free customers, the changes are transmitted one-for-one from the cost of funds rate to the lending rates; the ratio in lending rate to cost of funds rate should be equal to 1. However, when banks are lending to the second class of

borrowers, the ratio in lending rate to the cost of funds rate is greater than 1, because the probability of default is higher than the increase in lending rates for the second class of borrowers. For this second class of borrower, the change in lending rates should be made greater than the change in the cost of funds to compensate for the riskiness of defaults and to reduce the probability of no repayments.

2.3.2 Collusive Pricing Behaviour and Adverse Customer Reaction

As already noted, rigidity in the pass-through is the reason for asymmetries in financial markets. Neumark and Sharpe (1992), following Hannan and Berger (1991), were the proponents of asymmetries in retail bank interest rates. From their respective studies on the US market, they were able to propose two competing hypotheses to explain asymmetry: the collusive behaviour of banks and adverse customer reaction.

The collusive behaviour hypothesis relates to the degree of competition among banks and the level of concentration of the retail market. The theory states that banks are unlikely to decrease lending rates because they do not want to disrupt their collusive arrangements (de Bondt, 2005). According to Scholnick (1996), a decrease in the lending rate will result in lower revenue to the bank because of the loss of interest income. On the other hand, banks are highly unlikely to increase the deposit rate when the PR increases, as such an increase implies extra payment by the bank for deposits. This reluctance implies rigidity with regard to increasing deposit rates, which means the lending rate will have more downward rigidity, as banks perceive a loss of revenue. Wang and Lee (2009: 1237) summarize the concept by suggesting that collusive pricing implies rigidity in increasing the deposit rate and decreasing the lending rate.

Conversely, another hypothesis, known as the customer reaction hypothesis, which is related to moral hazard and credit rationing, concerns the reaction of borrowers to policy rate changes. The hypothesis suggests that banks will not increase their lending rates with increases in PR because of the fear of negative reactions from customers (de Bondt, 2005).

Following Hannan and Berger (1991) and Neumark and Sharpe (1992), Scholnick (1996) finds evidence of asymmetries in price settings in Malaysia and Singapore. He shows that deposit rates in both countries are more rigid when below equilibrium than above it, and further states that banks in both countries tend to adjust deposit rates downward more rapidly than upward. Lim (2001), using a multivariate asymmetric error-correction model, also provides evidence of upward adjustment rigidity in deposit rates and downward rigidity in lending rates in Australia.

2.3.3 Menu Costs

Menu costs are costs incurred by firms as a result of changing prices, creating new advertisements, updating price lists, producing brochures, publishing and distributing new catalogues to its customers, and making sales staff aware of changes in price when underlying cost and demand conditions change, or when inflation erodes existing prices (Madsen and Yang, 1998: 296– 297). Owing to the fact that these activities are time consuming and costly, firms do not often alter their prices, which thus contributes to price stickiness. Rotemberg and Saloner (1987: 919) noted that the reason why prices do not respond to changes in underlying conditions is that there may be fixed costs attached to changing prices, in the presence of which monopolists sluggishly adjust prices.

It is usually costly to change prices and, as a result, banks may delay in responding to PR changes. In situations where banks expect that the change in PR is temporary or they expect a reversal in the rate change within a few weeks, they might leave their own rates unchanged (Cottarelli and Kourelis, 1994: 591). Additionally, the level of change in the PR can also determine whether commercial banks will react. As noted by Mahadeva and Sinclair (2005: 19), 'There may also be a narrow range within which official rates can move while provoking no retail interest rate response'. Heffernan (2002, 2010) argues the stickiness and heterogeneities in retail rates in the UK banks can be because of menu costs administrative costs. It should be noted that menu costs have been considered one of the key determinants for retail interest rate stickiness in bank lending and deposit rates.

2.3.4 Consumer Irrationality

Ausubel (1991) presented another theory to explain the interest rate stickiness, known as consumer irrationality theory. Ausubel (1991: 71) argues that there is a class of borrowers who repeatedly believe that they will pay the outstanding balance before the due date but fail to do so, and these customers, who are insensitive to interest rate changes, are the type of borrowers that banks prefer. Lowe and Rohling (1992) argue that switching costs alone cannot fully explain interest rate stickiness in financial markets. Further, Lowe and Rohling (1992, P. 12) argue that credit card borrowers are high-risk customers and they are insensitive to the interest rates on credit. A credit card rate reduction will only attract customers who are high risk customers. This 'reverse' adverse selection problem makes banks less likely to compete on credit card rates and thus rates are likely to be sticky, especially in the downward direction (Lowe and Rohling, 1992, p. 12).

2.4 Interest Rate Pass-Through Dynamics and Variable Definition

IRPT, which is the extent to which changes in PR are reflected in short-term and long-term retail interest rates, is measured by the degree and speed of adjustment from PR to retail interest rates. According to Ozdemir (2009: 7), IRPT is defined as 'the degree and the speed of adjustment of retail interest rates to money market rates'. Therefore, it is worth noting that most central banks use short-term interest rates as the main instrument of monetary policy. As indicated earlier, changes in short-term interest rates are the first stage in the process of monetary policy transmission.

Empirical literature on IRPT presents the same view that most of the central banks use short-term money market rates as a major monetary policy tool (Manna et al., 2001; Wang and Lee, 2009). Manna et al. (2001) further argue that, during the transmission process, the interest rate fluctuation becomes an important indicator for monetary policy. Moreover, de Bondt (2002; 2005) provides useful insights into the pass-through process by commenting that retail IRPT is an important factor in monetary policy transmission. They suggest that the pass-through process is an important issue to address because a quicker and fuller IRPT of official and market interest rates to retail bank rates strengthens monetary policy transmission.

Several researchers, especially in the Euro area, have extensively used IRPT analyses. Stemming from the BIS (1994) report and early work of Cottarelli and Kourelis (1994), pass-through analyses have been widely applied in financial markets, and can be used to examine how fast and how completely changes in monetary policy rates are passed on to bank lending and deposit rates. Furthermore, pass-through analysis can reveal information about competition in banking markets and asymmetries across countries under a single monetary policy (Kleimeier and Sander, 2007).

In the UK, some studies have also applied IRPT analysis. One such study is by Aziakpono and Wilson (2010), who use pass-through analyses to measure financial integration among the Southern African Customs Union (SACU) countries. Kleimeier

and Sander (2007) also made use of pass-through analyses for the Common Monetary Area (CMA) countries of the SACU during the period 1991 to 2005. In addition, Kleimeier and Sander (2007) and Aziakpono and Wilson (2010) investigate banking market integration in the member countries of the Southern African Developing Countries (SADC) using a principal component as well as pass-through analyses. Alternatively, Samba and Yan (2010) use pass-through analysis to examine the degree of responsiveness of deposit and lending rates to changes in PR in the Central African Economic and Monetary Community (CAEMC) area from 1990 to 2007.

2.4.1 Price Rigidity of Short-run Adjustment Speed or Short-run Pass-through

The *SRAS* (γ) indicates how much of the gap or error prevailing at month t-*J* is closed at month t. It can be defined as the level of the adjustment made at month t to close the error at month t-j. Ideally, there would be 100% adjustment in retail rates following a change in the BoE official rate. The *lag length* (j) indicates how much time (in months) banks and building societies take to adjust these retail rates.

Researchers have found that the *SRAS* is rarely complete (100%), which is representative of stickiness or sluggishness in retail rate adjustment. Cottarelli and Kourelis (1994) and Verheyen (2014) also find incomplete short-run pass-through on harmonised European Monetary Union (EMU) data. Kleimeier and Sander (2004) focus on pre-EMU data for 15 European countries, of which 12 are now members of the single currency area, and find short-run stickiness in lending rates. As discussed above, the literature proposes various explanations for the stickiness of pass-through, such as menu costs, high switching costs, imperfect competition and asymmetric information (Chong et al., 2006; Liu et al., 2006). Banks and financial institutions are unable to eliminate such factors and their corresponding effects in the short-run. Therefore, it is plausible to assume that those factors have the same impact on pass-through in the UK.

2.4.2 Long-run Pass-through

Given the fact that the effectiveness of monetary policy implementation is determined by the degree of IRPT, a quick and complete pass-through could strengthen the monetary policy transmission and therefore achieve the desired macroeconomic goals. Thus, the IRPT is expected to be complete in the long-run, when retail interest rates fully adjust to the response of PR changes. However, extensive literature has observed partial pass-through from PR to retail interest rates across countries, and the level of pass-through is less than 1. De Bondt (2005) presents his model of bank retail rates price setting, following the marginal cost pricing model equations of Rousseas (1985) and Ho and Sanders (1981) as follows:

$$x_{it} = A_i + C_i y_t$$

where, subscript i stands for banks and t is for time. x_{it} is the price set by banks (that is, bank interest rate), A_i is the constant mark-up, C_i is elasticity of demand and y_t is the marginal cost price approximated by LIBOR. The underlying idea is that market rates reflect the most accurate marginal costs faced by banks. This is the reason why LIBOR is the most appropriate proxy of the cost of funds. C_i is the *LRPT*, which can be used as a measure of bank competition. If C_i <1, this represents partial competition in the market. C_i = 1 represents perfect competition, which is the ideal situation. Theoretical studies suggest that lower competition leads to lower integration in the market. According to Heffernan (2009), if C_i is >1, it represents very high competition in the market. The long-run equilibrium rate (x_i*) is the rate at which retail rates settle in the long run. According to Heffernan (2009, p49), the retail rate cannot drift too far away from the official rate over long periods; that is to say, there should be a long-run equilibrium relationship between them. Pricing in retail banking will be more closely tied to the base rate within more integrated markets (Kleimeier and Sander, 2000). Thus, in integrated markets there should be a certain long-run relationship between the interest rates of firms and the base rate. This relationship does not require rates to equalize. In the short run, retail rates will deviate from this long-run equilibrium but the existing long-run relationship limits divergence of rates in an integrated market.

Researchers have also found that the *LRPT* in individual banks does not differ from the pass-through in the industry, in order to avoid arbitrage activities (Łyziak et al., 2012). However, factors such as individual marketing policy, financial structure, customer preferences and solvency ratio may cause the long-run pass- through in individual banks not to converge at the industry level (Sznajderska, Polski, and Ekonomiczny, 2012). Therefore, it is plausible to assume heterogeneous behaviour as regards the *LRPT.*

2.4.3 Long-run Mark-up

The long-run mark-up (A_i) represents how much the interest rate charged is above or below the BoE official rate. If the mark-up/down is negative that means banks are paying lower prices that the BoE official rate; if it is positive, they are paying higher interest rates compared to the official rate. If A_i is heterogeneous among firms, that means the markets are not fully integrated and the Law of One Price does not hold. This law remains a useful theoretical reference when one analyses price convergence. First, financial theorists have used the law as an uncontroversial minimal condition, upon which they have built the edifice of modern financial theory, including the Modigliani-Miller capital structure propositions and the Black-Scholes option pricing formula (Lamont and Thaler, 2003). Second, the ECB considers the law a natural way to assess the state of European financial integration (for example, Trichet, 2006). Third, several scholars indicate that, even with its imperfections, the Law of One Price is the sole basis for measuring integration (Adam et al., 2002; Adjaouté and Danthine, 2003; Baele et al., 2004; Dermine, 2006; Kok Sorensen and Werner, 2006; Gropp, Kok Sorensen, and Lichtenberger, 2007; Kok Sorensen and Lichtenberger, 2007; Gropp and Kashyap, 2010).

Traditionally, economists thought that the Law of One Price could be applied in the financial market almost exactly as it is applied in the goods market because of the working of arbitrage. Arbitrage, defined as the buying and selling of the same security at two different prices, is a crucial concept of modern finance. The absence of arbitrage is the basis of serveral modern theories, which include option pricing and corporate

capital structure. In capital markets, *the law of one price* says that securities that have the same pay-off should have the same price; otherwise, smart investors could take unlimited profits by buying cheap securities and selling expensive ones. According to the standard assumptions, the law should hold in financial markets because if some investors mistakenly think that odd numbers of some stocks are better than evenly numbered stocks, rational arbitrageurs will prevent these investors from driving up the price of odd-numbered shares. Moreover, unlike international trade, where it may take some time to move gold physically from London to Zurich, one would expect the law to hold not only in long-run, but almost instantaneously, since one can quickly buy and sell securities (Lamont and Thaler, 2003, p. 192).

According to Ashton (2001), if products are similar in function, they should behave as substitutes for one another. Therefore, in a single market, products which act as substitutes should display little variation in price. This said, within the UK, suppliers of deposit savings accounts offer the same interest rate across their entire branch networks (Ashton, 2007). While this practice has been interpreted by some commentators as an indication of quite large market areas (for example, Redecki, 1998), others (for example, Heitfield, 1999) correctly suggest that all prices of substitutes should be similar within a market. This provides an indication of similar demand and supply conditions, therefore suggesting an integrated market. Following Heitfield (1999), all testing is directed at the possible rejection of a larger geographic market. Such an approach is adopted, as persistent systematic differences in the variation of interest rates paid for similar products sold at different locations will provide evidence that such locations are in distinct markets. Conversely, the provision of similar levels of dispersion in interest rates at different locations may imply the locations are in the same market. Within his study, using linear regression, Heitfield (1999), finds that an integrated UK deposit savings account market does not appear to exist.

2.5 Review of Relevant Literatue on IRPT Dynamics and the determinants of IRPT

2.5.1 Introduction

The early studies on the topic of monetary policy transmission and its effectiveness mainly focused of price rigidity and asymmetric adjustment, and most were carried out under the framework of oligopolistic competition. Due to the significance of the IRPT process for the success of monetary policy, interest in the speed and magnitude of retail interest rate adjustments to changes in the central banks' PR has increased in recent years. This has led to several landmark research studies. After the introduction of the single economy in the European Union and introduction of the Euro, studies on IRPT became very popular. In particular, the asymmetric nature of adjustment speeds and observed differences in financial structures and how they affect pass-through in the Eurozone have attracted much attention in the literature (Wang and Lee, 2009: p1272). For this reason, many studies on interest rate rigidity have been conducted for EU member countries (Sander and Kleimeier, 2002). These include: Donnay and Degryse (2001), Toolsema et al. (2002), de Bondt (2002), and Mirdala (2009).

Even though some authors have attempted to classify pass-through studies, it is important to note that there is no consensus on how this can be achieved. For instance, Kleimeier and Sander (2004) consider two approaches to IRPT studies: the cost of funds approach and the monetary policy approach. However, de Bondt (2002) takes a different approach and classifies the research into: studies that show the transmission of PR and/or money market rates to lending rates are sticky and lack of competition; studies that examine IRPT using different methodologies ; studies that examine the pricing behaviour of banks by using bank level data; and studies that use aggregate data.

For the purposes of this review, the literature is divided into three categories. First, we consider studies which not only investigate the stickiness or completeness of the adjustment speed, but also examine the heterogeneities in short- and long- run interest

rate variables for different financial products offered by banks. This type of study is often conducted to make cross-country comparisons or cross-product and firm comparisons within the same country. If the IRPT parameters are quite heterogeneous, it means that the market is quite segmented and less integrated, whereas if the parameters are homogeneous, the market is quite integrated. A second type of study investigates the market extent, integration of the financial product pricing, and existence of *the Law of One Price* in the financial market. Third, the current research considers studies that investigate the determinants of interest rate margins, or the determinants of price setting for retail rates.

2.5.2 Studies on Interest Rate Stickiness and Heterogeneities

Following the earliest study on interest rate stickiness and heterogeneities by Stiglitz and Weiss (1981); Hannan and Berger (1991) and Neumark and Sharpe (1992) formed the basic theoretical framework, used by many researchers for IRPT studies. Neumark and Sharpe (1990) probed the link between US monthly wholesale rates and retail deposit rates. The studies report strong evidence of sluggish retail rate responses.

The first attempt to provide a comprehensive analysis of the dynamics of interest rate adjustment was made by the Bank for International Settlements (BIS) in 1994. The BIS (1994) report shows that there are significant differences in monetary transmission within the Euro area and that short-term bank lending rates to enterprises are sticky (BIS, 1994). These findings initiated the debate on the efficiency of the interest rate transmission mechanism as a tool of monetary policy. Subsequently, several researchers were keen to investigate the IRPT dynamics and uncover the factors responsible for such stickiness in bank lending rates.

While investigating the IRPT for 31 developing and developed countries, Cottarelli (1994) confirms the BIS (1994) findings that short-term pass-through is sticky. They find that, following a change in money market rates, the loan rate adjusts on average by 32% in one month, 64% after three months, 77% after six months, and 97% over the long run. The research of Cottarelli and Kourelis (1994) can be seen as one of the pioneering studies on the IRPT mechanism and its determinants.

Mojon (2000) considers 6 Eurozone countries, namely Belgium, France, Germany, Italy, the Netherlands and Spain. In his study, he analyses transmission from the money market rate to retail rates using a VAR model. He uses several different retail deposit and lending rates during the period 1979 to 1998. The *LRPT* turns out to be incomplete and seems rather sluggish, especially for rates on the products with higher maturity.

De Bondt (2002) studies the short- and *LRPT* in the Eurozone countries, using an error-correction model of IRPT based on a marginal cost pricing framework. The study finds the immediate pass-through of market interest rates to retail bank interest rates is incomplete. The proportion transferred to the retail rate following a change in market rate is found to be 50% at the most, within one month. The *LRPT* is higher than the *SRAS* and is close to100% for bank lending rates. The stickiest retail rates are over-night deposits and deposit redeemable at up to 3 months' notice with a max *LRPT* of 40%. In general, for all the countries, the *LRPT* and short-run adjustment is more complete and the speed faster compared to previous studies.

Donnay and Degryse (2001) explore the pass-through from the money market rate to several bank lending rates for householdsfor 12 EU countries from 1980 to 2000. They look at IRPT dynamics and find heterogeneities in the price adjustment both within and across countries in Europe. The study finds an incomplete *LRPT* for all retail rates except for short-term bank lending. The study also finds that government bonds and long-term product rates for households react faster. The most complete *LRPT* is found for Spain, Italy, Greece and the Netherlands. In the short run, only 50% of changes in the money market rates are reflected in lending rates in Ireland, Belgium, Portugal Austria and the UK. Results for France, Germany and Finland are somehow in between these extremes.

In a similar study, using a data set of monthly observations taken from the Central Bank of Ireland for the period January 1980 to March 2001, Bredin, Fitzpatrick, and Reilly (2002) analyse the short- and *LRPT* for Irish banks. Their analysis is based on overdraft facilities, lending to small and medium size enterprises, and variable

mortgage rates. The one-month wholesale money market rate is used as a proxy for the base rate. In descriptive statistics they find the spread between the money market rate and prime rate is the smallest compared to lending rates and the mortgage rates. They use ECM to measure the adjustment speed and the degree of *LRPT*. The consumer rate reacts only sluggishly, with a lag of 10 months. They finds that for all the series the pass-through is less than unity, varying from as high as 0.92 for prime rates to as low as 0.54 for overdrafts. Moreover, there is a lower degree of pass-through in Irish banks compared to other countries. The adjustment speed varies from 0.56 for prime rates to 0.06 for overdrafts, indicating high degree

Wróbel and Pawlowska (2003) in a study on Polish banks find imcompete immediate pass-through and a complete *LRPT* for most of the deposit rates and for short and medium-term lending rates to firms. They find less than complete pass-through for lending rates on consumer credit. The lag period is 2.5 to 4.1 months in case of deposit rates; slightly shorter lag ranging from 1.4-3.8 months in case of lending rates. Similarly, Tomasz (2003) also found evidence of sluggishness of retail interest rate pass-through in Poland.

Sander and Kleimeier (2004 a) used monthly country averages of loan and deposit rates, from January 1993 to October 2002, for each of the 10 countries comprising the Eurozone. Their study provides evidence of short-run price rigidity. They find complete *LRPT* for corporate loan rates where the *SRAS* is also high. For consumer loans and deposit products, the pass-through is smaller.

De Bondt (2005), measures the pass-through from overnight interest rates to deposit and loan rates in the Eurozone in the period 1996 to 2001. The study observes that the *SRAS* for both deposit and lending rates is incomplete, while the *LRPT* to lending rates is complete, but incomplete for deposit rates.

De Graeve et al. (2006) use monthly data from January 1993 to December 2002 for six loan and seven deposit products for 31 Belgian banks. They report evidence of heterogeneity in pricing behaviour between banks, with the adjustment speed being highly variable across products. Pass-through is incomplete in the long run, which is

rationalized in terms of an imperfectly competitive banking market. The findings also suggest less rigidity in corporate loan rate adjustment than in consumer credit.

Baugnet (2007) shows that Belgian banks tend to adjust their retail interest rates relatively rapidly to changes in market rates. The study also finds significant heterogeneity across sectors, products and banks. Results suggest that Belgian banks tend to price less competitively on consumer-oriented loans in both the short and long run. Interest rates offered on overnight deposits, which represent the banks' liability, tend to react less completely compared to time and redeemable deposits. Savings deposits are found to exhibit a much higher degree of stickiness in adjustment speed compared to other type of deposits. Moreover, the study reveals a significant degree of heterogeneity in products in the short-run. Baugnet (2007) argues that this heterogeneous behaviour mainly stems from the differences in market power and the bank lending channel. In line with the market power hypothesis of Berger (1995), banks with a larger market share tend to react less rapidly and less completely to changes in market conditions. In addition, less liquid banks adjust interest rates on loans and deposits more quickly.

Kleimeier and Sander (2007) conclude that IRPT in Europe can be characterized as sticky, and that there are differences in pass-through to lending and deposit rates, as well as between countries. De Graeve, de Jonghe, and Vennet (2007) point out that the IRPT to products offered to consumers is weaker compared with pass-through to products offered to firms.

Jobst and Kwapil (2008) measure the change in the degree of pass-through in the period of crisis, but do not support the view that it is impaired. They investigate the pass-through to loan rates in Austria and cannot detect striking differences in the process after the start of the crisis. Chihák et al. (2009) focus on the IRPT mechanism during the financial crisis. For the EMU area as a whole, they find a slower and incomplete pass-through. For example, Hristov et al. (2012) analyses interest rate transmission in the euro area and found that the IRPT during the financial crisis

became less complete for both deposit and lending rates.The monetary policy impulses have been less effective during recent years.

Based on results obtained using a Markov-switching VAR model, Aristei and Gallo (2012) conclude that the immediate reaction of retail rates to changes in market rates has weakened in the euro area, but, at the same time, the reaction to any changes between the base rate and retail rates has strengthened. They provide further evidence of asymmetry in the pass-through process, and report that banks tend to adjust loan rates more quickly in response to changes in PR when rates are increasing than when they are falling. However, the reverse is reported for deposit rates. These findings are in line with the theoretical literature, which poposes that banks hold some degree of pricing power in the markets for loans and deposits.

Kwapil and Scharler (2010). They compare the IRPT process in the Euro area and US, using monthly data from January 1995 to September 2003 for various deposit and lending rates. Their results for the average short-run pass-through in the US are 97% and 79% for deposit and lending rates, respectively, while in the Euro area they are 16% and 34%, respectively. On the other hand, the *LRPT* for US deposit and lending rates is 93% and 57%, respectively, while for the Euro area it is 32% and 48%, respectively.

Łyziak et al.(2012) point to a comparable scale of transmission to households and firms for deposit and lending rates in a study on Polish banks. The pass-through is close to one for deposits but they find a faster speed of adjustment in the case of firms compared to households. For the lending rates, the *LRPT* is complete in the cases of loans to households, loans for housing purposes, and firm credit in current accounts, but just 0.5 for loans to sole proprietors. Hristov et al. (2012) analyse interest rate transmission in the Euro area and find that the pass-through during the financial crisis becomes less complete for both deposit and lending rates.

Stanisiawska (2014) analyses IRPT before and after the financial crisis for Polish banks, reporting some differences in the adjustment speed. In the post-crisis period, the speed increases slightly for deposit products, but decreases a little for lending

products. In both cases, differences were small. The study finds *LRPT* is more complete for deposit products in the post-crisis period but pass-through for lending products decreases. This suggests that the speed of adjustment to deposit rates is faster than lending rates. In the post-crisis period, interest rates mostly decreased. This suggests that the slower adjustment on lending could be due to asymmetric adjustment settings; banks may want to take advantage of the increase in spreads between lending and deposit rates.

Most early studies on retail interest rate stickiness or IRPT were mainly done in developed economies, such as the US and Euro area. However, there has been an increasing interest in this issue in emerging and developing countries. There has also been extensive literature on interest rate rigidity in developed countries over the last two decades, with relatively few studies on emerging and developing countries. However, in the mid-2000s, most emerging markets and developing economies moved from targeting the exchange rate to targeting inflation. This move towards a market-oriented monetary policy system has increased the importance of the role of interest rates in these economies (Mohanty and Turner, 2008: 2-5).

Accompanying a shift towards market-oriented monetary policy in developing and emerging countries, interest in the studies of bank interest rate stickiness has heightened in recent years. This is mainly on account of rigidity in retail interest rates and higher margins, despite financial reforms and liberalization (Acheampong, 2005).

Jankee (2004) investigates IRPT to retail interest rates in the context of emerging and developing African economies. He examines the rigidity of commercial bank interest rates within a nonlinear framework in Mauritius. Using Johansen co-integration, TAR and M-TAR models on data from 1988 to 2003, the study finds asymmetry in lending rate adjustments. It is evident from the results that pass-through is incomplete in Mauritius, with observed values of 41% and 24% for deposit and lending rates, respectively. Tieman (2004), using data for 1995-2004 for Romania and Eastern European transition countries for lending and deposit products finds the *SRAS* is higher

for deposit rates compared to lending rates and pass-through is incomplete. Deposit products, however, show higher pass-through compared to lending products.

Humala (2005) conducted one of the few studies to examine IRPT in a market characterized by periods of financial instability. His study focuses on Argentina for the period June 1993 to December 2000. The analysis is based on the local inter-bank rate (as proxy for the official rate) and four types of loans with different degrees of credit risk. Using aggregate rates (weighted average loan rates across banks), a Markov-switching VAR model is estimated to capture financial crises. He finds that credit risk increases loan rate stickiness in normal periods and pass-through is higher in volatile markets.

Egert and Reininger(2004) show that the null hypothesis of complete pass-through cannot be rejected for any interest rate in Poland. On the contrary, there is evidence of incomplete pass-through in Hungary for the deposit rates (both the short and long-term) and the yield on the 5-year government bond. There is also some evidence of an overshooting effect observed in the interbank money market rate, but this effect is quantitatively tiny and only marginally significant. The results for the Czech Republic give evidence of incomplete pass-through for all rates except for the interbank money rate.

Isakova (2008) focuses on three CIS economies in Central Asia namely Kazakhstan, the Kyrgyz Republic and Tajikistan. In the case of Kyrgyzstan, he demonstrates that there is nearly a complete pass-through to interbank money rates and also the average household deposit rates, while lending rates and Lombard rates overshoot the policy rate. He explains this phenomenon by the overreaction of creditors to rising interest rates in the economy in order to hedge their credit risks in the face of uncertainty and underdeveloped financial markets. For Kazakhstan, Isakova(2008) shows that all interest rates exhibit an overshooting effect in reaction to the changes in the policy rate. Moreover, the 1998 financial crisis in Russia might have had a significant effect on the economy of Kazakhstan. This is illustrated by the presence of co-integration relationships between different interest rates and the policy rate. Finally, results for

Tajikistan are contradictory, as no co-integration is established between the central bank's refinancing rate and the deposit and lending rates

Samba and Yan (2010) focuses on the *IRPT*, using monthly interest rate series for the Central Africa Economic and Monetary Community (CAEMC).They find *SRAS* for the lending rate is twice that for the deposit rate. Similarly, they find that the *LRPT* of the lending rate is greater than for the deposit rate. Second, the results show that lending rate is characterized by an overshooting effect in response to changes in the PR, while the *LRPT* for the deposit rate is incomplete (less than unity). They attribute the overshooting effect on loans due to the poor financial structure, characterized by the inefficiency of the two stock markets of the region may contribute to reinforce the pre-eminence of bank loans as the only debt instrument available to economic agents. In such a context, creditors may also overreact to rising interest rates in the economy in order to hedge their credit risks in the face of uncertainty and under-developed financial markets. Tai, Sek and Har (2012) finds evidence of sluggish transmission across six Asian economies, indicating that a high degree of interest rate stickiness or failure of government to control the market rate may be possible factors in the slow and small transmission into deposit and lending rates.

There have been a few studies on interest rate transmission in UK banks. Heffernan (1997) analyses UK bank level data on a monthly basis from1986 to 1993, collected from one of the major clearing banks in (unpublished source The novelty of the study is the use of linear ECMs to capture adjustment speed and *LRPT* in response to changes in London inter-bank offer rate (LIBOR). The study finds very sluggish adjustment speeds for savings accounts, with particularly slow adjustment for personal loans. The error correction mechanism is on average just over 37% complete within a month for savings and cheque accounts, and mortgages. For personal loans, however, it is found to be only 10%.

Mizen and Hofmann (2002) finds a complete pass-through from base rates to deposit rates for commercial banks and building societies in the UK. By contrast, changes in the base rate feeds into mortgage rates only in an incomplete manner seek to identify

On the other hand, Hofmann and Mizen (2004) finds complete IRPT for mortgages but incomplete pass-through for deposits. They also find slower adjustment of deposit rates compared to lending rates.

In an attempt to better understand individual bank responses to policy rate changes of the UK retail banking market Heffernan (2005, 2009) analyses IRPT) on a wide range of products credit, deposit and mortgage products Tests reveal marked heterogeneities across FIs in both the short-run speed of retail rate adjustment to PR changes and long-run mark-up. For the vast majority of FIs, *LRPT* is higher for PL and CC, compared to mortgages, which provides evidence of a collateral effect. The pass-through of 90-day high tier saving rates (HT) also significantly exceeds that of mortgages, which supports the presence of a balance sheet effect. Author finds that higher the deposit level and maturity more complete is the *LRPT* indicating a tier effect and term effect. FIs differ widely in the character of their responses. Some FIs match the PR quickly for certain products, whereas others let the gaps build up before changing their deposit or loan rates. Thus, as far as this aspect of the transmission mechanism is concerned, the repercussions of monetary policy changes are slower, less uniform and more complex than typically modelled.

Ahmad, Aziz, and Rummun (2013) analyse products offered by UK banks and building societies, focusing on the period January 1999 to July 2007, using aggregated data for instant deposits, time deposits, and lending and mortgage rates. The study reports a very sticky *SRAS* (20.7%, 14.7%, 25.7% and 27.6%) on instant deposit accounts, time deposits, lending rates, and mortgage rates. They also find complete pass-through (C = 1) for time deposits, lending rates and mortgage rates, whereas pass-through for instant deposits is high but not complete. Results show a mark-down for deposit products, indicated by a negative sign. This is consistent with theory, as banks usually pay a lower rate than LIBOR for deposit products. There is a positive mark-up for lending and mortgage products, since banks tend to charge higher rates on lending and mortgage products than LIBOR. Ahmad, Aziz, and Rummun (2013) argue that the adjustment speed is slow in the short-run in the UK banking industry, while in the long run, pass-through is complete and there is co-integration.

In summary, these studies find that the adjustment speed is sticky in the short run. Moreover, heterogeneities exist between lending and deposit products, and also across countries for short-run and *LRPT* parameters. These studies provide consistent evidence that *LRPT* shows less than one to one transmission, and short-run pass-through is sticky and incomplete. However, some studies have found evidence that the lending rates have higher *LRPT* compared to deposit products; for example, de Bondt, 2002 and 2005; Kleimeier and Sander, 2004; Sander and Kleimeier, 2004. Some find that the adjustment speed is stickier on consumer products, overnight, and redeemable deposits (de Bondt, 2005; de Graeve et al., 2007). Some research finds contradictory results for the same country; for example, Mojon (2000) and Donny and Degryse (2001) for Spain. The pass-through parameters show heterogeneities within and across countries, and across different products for short- and *LRPT* (de Haan 2001; de Bondt 2005; Hulseqig, 2009; Mojon, 2000). These findings are in line with the findings of the BIS (1994) report and other researchers. Corporate products are also found to have faster IRPT in the short and long-run compared to consumer products (Sander and Kliemier, 2004a; Kleimeier and Sander, 2004; Baugnet et al., 2007; de Graeve et al., 2007; Fuertes and Heffernan, 2009). However, some studies find that household products react faster and have higher *LRPT* (de Bondt, 2005; de Graeve et al., 2007; Moratta, 2009; Aristei and Gallo, 2012). Some studies report differences in pass-through parameters in products with different maturities or tier level, or according to the type of bank (Mojon, 2000; Fuertes and Heffernan, 2009).There is also some evidence that *LRPT* tends to be more complete the higher the deposit level, indicating a tier effect, and the higher the maturity, which is consistent with a term effect. FIs differ widely in the character of their responses. Some FIs match the PR quickly for certain products, whereas others let the gaps build up before changing their deposit or loan rates.There is evidence of impaired IRPT during the financial crisis period (Cihák, Stavrev, and Harjes, 2009; Hristov, Hülsewig, and Wollmershäuser, 2012). However, Jobst and Kwapil (2008) do not find evidence of impaired pass-through during the crisis.

2.5.3 Studies that investigate Integration/Competition and The Law of One Price

Another type of study related to IRPT investigates integration using price convergences in the market for the same product. The Law of One Price provides the theoretical framework for measuring price convergence. It represents a clear benchmark, whereby full convergence exists once returns and risks have been taken into account. According to this law: "In an efficient market all identical goods must have only one price"(Wikipedia). On this basis, in a single market, prices should converge due to arbitrage (Affinito and Farabullini, 2006).

A number of researchers use the Law of One Price to measure homogeneity in interest rates. If the law holds, it means there should not be any market segmentation, although differences in price levels mean that barriers to entry exist. In reality, many researchers have criticized the law on various grounds, but the test of validity is especially complex in the banking market. Nevertheless, arbitrage is easier in financial markets compared to goods markets because of the absence of transportation costs. For this reason, the law should be expected to hold instantaneously. However, several banking products are not similar and cannot be substituted for each other, which suggests the law may not hold within countries, even if the markets are integrated (Affinito and Farabullini, 2009). According to (Ashton, 2001), if products are similar in function, they should behave as substitutes for one another. Therefore, in a single market, products which act as substitutes should display little variation in price. This said, within the UK, suppliers of deposit savings accounts offer the same interest rate across their entire branch networks. While this practice has been interpreted by some commentators as an indication of quite large market areas (for example, Redecki, 1998), others (for example, Heitfield, 1999), correctly suggest that all prices of substitutes should be similar within a market, to provide an indication of similar demand and supply conditions, and therefore an integrated market.

Nonetheless, the Law of One Price remains a useful theoretical reference point for the analysis of price convergence.

Recent literature admits the Law of One Price as the sole theory for measuring integration, it can be verified only on similar assets. Adjaout′e and Danthine (2003) and Baele et al. (2004) agree that, in order to verify the law, if assets are not sufficiently homogeneous, differences in systematic risk factors and other important characteristics must be taken into account. It is easier to find homogenous assets for bonds but difficult in retail banking. Likewise, Gropp and Kashyap (2008) argue that the law will not send a clear message regarding the state of integration: '…unless one accurately controls for those factors, which may very likely systematically differ across countries.' They highlight the fact that, if the observed violation of the law is due to unobserved heterogeneity in demand, which may be a function of differences in preferences, risk characteristics, or other demand characteristics in different markets and countries, the price differences would have nothing to do with the failure of integration. Dermine (2006) signals that empirical tests could be misleading because, if customers buy a bundle of financial services from their bank, the law should hold for the entire package. Adam et al. (2002) highlight the need for new and more accurate data in order to assess the extent to which the law holds in the Euro area banking markets.

One of the first studies conducted in the UK on this topic was Heffernan (1993). The study investigates whether the Law of One Price exists in British retail banking. Using a disaggregated data set for the period 1985 to 1989, the research focuses on a sample of nine banks and seven building societies offering deposit and loan products. LIBOR is used as a benchmark to measure competition among the banks. Heffernan (1993) reports that the UK retail banking market is characterised by complex imperfect competition, with sluggish loan and deposit rate adjustments to changes in the LIBOR. Empirical values of coefficients for deposit rates are 43.5% to 61% less than 100%, which is against the perfect competition. For loans, the sum of coefficients is 1.70, which suggests that the prices of loans are 70% higher than perfect competition.

In a later study, Heffernan (2001) analyses the retail pricing behaviour of five generic products offered by British financial institutions, for the period of 1993 to 1999. The study finds considerable price dispersion among the financial products offered by

banks and building societies and the absence of any Law of One Price. Furthermore, evidence of increased competition is found for some products in British markets in the 1990s compared to 1980s. The deposit rate in the 1990s ranges from 63% to 71% for saving accounts. The Libor coefficient shows that the rate paid on low chequing 18% and for high chequing 38% of the competitive rate. The comparable rates in Haffernan (1993) were 44% and 57% for saving accounts and 56% and 61% for chequing accounts. This suggests an increase in competition in savings accounts and decrease in competition for chequing accounts.

In another later study, Heffernan (2004) compares the pricing behaviour of building societies and mutuals. The products under examination are 90-day term deposits, instant deposits, chequing accounts and variable rate mortgages for the period of January 1999 to December 2001. Following earlier research (Heffernan, 1993 and 2001), the study uses a modified version of a generalised linear pricing model. Findings suggest the presence of imperfect competition in the market. The study finds that converted building societies are far more likely to rapidly respond to a change in current LIBOR than the building societies. Regression of pooled data (across converts and mutuals) reveals that, following conversion to bank status, the rates on all the converts' deposit products are permanently lower, and their mortgage rates permanently higher. The results show that the new converts offer predominantly rip-off products, providing further evidence to support the expectation that, in an imperfectly competitive environment, they become more responsive to shareholders post-conversion.

Martin et al. (2005b) uses a sample of bank-level data for the Spanish banks to study IRPT in Spain. After controlling for product differentiation, the study finds that the Law of One Price does not apply for similar products, pointing towards the existence of price dispersion and a non-integrated Spanish loan market. Martin et al. (2005b) argue that this dispersion reflects bank specific effects owing to different credit policies, including relationship lending. In addition, they find that bank market power affects the speed of adjustment of bank interest rates to changes in market rates.

Similar results are found in a study by the ECB (2006c). Results suggest that the Euro area banking markets continue to be fragmented, whereas inter-bank (or wholesale) markets and capital market-related activities show solid signs of increasing integration. The study finds high cross-country dispersion in bank interest rates compared to the government bond market. In particular, there appear to be differences in loan rates to households for consumption purposes in individual Eurozone countries, while dispersion on loans to households is found to be lower, suggesting greater homogeneity in this product. However, dispersion is still higher compared to debt securities (ECB, 2006c). In another report by the ECB (2005), evidence suggests that the Eurozone banking market remains highly fragmented, as indicated by a high cross-sectional dispersion of the same types of interest rates and low cross-border bank activity. However, the inter-bank market shows signs of increasing integration (ECB, 2005 p.10).

Heitfield (1999), investigating the geographic scope of deposit markets, uses data from a nationwide survey of retail interest rates conducted by Bank Rate Monitor. Results show systematic differences in the prices charged for similar products sold at different locations. Radecki's finds that pricing or products are the same within a state by multi-market banks. He argues that this finding does not apply to expanded geographic markets, since the deposit interest rates offered by single-market banks vary substantially across cities within a state.

Ashton (2001) investigates the existence of the Law of One Price in the UK deposit market in different geographical regions of UK. He uses deposit products data, which are divided into seven representative groups on the basis deposit tier levels and further subcategorised on the basis of the number of days of deposit required. He finds significant price variation in deposit accounts in different geographic regions for the same products. This suggests that the Law of One Price does not apply in the UK deposit market. Instead, it appears that geographical factors may be influential and an integrated market does not exist. These findings are consistent with previous surveys of customer preferences by Kwast et al. (1998) and Cruickshank (2000), which provide an indication of demand conditions in this market. Ashton's (2001) results

also find similarities with the studies conducted by Goodhart (1987), who proposed a two tier market structure model of European banking markets. In his study, Goodhart (1987) finds that the low-yield European banking market continues to show regional and local characteristics.

Biehl (2002), in a study to define the structure and extent of the banking market, measures the geographical price differences in the US banking market. He uses interest chequing, money market accounts (MMA), and eight CD (certificate of deposit) rates rate data for the ten largest financial institutions in each of the five largest cities in New York State. The study finds that local dispersion is quite striking within each city, with rates varying between 28 and 72 points. In addition, even higher dispersion is observed within different cities. Biehl (2002) finds that deposit rates within city rates move more closely as compared to across different cities.

Hannan and Prager (2004) report two findings that are relevant to multimarket bank pricing. First, single market banks tend to offer higher deposit interest rates than multimarket banks in the same local market; second, the deposit interest rates offered by single market banks are lower if the presence of multimarket banks is greater in their local market. This second finding casts doubt upon a commonly offered explanation for the first – that large multimarket banks can offer lower deposit rates because they provide a higher quality of service – since it does not seem plausible that single market banks would offer lower rates in response to the better service provided by their multimarket rivals.

Hannan and Prager (2004) speculate that large banks have greater access to wholesale funds. This implies that larger banks do not need to offer as high a retail deposit rate as small banks, and that smaller, single market banks tend to offer lower deposit rates, the greater the presence of large multimarket banks in their local areas. This explanation is consistent with the findings of Kiser (2004) and Schuller and Heinemann (2002) in a paper that explicitly models the relationship between the cost of wholesale funds and the interest rate offered on retail deposit accounts.

The common evidence is that financial markets are still quite dispersed. There is very low competition, less integration and the Law of One Price does not apply for the same product types within the same country across. However, integration and pricing competition varies according to product type, market type, and type of target customer to whom a product is offered. For example, some studies observe significantly different levels of integration and competition for different products. Heffernnan (2001) finds substantially less competition for high and low savings, high chequing, credit cards, and personal loans. Heffernan (2004) finds information asymmetries, which indicate that firms' pricing behaviour differs depending on the product. For example, some firm's price competitively in the new borrower mortgage market and offer better rates to new customers compared to existing ones. The ECB (2006c) finds that the dispersion in loans to households for house purchases is lower compared to loans to household for consumption purposes. A number of studies report that the corporate capital markets are more integrated compared to retail banking and consumer markets. Baele (2004) finds that the corporate lending market, and the medium and the long-term product segments of the market, are more integrated and prices are less dispersed compared to the short-term segment. Loan rates seem to be more uniform across countries compared to the past, although the consumer credit section is still segmented. The ECB (2006c) reports that the Eurozone retail banking markets continue to be fragmented. In contrast, the Euro area interbank (or wholesale) markets and capital market related activities show solid signs of increasing integration. Shuller (2002) finds that the market for loans to households is less integrated than the enterprise loans market, and the market for mortgages more integrated compared to consumer credit. He finds the European time deposit market to be quite integrated, but the savings accounts market less. Some studies find higher competition and integration in markets compared to previous periods. Heffernan (2001) finds an increase in competition for savings accounts in the 1990s compared to 1980s. Baele (2004) finds that loan rates across Euro countries are more uniform than in the past, while the adjustment speed is faster after the introduction of the Euro.

Other studies find that different type of firms or firms in different geographical areas offer different rates for the same products. Heffernan (2004), in a UK retail market study, finds that converted building societies offer lower deposit and higher mortgage rates. The reverse is found for building societies, however, as they offer higher deposits and lower mortgage rates. Ashton (2001) finds significant variation in deposit accounts offered in different post code areas. Biehl (2002) finds price dispersion among retail products in different cities for the 10 largest financial institutions.

2.5.4 Studies that examine the determinants of interest margins between bank retail rate and cost of funds rate

Section 2.5.4 describes the literature on the determinants of interest rate. Broadly speaking we can divide the literature on determinants of interest rates into 3 categories; (i) market structure, (ii) bank specific factors (iii) macro-economic factors. In the following sections we look at the literature and findings about these categories in detail.

2.5.4.1 Banking Market Structure Variables (Degree of Competition and Bank Concentration)

Competition in the banking sector is very much desired for driving successful transmission of monetary policy. Competition among bank and non-bank financial markets brings about profit-maximising behaviour. The traditional SCP hypothesis asserts that if higher market concentration is a good proxy for less competition, there should be a positive relationship between the bank interest margins and the degree of market concentration. This may reflect the fact that in highly concentrated or low competitive markets banks set low interest rates on deposits and high interest rates on loans.

Berger and Hannan (1989) provide strong evidence of a negative relationship between deposit rates and market concentration in the US. Neumark and Sharpe (1992) also find evidence that in concentrated markets deposit rates rise more slowly and fall faster in response to changes in input costs. They also find that banks offer lower deposit rates in concentrated markets compared to less concentrated ones. These findings indicate a positive relationship between market concentration and interest margins for a given loan rate. For a given interest rate on loans, an increase in concentration reduces the deposit rate, thereby increasing the bank interest margin. Corvoisier and Gropp (2002) also find a positive relationship between concentration and interest margins in a study to examine the determinants of interest rate spreads for different loan products at the aggregate level for 10 euro-zone economies. In a later study, Demiuguc-Kunt et al. (2003) find a direct positive relationship between bank

concentration and margins, although, the impact on net interest margins is not particularly large. Maudos and Guevara's (2004) study of European banking markets over the period 1993 to 2000 finds that the increase in the level of concentration, as a consequence of the wave of mergers that took place in the 1990s, caused a reduction in competitive pressure. They also find an increase in the market power of firms, placing upward pressure on bank interest margins.

More and Nagy (2003) find a negative relationship between interest margins and concentration for the eight new EU member states from CSEE. Claeys and Vennet (2004) find a positive results in a sub-sample of the Western European banking system. However, they find no clear relationship. They also find a negative relationship between bank concentration and margins in various East European countries and suggest this is because of the high proportion of foreign banks that exhibit lower interest margins in these markets. Moreover, there is evidence that greater concentration is associated with a lower probability of a country facing a systemic banking crisis (Demirguc-Kunt and Levine, 2005), therefore a more diverse banking sector might require better supervision. In this context, Crowley (2007), explaining his finding of a negative relationship between concentration and spreads, argues that more diverse banking systems may be more common in countries with well supervised financial sectors since both characteristics may be associated with greater financial sector development. Oversight may increase costs by requiring better provisioning, higher levels of reserves, and limiting credit expansion. This could require banks to charge higher spreads to cover the increased costs.

From a competition point of view, Ruthenberg and Elias (1996) argue that in countries with a small number of powerful banks, the large banks could restrict competition by keeping spreads artificially low. In the case of a large public-sector bank there would be less of a profit constraint because the bank could be recapitalized by the government. Even in the case of a large private bank, there could be an expectation of assistance when needed. Rhoades (1995), Hannan (1997) and Jackson (1997) also find an inverse relationship between spreads and concentration indexes.

To address the relationship between market concentration and bank net interest margins, we employ the Herfindahl-Hirschman index (HHI), calculated as the sum of the squares of the market shares, to proxy for the structure of the market. It is computed using bank-level data from the Bankscope database.

2.5.4.2 Bank-Specific Variables

2.5.4.2.1 Bank size

Flannery (1984) argues that large banks effectively hedge themselves against market rate risk by holding assets and liabilities of similar average maturities. This provides a rationale for why larger banks might charge smaller margins. In addition, economies of scale can lead these banks to operate with lower average costs, which work to reduce margins. On the other hand, Afanasieff et al. (2002) argue that larger banks can have more market power, which is conducive to higher interest margins. Brock and Franken (2002) find a positive relationship between bank size and margins, which has two alternative interpretations: it suggests a link between size and market power or reflects diseconomies of scale.

More recent literature finds greater support for a negative relationship between bank size and margins (for example, Demirguc-Kunt et al. (2003), Levine (2003), Claeys and Vennet (2004). The results of Vaskov et al. (2010), using various model specifications, indicate a significantly negative impact on the interest rate spreads of banks and bank size. Ho and Saunders (1981) also show that smaller banks have a one third of a percent larger spread than larger banks. Abreu and Mendes (2003) also find that large banks tend to have lower interest margins but also lower profits than smaller institutions. In this paper, *Bank size*, measured as the logarithm of total bank assets in thousands of US dollars, is included as a determinant of bank net interest margins.

2.5.4.2.2 Bank equity

Bank equity capital acts as a cushion against credit risk. Normally, banks hold more capital than required for regulatory purposes because of their greater aversion to risk (McShane and Sharpe, 1985) or additional credit risk exposure (Hellmann, Murdock,

and Stiglitz, 2000). The more capital the bank has, then the more stable it is, and risk averse. Alternatively, banks have the possibility to increase their portfolios of risky assets. In a growing market, banks may benefit from the enhanced risk adjusted returns and, hence, increased interest margins. In addition, since equity is a more expensive funding source than debt (bank deposits), an increase in equity capital may increase the average cost of capital. Thus, banks with relatively high capital ratios (total capital to total assets) for regulatory or credit reasons need to charge higher net interest margins to compensate for the higher capital costs (Saunders and Schumacher, 2000). Claeys and Vennet (2004), however, argue that holding higher levels of equity, which is more expensive than other forms of liability, is a credible signal of creditworthiness on the part of banks. This may enable them to lower deposit funding costs because of increased credit rating, and hence increase interest margins. By any means, however, a positive relation is expected.

Previous literature consistently finds a positive relationship between bank margins and the ratio of equity capital to total assets. On the other hand, Wong (1997), Afanasieff et al. (2002), and Brock and Franken (2002) find a negative relationship, although the coefficients are not statistically significant.

2.5.4.2.3 Liquidity ratio

Liquidity risk relates to not having sufficient cash or borrowing capacity to meet deposit withdrawals or new loan demands, thereby forcing banks to acquire funds at excessive cost (Angbazo, 1997). A bank with a relatively high level of liquid assets is better prepared to meet these unforeseen contingencies. Liquidity stored in its balance sheet also serves as a cushion or buffer against losses arising from the 'fire-sale' of assets to meet liquidity need. Hence, sufficient liquidity may mean less liquidity risk, which may reduce interest margins due to a lower liquidity premium charged on loans (Afanasieff et al., 2002). In addition, banks with higher levels of liquid assets in cash and government securities may mean fewer available assets can be used to generate interest income, which could lead to lower net interest margins. Thus, if Liquidity is

defined as the ratio of liquid assets to total assets, a negative sign on the coefficient would be expected.

Empirical results from previous literature are conflicting. Brock and Suarez (2000) find that the liquidity ratio is positively correlated with the interest rate spread for all Latin American countries considered, and statistically significant for Bolivia, Colombia, and Peru, indicating the impact of holding low yielding short-term assets. The results of Vaskov et al. (2010) from various model specifications indicate a significant and positive impact of liquidity on the interest rate spreads of banks. Aliaga-Diaz and Olivero (2005) find no conclusive evidence of the relationship between the liquidity of bank portfolios and margins. While Angbazo (1997), Drakos (2003), Levine (2003), and Doliente (2005) find a significant negative relationship between the two, which may reflect the lower remuneration on liquid assets.

2.5.4.2.4 Diversification

Increasingly banks have moved away from focusing on generating interest income towards the earning of fees. Gischer and Juttner (2003) identify five factors driving this trend. First, the deregulation of interest rates creates more competitive markets and banks are forced to find other ways to generate income. Second, the development of technology and application of advanced financial models encourages trading and dealing in currencies, securities, commodities and their associated derivatives. Third, increased direct and indirect personal wealth improve fee-generating fund management activities. Fourth, the rapid growth in international trade provides opportunities to earn fees (for instance, by arranging letters of credit). Fifth, investment banking and other financial consulting services create more fee earning opportunities.

Levine (2003) argues that banks have different product mixes. These differences may influence the pricing of loan products. Banks with well-developed fee generating activities may produce lower interest margins due to the cross-subsidization of bank activities. Valverde and Fernandez (2007) note that diversified banks may be in a strong position to compete against a specialized rival because the former can draw on

profits earned from non-interest activities, effectively cross-subsidizing the costs of engaging the rival in price competition (by reducing lending rates or increasing deposit rates). Assuming that there are barriers to entry, a diversified bank might undercut the specialized bank's prices in an attempt to force it out of the market.

From an efficiency perspective, De Yong and Rice (2004) argue that a well-managed bank will set fees to fully exploit market demand, and will cross-sell additional fee-based products to a larger percentage of its core customer base. Thus, holding the product mix and banking strategy constant, the intensity of non-interest income is likely to be a forward-looking signal of financial success. Thus, an efficient bank should generate larger amounts of non-interest income. In turn, higher efficiency may lead to lower net interest margins. However, Stiroh and Rumble (2006) suggest that diversification gains are frequently offset by the costs of increased exposure to volatile activities. Similarly, Laeven and Levine (2007) find agency problems in financial conglomerates engaged in multiple activities and propose that economies of scope are not sufficiently large to produce a diversification premium. From their point of view, higher non-interest income may not necessarily mean higher efficiency, and, in turn, lower net interest margins.

After examining features common to banks that are heavily engaged in non-traditional areas, Rogers and Sinkey (1999) suggest that such banks tend to have smaller net interest margins, relatively fewer core deposits, and less risk. This may mean that traditional forms of intermediation are less profitable and banks may benefit from the diversification of earnings from non-traditional activities. Gischer and Jiittner (2003), Demirguc-Kunt et al, (2003) and Doliente (2005) also provide evidence that a negative relationship exists between the non-interest income of banks and margins.

2.5.4.2.5 Credit risk

The risk of non-repayment or default on a credit (credit risk) requires banks to apply a risk premium implicitly to interest rates charged for their operations. Furthermore, to better manage increasing credit risk, banks may incur additional expenses to

intensify their monitoring of loans (Barajas, Steiner, and Salazar, 1999). Thus, banks with more credit risk tend to require higher net interest margins for compensation.

Empirical results are consistent with this hypothesis. As a measure of credit risk exposure, Angbazo (1997) employs net charge-offs (NCO), based on the difference between loans actually written off and recoveries on loans previously classified as uncollectible. He also uses two alternative measures of loan portfolio risk (allowances for loan losses and provision for loan losses) for robustness tests. His study finds the default risk proxy to be both significant and positive, which is consistent with the prediction that banks with more risky loans earn higher net interest margins. Wong (1997) considers a firm theoretical model to explain optimal bank interest margins under multiple sources of uncertainty and risk aversion. In his framework, an increase in credit risk is reflected by a higher optimal loan-deposit interest rate spread. Brock and Rojas-Suarez (2000) find that higher non-performing loans are related to higher spreads. More and Nagy (2003) find a positive relationship between interest rate margins and credit risk exposure for eight new EU member states from CSEE. Barajas, Steiner and Salazar (1999) find spreads widened in Columbia in the 1990s as a result of high non-performing loans of the public banks and private banks' greater responsiveness to credit quality. Loan loss provisions as a proxy for bank credit risk, as reported by Vera et al. (2007), is a significant factor contributing to the widening of interest spreads, indicating that banks may have had to commit additional resources to deal with changes in loan quality. Drakos (2003), Abreu and Mendes (2003), and Valverde and Fernandez (2007) also find empirical support for the positive relationship between credit risk and bank margins.

Brock and Suarez (2000), however, report a different scenario. Using the ratio of nonperforming loans to total loans as a measure of credit risk, they find that nonperforming loans are associated with smaller spreads in all seven Latin American countries examined, except Colombia. Two possible explanations are proposed. First of all, the result could be the consequence of inadequate provisioning for loan-losses: higher nonperforming loans would reduce bank income, thereby lowering spreads in the absence of adequate loan-loss reserves. Second, banks with a high proportion of

bad loans may offer lower spreads as a high-risk, high-growth strategy to grow out of their difficulties, especially if regulatory authorities are reluctant to close banks that are in trouble.

Doliente (2005) finds mixed results in his study of Southeast Asian banking markets. Results for Indonesia and Thailand concur with the findings for Latin American reported by Brock and Suarez (2000), where declines in loan quality are significantly associated with lower net interest margins. Results for the Philippines and Malaysia, however, lend support to a positive relationship.

2.5.4.2.6 Bank reserves

The existence of non-interest-bearing reserve requirements set by central banks, increases the cost of funds over and above the published interest expense. The opportunity cost of reserves relates to the average return on earning assets foregone by holding deposits in cash. This additional cost factor will depend on the size of reserve requirements, as well as the opportunity cost of holding reserves (Saunders and Schumacher, 2000), To compensate for this, banks may increase their net interest margins. On the other hand, one may expect that if banks hold too much cash, which could have earned interest, as reserves, this will reduce their ability to generate interest income and, in turn, lead to lower interest margins.

By measuring the opportunity cost of reserves as the ratio of non-interest-bearing assets to total assets, Angbazo (1997) finds a positive relationship between bank reserves and margins, indicating that non-interest-bearing assets do not impose a negative reserve burden. Saunders and Schumacher (2000) also report positive and significant coefficients on the opportunity cost variable in most countries and years. Chirwa and Mlachila (2004) find that spreads in Malawi increased after financial liberalization because of increases in reserve requirements and provisioning. By introducing liquid reserves to represent bank reserves, Maudos and Guevara (2004) find the expected positive sign, though the variable is not statistically significant.

Demirguc-Kunt and Huizinga (2000), on the other hand, find a negative and significant coefficient on the non-interest-earning assets over total assets variable. In addition, by interacting the ratio of non-interest-earning assets over total assets with per capita GDP, they find that in wealthier countries the presence of non-interest assets depresses net interest income and profitability more than in poorer countries.

2.5.4.2.7 Managerial efficiency

Efficiency in delivering banking services constitutes an important determinant of the profitability of banks. A lowering of the cost ratio, and hence higher managerial efficiency, is expected to increase profitability. With regard to net interest margins, Angbanzo (1997) argues that good management implies selecting highly profitable assets and low-cost liabilities, therefore resulting in higher net interest margins. The opposite view, as suggested by Abreu and Mendes (2003), is that higher operational efficiency induces banks to pass the lower costs on to their customers in the form of lower loan rates and/or higher deposit rates, thereby lowering net interest margins.

Measuring managerial efficiency as the ratio of total loans to the number of employees, Brock and Franken (2002) find a negative and statistically significant relationship between efficiency and bank margins. A decrease in this ratio may be driven by lower levels of efficiency or the provision of better quality services, which requires devoting more human resources for each unit of loan. As a result, banks incur more costs and, in turn, lower net interest margins. Gischer and Juttner (2003) also find that margins are negatively influenced by managerial efficiency, measured by the cost-to-income ratio.

In the current study, the quality or efficiency of management is proxied by the cost-to-income ratio, defined as the operating cost necessary to generate one unit of gross income. A decrease in this ratio implies an increase in the efficiency or quality of management. According to the discussion, a negative sign on the coefficient is expected.

2.5.4.2.8 Market share

Berger (1995) finds support for the relative-market-power hypothesis, which asserts that only firms with large market shares and well-differentiated products are able to exercise market power in pricing these products and earning supernormal profits.Similarly, Peria and Mody (2004) provide arguments from the perspective of larger banks. To the extent that market share gets translated into market power, banks with higher shares of the market may be able to charge higher rates on loans. On the other hand, larger banks may be able to reap economies of scale and may pass on some of these benefits to their customers in the form of lower spreads.

Ruthenberg and Elias (1996) argue that there is no *a priori* indication as to the explanatory power of the market share variable. On the one hand, small banks normally extend credit to more risky customers and charge a higher risk premium, reflected in a higher interest rate margin. It can be argued that smaller banks, in an attempt to increase their competitiveness with larger banks, will lower their loan rates and/or increase their deposit rates, and thus lower their margins.

Demirguc-Kunt et al (2003) examine market share (in a robustness test) and find a positive and significant relationship between market share and bank margins, supporting the view that banks that are relatively large can exert market power to increase rates. In their comparative analysis of the determinants of bank net interest margins in Central, Eastern and Western Europe, Claeys and Vennet (2004), however, find no clear relationship between market share and margins in the full sample or for Western European banks. The Eastern European banks provide some evidence of a positive relationship but the statistical significance is not strong. Abreu and Mendes (2003) also find that market share is insignificant in explaining variations in net interest margins. The results of Vaskov et al. (2010) from various model specifications indicate a significant and positive impact on the interest rate spreads of banks and market share.

2.5.4.3 Macroeconomic variables

The macroeconomic environment affects the performance of the banking sector by influencing both the ability of customers to repay borrowed loans as well as the demand for loans. With an unstable macroeconomic environment and/or poor economic growth, investors face uncertainty about investment returns and these raise lending rates as the level of non-performing loans increases, squeezing bank margins (Ngugi, 2001).

To capture the important impact of domestic macroeconomic conditions on the determinants of bank net interest margins, the current study includes three macro-economic variables: inflation, real GDP growth and stock market capitalization.

2.5.4.3.1 Inflation

A growing body of theoretical literature describes mechanisms whereby increases in the rate of inflation can interfere with the ability of the financial sector to allocate resources effectively. More specifically, recent theories emphasize the importance of informational asymmetries in credit markets (or credit market friction). Generally, an increase in the rate of inflation drives down the real rate of return on assets, which exacerbates credit market frictions. For example, lower real rates of return reduce agents' incentives to lend and increase their incentives to borrow. Consequently, lower real returns can reduce the availability of credit and draw additional lower quality borrowers into the pool of credit seekers. The diminished availability of funds and erosion in the quality of the borrower pool increases the severity of credit market frictions. As a result, the financial sector makes fewer loans, resource allocation is less efficient, and intermediary activity diminishes with adverse implications for capital investment (Boyd, Levine, and Smith, 2001). The diminishing intermediary activity of financial institutions may lead to higher bank net interest margins, as discussed previously.

Abreu and Mendes (2003) also state that high inflation is associated with high nominal interest rates and may also be viewed as a proxy for poor macroeconomic management. High inflation is often associated with higher relative price volatility, which makes the accurate assessment of credit and market risks more difficult. Overall, one may expect higher inflation to be associated with higher net interest margins.

This relationship is further confirmed by empirical studies. Boyd, Levine and Smith (2001) find a significant, and economically important, negative relationship between inflation and banking sector development. In turn, lower levels of development can be seen as related to increased net interest margins. Saunders and Schumacher (2000) present evidence for margins increasing with higher interest rate volatility, which can also be associated with high and variable inflation. Demirguc-Kunt and Huizinga (2000) provide evidence that bank profits increase in inflationary environments. Demirguc-Kunt et al. (2003) show that inflation has a robust, positive impact on bank margins and overhead costs. Brock and Suarez (2000) find a higher inflation rate raises the spread in Bolivia, Colombia, Chile and Peru, but not in Argentina. Generally, inflation brings higher costs (deposit rates) but also higher income (loan rates). However, Abreu and Mendes (2003) find that for small and medium-sized banks, revenues increase more than bank costs, indicating higher net interest margins, while the same reasoning does not apply to large banks, which seem to be unable to transfer higher nominal costs to customers.

A negative relationship between inflation and bank margins has rarely been found, with the exception of Crowley (2007), who examines the characteristics of banking systems in English-speaking African countries for the period 1997 to 2000. He explains the phenomenon of inflation associated with the presence of large dominant banks that lend irresponsibly. Large state-owned banks and dominant banks, which are not state-owned but can be pressured by the government, would also fit this pattern. The relationship could even be affected simply by government interference in the banking sector, whereby the authorities are willing to subjugate sound economic

management to political considerations, including by pressuring banks to lend at low rates to support the economy.

2.5.4.3.2 Real GDP growth

The effect of output growth on net interest margins can be either positive or negative. According to Afanasieff et al. (2002), on the one hand, higher output growth signals a greater demand for bank loans, leading banks to charge more on their credits. On the other hand, to the extent that economic growth is indicative of increased competition, one can expect that lower spreads are associated with stronger growth.

According to Abreu and Mendes (2003), in adverse macroeconomic conditions, banks may suffer from increasing shares of non-performing loans. In other words, deteriorating macroeconomic conditions are associated with reduced bank performance. A positive relationship between GDP growth and business opportunities for banks, or improved bank performance, can therefore be expected.

The empirical evidence is also ambiguous. Abreu and Mendes (2003) provide evidence that net interest margins, as well as returns on average equity, are positively affected by the GDP growth rate. In contrast, Levine (2003) shows that economic growth is negatively associated with net interest margins (at the 10 percent significance level), so it is weakly associated with a fall in margins. Claeys and Vennet (2004) include real GDP growth to proxy for business cycle fluctuations, and find a positive association between the business cycle and bank margins in Western European banking systems, a reflection of more lending and lower default rates. In Eastern Europe, no such relationship is found. This may be explained by the relatively high volatility of the business cycle in transition economies, where periods of economic growth are sometimes interrupted by periods of crisis. Others (for example: Brock and Suarez, 2000; Demirguc-Kunt and Huizinga, 2000) find no clear relationship between real GDP growth and bank net interest margins.

In our model, real GDP growth is used as a measure of macroeconomic performance.

2.5.4.3.3 Degree of financial deepening

Corvoisier and Gropp (2002) examine the determinants of interest rate spreads for different loan products at the aggregate level for the 10 Eurozone economies. The results of the study suggest that interest rate spreads are positively correlated to the level of concentration in the banking sector and the degree of financial deepening of the economy. However, the estimated positive sign of the financial deepening variable (measured by the credit-to-GDP ratio) is not in line with standard *a priori* expectations that imply a reverse relationship. The authors suggest this is because when the financial deepening indicator is higher, then economic agents are more dependent on bank loans, the market power of banks increases, and thus they can set higher spreads. Regarding the transition economies, More and Nagy (2003) investigate how some macroeconomic and bank financial characteristics determine spread-setting among banks in the eight new EU member states from CSEE. Their results from a panel data model suggest that of the macroeconomic factors included only the level of financial deepening plays a significant and negative role on spread setting decisions, consistent with the findings of Corvoisier and Gropp (2002) and other studies discussed above.

2.6 Conclusion

In summary, the studies on interest rate stickiness and heterogeneities these provide consistent evidence that *LRPT* shows less than one to one transmission, and short-run pass-through is sticky and incomplete. The pass-through parameters show heterogeneities within and across countries, and across different products for short- and *LRPT* (de Haan 2001; de Bondt 2005; Hulseqig, 2009; Mojon, 2000). These findings are in line with the findings of the BIS (1994) report and other researchers. However, other studies also provide some important results. Some studies report relatively fast and complete pass-through for certain products, but weak and incomplete pass-through for other products.

Some studies find pass-through in one country higher compared to other countries (Chmielewski, 2003; de Graeve et al., 2007; Donnay and Degryse, 2001; Mojon, 2000), Ozedemir (2009), Burgstaller (2005), Aydin (2007)). There is also evidence of stronger pass-through in CEE countries compared to Eurozone countries (Kleimeier and Sander, 2007; Egert, 2007). On the other hand, there is evidence that developed and stronger economies seem to have much higher *SRAS* and complete pass-through (Wang and Lee, 2009; Kwapil and Scharler, 2010). There is evidence of impaired IRPT during the financial crisis period (Cihák, Stavrev, and Harjes, 2009; Hristov, Hülsewig, and Wollmershäuser, 2012). However, Jobst and Kwapil (2008) do not find evidence of impaired pass-through during the crisis.

Most of the studies on Integration, competition and *The Law of One Price* find the common evidence that financial markets are still quite dispersed. There is very low competition, less integration and the Law of One Price does not apply for the same product types within the same country across the Eurozone. However, integration and pricing competition varies according to product type, market type, and type of target customer to whom a product is offered. For example, some studies observe significantly different levels of integration and competition for different products. Heffernnan (2001) finds substantially less competition for high and low savings, high chequing, credit cards, and personal loans. Heffernan (2004) finds information asymmetries, which indicate that firms' pricing behaviour differs depending on the product. For example, some firm's price competitively in the new borrower mortgage market and offer better rates to new customers compared to existing ones. The ECB (2006c) finds that the dispersion in loans to households for house purchases is lower compared to loans to household for consumption purposes.

In summary, the empirical studies investigating the determinants of bank interest rate margins that have been assessed in this section point to similar results to those found in the studies surveyed in the previous two subsections. The findings presented are also largely in line with the theoretical predictions. The major macroeconomic determinants of interest rate margins are identified as inflation and economic growth. The major indicators for the financial system are estimated to be the money market

rate volatility and level of concentration in the banking sector. The most significant bank balance sheet characteristics are: credit risk and interest rate risk exposure, liquidity and capital ratios, operating costs and the extent of portfolio diversification.

3 INTEREST RATE TRANSMISSION IN UK BANKS AND BUILDING SOCIETIES FOR LENDING AND DEPOSIT PRODUCTS

3.1 Introduction

3.1.1 Motivation for the study

The banking sector of the financial system in an economy plays an important role in transmitting the monetary policy stance of its central bank. A well-functioning sector contributes to economic growth, welfare and smooth business cycles. Banks act as the conduit through which monetary impulses from the central bank are transmitted to the rest of the economy. In all industrialised countries, central banks, including the BoE (Bank Of England), conduct monetary policy through the retail rate channel. The BoE sets the official rate with the aim of influencing aggregate demand and prices, which, in turn, serves the purpose of targeting inflation. The IRPT (Interest Rate Pass-Thgough) is defined as the degree and speed of adjustment of the retail rate due to changes in the monetary policy rate (Aydin, 2007).

Monetary policy is considered effective if changes in the PR (Policy Rate) are completely passed to the retail rate over a reasonably short period (Hofmann and Mizen, 2004). By implication, the activities of banks and their position as intermediaries make them relevant in the transmission of the central bank's monetary policy impulses to the rest of the economy (Ahumada and Fuentes, 2004, p. 1). A key aspect of monetary policy transmission is the speed at which central bank changes are transferred and reflected in the deposit and lending rates of commercial banks.

The effectiveness of the monetary policy largely depends on how commercial banks change their lending and deposit rates following a change in their central bank's PR. How effective these tools of monetary policy are largely depends on the speed and the magnitude of the adjustment applied by commercial banks to their lending and deposit rates following a change in the PR. The effectiveness of a central bank's monetary

policy is also crucial for the stabilization of inflation and other economic activities in the economy. If the policy is to be effective, changes in the PR should be transmitted to the retail rate quickly, and the magnitude of the change should be large enough to influence investment, consumption and the aggregate demand in the economy (Aziakpono and Wilson, 2010, p. 3).

In general, the studies on IRPT find a small degree of pass-through and a slow adjustment speed. Therefore, it is important to find out how fast and how much the retail rate responds to changes in the official rate. Recently, monetary authorities in the UK have had to face more challenges because of the global financial crisis. Recent studies have found that post-crisis pass-through has been impaired. There is evidence found of impaired IRPT during the financial crisis period Cihák, Stavrev, and Harjes, (2009) and Hristov, Hülsewig, and Wollmershäuser, (2012). However, Jobst and Kwapil (2008) do not find evidence of impaired pass-through during the crisis. Because of the crisis, an unconventional monetary policy, *quantitative easing* (QE), was adopted and the Monetary Policy Committee (MPC) of the UK cut the official rate to 0.5% in 2009. In August 2016, the official rate was further reduced to 0.25%, then in November 2017, for the first time in 10 years, rose from 0.25% to 0.5%. It is, therefore, useful to investigate IRPT in the UK banking market post-crisis to see whether the pass-through is impaired or has it become more efficient?

Past studies conducted on IRPT in the UK banking market mostly used only one or two products. For example, the study of Becker et al. (2012) analyses only mortgage rates, while Panagopoulos, Reziti, and Spiliotis (2007) consider only deposit and loan rates; similarly, Hofmann and Mizen (2004) cover deposit and mortgage rates only. In terms of structure, the UK financial sector has undergone changes in terms of competition and ownership. There has been the entry of foreign banks, as well as a number of mergers and acquisitions. These changes will have an impact on competition, which will invariably affect the IRPT.

In light of the limitations of earlier studies, the present study extends the previous work in three aspects. First, it examines the short- and long-run dynamics of adjustment to

official rate changes of 13 retail rates for six mortgage, three lending and four deposit products, thereby extending the number of retail rates covered in previous studies. Second, the study seeks to identify changes in the behaviour of UK banks in setting their retail rates by using a data set that covers a longer period of time (January 1999 to April 2012). Third, the present study includes data since the financial crisis, which facilitates analysis of any changes in retail rate pass-through arising from the MPC's lowering of the official rate to 0.5 percent.

3.1.2 Research Questions

This study uses a large sample of aggregated data to shed light on how bank retail rates for deposit, lending and mortgage products respond to changes in PRs. The main goal of the study is to analyse the dynamic adjustment of UK bank and building society interest rates in response to PR changes.

The main research question is: how complete and efficient is UK monetary policy transmission mechanism before and after the financial crisis for different financial products? Accordingly, the study poses the following questions:

- How complete and homogeneous is the UK monetary policy transmission mechanism before and after the financial crisis for deposit, lending and mortgage products?
- How long does it take for a change in PR to be transmitted to deposit, lending and mortgage rates?
- How complete and homogeneous is the competition prevailing in the financial market for different types of financial products?
- How do banks price different financial products in the market by considering the mark-up/-down?

3.1.3 Structure of the paper

Section 3.1 is the introduction, comprising the motivation for the study; monetary policy framework in UK; research questions and objectives; and structure of the paper.

Section 3.2 describes data sources and gives details of data collection; it also provides definitions and abbreviations for the financial products. Section 3.3 comprises a brief literature review, focusing on those studies closest to the present one. Section 3.4 describes the methodology used in this paper; it presents the study's econometric model, provides definitions of variables, and explains the mechanics of the tests used. Section 3.5 presents results and discussion; it provides descriptive statistics and discusses empirical results and their interpretation for both the pre- and post-crisis periods. Section 3.5 reports results and discussions for pre-crisis and post-crisis period. Finally, section 3.6 provides concluding remarks.

3.1.4 Monetary Policy in the UK 1999–2014

Monetary policy transmission has several channels (interest rate, bank lending, balance sheet, asset prices, exchange rate, and expectation channels), through which monetary policy stance of the central bank is transmitted to the rest of the economy. The traditional interest rate channel is considered to be the first link in the monetary policy transmission process, and it is the most important channel in the transmission mechanism owing to the fact that it cannot be isolated from the other channels of the monetary policy transmission mechanism (Baugnet et al., 2007: 2; Ozdemir, 2009: 8; Wang and Lee, 2009; Samba and Yan, 2010).

Commercial banks are very relevant in transmitting central banks' monetary policy via two channels; traditional interest rate channel and lending channel. Monetary policy is effective through the interest rate channel when the central banks' adjustments to PR have an impact on the real interest rates which are charged by commercial banks to their customers and, ultimately, on investment and consumption in the economy. The interest rate channel is effective if commercial banks quickly transmit the changes in the monetary policy interest rate to their customers, if it's not transferred immediately it become ineffective.

The interest rate channel is the core link in the monetary transmission mechanism and has been a key tool in the Keynesian IS-LM framework, which indicates that a change in the monetary policy stance, for instance an expansionary monetary policy, may

affect aggregate demand in the economy. This has been a key emphasis of the Keynesian monetary transmission mechanism in the IS-LM and AD/AS models. Mishkin (1996: 2) provides a schematic, which shows the effect of an expansionary monetary policy as follows:

Expansionary monetary policy ⇒ ir ↓ ⇒ I ↑ ⇒ Y ↑

The above schematic implies that an expansionary policy leads to a fall in real interest rates (ir↓), which in turn lowers the cost of capital, causing a rise in investment spending (I↑), thereby leading to an increase in aggregate demand and a rise in output (Y↑).

However, when nominal interest rate is at zero, a commitment to future expansionary monetary policy can raise the expected price level (Pe↑) and hence expected inflation (πe↑), thereby lowering the real interest rate (ir↓) even when the nominal interest rate is fixed at zero and stimulating spending through the interest rate channel as the schematic below depicts:

Expansionary monetary policy ⇒ Pe ↑ ⇒ πe ↑ ⇒ ir ↓ ⇒ I ↑ ⇒ Y ↑

The above mechanism indicates that monetary policy can still be effective when real interest rates have already been driven down to zero by the monetary authorities.

The BoE is an independent body whose MPC (Monetary Policy Authority) conducts monetary policy in the UK. The MPC, established on 6th May 1997, was designed to be independent of any political influence and was officially given the operational responsibility for setting interest rates under the Bank of England Act, 1998. HM Treasury (HMT) appoints the members of the MPC and sets the monetary objectives and inflation target for the monetary policy. In this framework, the BoE, via the MPC, decides on the instrument to be used to meet the objective(s) and inflation target set by HMT. The BoE, therefore, has instrumental independence.

The bank's monetary policy objective is to deliver price stability and low inflation, to support the government's economic objectives, including those for growth and

employment. Price stability is defined by the government's set inflation target of 2%. The remit recognises the role of price stability in achieving economic stability more generally, and the need to provide the right conditions for sustainable growth in output and employment. The 1998 Bank of England Act made the bank independent as regards setting interest rates, although it is accountable to parliament and the wider public. The legislation provides that, in extreme circumstances, if the national interest demands it, the government has the power to give the bank instructions on interest rates for a limited period.

The inflation target of 2% is expressed in terms of an annual rate of inflation, based on the Consumer Price Index (CPI). The remit is not to achieve the lowest possible inflation rate, since inflation below the target of 2% is judged to be just as damaging as inflation above the target. The target is therefore symmetrical. If it is missed by more than 1 percentage point on either side; that is, if the annual rate of CPI inflation is more than 3% or less than 1%, the governor of the BoE must write an open letter to the Chancellor of the Exchequer explaining the reasons why inflation increased or fell to such an extent, and outlining what the bank proposes to do to ensure inflation comes back to the target.

The bank seeks to meet the inflation target by setting an interest rate. The level is decided by the MPC, chaired by the Governor of the BoE. The MPC meets monthly for a two-day meeting, usually on the Wednesday and Thursday after the first Monday of each month. Decisions are made by a vote of the Committee on a one-person-one-vote basis.

Figure 3-1 shows a comparison of BoE official rates and inflation measures for the period 1999-2012. For the period 1999 to the end of 2003, the Retail Price Index (RPI) is used as the inflation measure; from 2004 onwards, the CPI is used. The original target of inflation was 2.5% on the RPI-X measure of inflation by the MPC. Later, in 2003, it was set to 2% CPI. Under the Bank of England Act, the Governor was obliged to write the first MPC open letter to the Chancellor of the Exchequer on 16 April 2007, explaining why inflation had deviated from the set target of 2% and reached 3.1%.

Figure 3-1 shows that the years 1999 to 2003 witnessed a period of price stability, during which inflation stayed within a percentage point of the target. The RPI averaged 2.17% against the target of 2.5% around this period and never deviated from the target by more than 1% (in either direction). The highest inflation was in the year 2000, when it averaged 2.93%. The BoE official rate for this period was 4.83%, with the highest average interest rate of 5.96% in 2000. The BoE official rate and RPI inflation rate moved in line from 1999 to 2003, which explains why the official rate movements correlated with the RPI inflation rate.

Over the CPI target period from 2004 (first quarter) to 2012 (first quarter), CPI inflation averaged 2.39% against the target of 2%, with inflation rising from 2004 to 2008. In the years up to 2007 Q4, CPI inflation averaged 2.01%, but during the crisis period, from 2008 Q1 to 2012 Q1, it averaged 3.39%. It then rose to 4.77% in 2008 Q3 before falling to 1.50% in 2009 Q3. However, in 2011 the level peaked at 5.30%. The BoE official rate from 2004 to 2012 Q1 was 3.19%, but averaged 4.79% from 2003 to 2007. The decline that followed was due to the change in the official rate to 0.5% in 2009 to tackle the financial crisis. In the first 10 years of the MPC, interest rates ranged from 3.5% to 7.5%. The base rate was cut six times between October 2008 and March 2009 to a record low of 0.5% to avoid rising inflation and increase growth.

The financial crisis, and the aftermath of the worst global recession since the 1930s, posed a number of challenges for central banks. The main challenge was to take the economy into sustainable recovery. There are many different issues to be considered here. The first is the *Zero Lower Bound* on nominal interest rates. A *Taylor rule* is a rule that stipulates how much the central bank should change the nominal interest rate in response to changes in inflation, output, or other economic conditions. In particular, the rule stipulates that for each 1% increase in inflation, the central bank should raise the nominal interest rate by more than 1%. Due to depth of the recession, the Taylor rule would recommend a negative nominal interest rate, but market interest rates are in effect bounded close to zero (agents can always hold non-interest-bearing cash). A

central bank, therefore, needs to do something else besides setting interest rates near zero.

The second problem arises due to the disruption of the financial system. Given the scale of losses incurred in the aftermath of the bubble bursting, the solvency of many banks and borrowers was called into question. The result was that the usually reliable relationship between changes in official interest rates and market interest rates broke down, again leading central banks to consider other forms of intervention. Related to this, were fears that banks were holding onto funds to improve their viability rather than lending on to the private sector, and this required some central banks to intervene with the direct provision of credit.

As a result, conventional monetary policy proved ineffective, since the official rate could not be changed in line with the Taylor rule; it did not impact on market rates in the expected way, and problems with financial intermediation meant that the usual monetary transmission mechanisms were not working. When central banks hold to the belief that, when recovery occurs, conventional monetary policy and macro-prudential tools will achieve price and financial stability, the challenge is to aid the economy in its recovery so as to reach that point. This is the challenge facing central banks, and explains why they have turned to unconventional monetary policy.

The high-profile form of unconventional monetary policy has been QE. The phrase was first applied in Japan as it dealt with the bursting of the real estate bubble, and the deflationary pressures that followed, in the 1990s. The phrase *quantitative easing* was introduced to signal a shift in focus towards targeting quantity variables. With interest rates at their zero lower bound, the Bank of Japan aimed at purchasing government securities from the banking sector and thereby boosting the level of cash reserves the banks held. The hope was that, by targeting a high enough level of reserves, this would eventually spill over to lending in the broader economy, helping drive asset prices up and removing deflationary forces. The central banks of the US, the Euro area and the UK have all followed Japan in adopting policies that have led to substantial increases in the size of their balance sheets, although there are significant differences both

among themselves and with Japan in terms of how they have implemented QE. The BoE has bought UK government bonds from the non-bank private sector through its QE operations; the Fed has bought US Treasuries, but also large quantities of agency debt and agency-backed mortgage backed securities (Joyce et al., 2012).

In March 2009, the MPC launched a programme of QE, initially injecting £75 billion into the UK economy. By March 2010, it had also increased the amount of money set aside for QE to £200 billion, a figure subsequently increased by a further £75 billion in the months following October 2011. The MPC announced two further £50bn rounds of QE in February and July 2012, bringing the total to £375 billion, while simultaneously keeping the base rate at 0.5% till the first quarter of 2016. In the first quarter of 2016 MPC reduced base rate to 0.2% till the end of 2017. From the end of 2017 the MPC started increasing base rate gradually from 0.2% to 0.8% by the end of 2018.

3.2 Data Collection

The present study uses data from banks and building societies in the UK, collected from the BoE website, published on 14 August 2014. The retail rate data were downloaded for deposit and lending products quoted to households by UK banks.

3.2.1 Sources and BoE Methods of Data Collection

The data for retail rate series are calculated monthly, as weighted averages for a range of lending and deposit products offered to households. The headline rates, advertised by a sample of banks and building societies, are collected and weighted together, using the monthly balances, or new business volumes, reported by those institutions on BoE statistical forms. The weights used to produce the weighted average series are derived from the end of month or average monthly balances, or new business volumes, reported by those institutions on BoE forms. These weights are then applied to the interest rates for individual banks and building societies. The sample is based on Effective Interest Rates and presents at least 75% of monetary financial institutions (MFIs').

Rates are included only for those institutions that advertise a product closely fitting the definition used for each series, with the result that the banks and building societies in the sample and the percentage coverage may vary from month to month. The data available also varies because institutions withdraw products and introduce others to the market.

(http://www.bankofengland.co.uk/statistics/pages/iadb/notesiadb/Household_int.aspx)

3.2.2 Data Sample

The data is aggregated monthly data for banks and building societies for the period January1999 to April 2012 for 13 products: six mortgage, three lending, and four deposit products. The six mortgage products are: Tracker Mortgage to Household (TR), 2-Year Fixed Rate Mortgage (2Y-FIX), 3-Year Fixed Rate Mortgage (3Y-FIX),

5-Year Fixed Rate Mortgage (5Y-FIX), 2-Year Variable Mortgage (2Y-VR), and Standard Variable Rate Mortgage (ST-VR). The three lending products are Credit Card Lending (CCL), Personal Loan 10K (10K) and Overdraft (OD). The four deposits products are Instant Access Account (INSTANT), Fixed Rate Bond (BOND), Cash ISA Account (ISA) and Time Deposits (TIME).

Data sample is divided into pre- and post-crisis period after the results of chow tests, which means that one single model for the period will render instable regression coefficients. The Chow test is a statistical and econometric test of whether the coefficients in two linear regressions on different data sets are equal. The results for the chow test are presented in appendix from Table 7-1 to Table 7-4. All the tests except one are significant; which means that we reject the null hypothesis of one single model and accept the alternate hypothesis that a structural break in data is needed. One single model for the data sample will render instable regression coefficients. To determine when to take a break we use the Bai-Perron (2003) sequential multi-break test. Structural break tests help us to determine when and whether there is a significant change in our data.

Error! Reference source not found. presents results of the Bai-Perron (2003) sequential multi-break test for l versus $l + 1$ breaks. We find that the break in our data is important for the stability of the regression coefficient as our test shows that a break is necessary in the data. Therefor analysis is divided into two section; pre- and post-crisis; data sample for pre and post crisis is chosen on the basis of Bai-Perron Sequential multi-break test.

Table 3-1 Results of the Bai-Perron sequential multi-break test.

Break Test	*F-statistic*	*Scaled F-stat*	*Critical Value***
*0 vs. 1 **	***90.152***	***90.15193***	***8.58***
1 vs. 2	***4.8546***	***4.854614***	***10.13***
** Significant at the 0.05 level.*			
Break dates:	***Sequential***	***Repartition***	

1	***2008M12***	***2008M12***

** Bai-Perron critical values (Econometric Journal, 2003).

Results suggest that there should be a break in the data at December 2008. The data sample runs from January 1999 to December 2008 and January 2009 to April 2012.

3.2.3 Product Types

3.2.3.1 Mortgage Products

- **TR:** Tracker mortgages usually follow a fixed indicator, such as the BoE official rate, to set mortgage interest rates. Prices therefore change with changes in PR.
- **ST-VR:** Banks and building societies, unlike TR rates, set the standard variable rates themselves. Every bank has a different standard variable rate.
- **2Y-FIX, 3Y-FI and 5Y-FIX:** The lender (bank) usually offers customers a special initial rate for a fixed period. After the fixed period is over, the banks charge the standard variable rate.
- **2Y-VR:** The lender (bank) usually offer customers a special initial variable rate for a fixed period of time. After that period, rates are charged on standard variable rates.

3.2.3.2 Lending Products

- **CCL:** This involves a card issued by a financial company giving the holder an option to borrow funds, usually at the point of sale. Credit cards charge interest and are primarily used for short-term financing. Interest usually begins one month after a purchase; borrowing limits are pre-set according to the individual's credit rating.
- **OD:** This is an extension of credit from a lending institution when an account reaches zero. An overdraft allows the individual to continue withdrawing money even if the account has no funds in it. Basically, the bank allows people to borrow a set amount of money.

- **10K:** These involve the interest rate charged by banks on personal loans given to customers for personal spending up to the value of £10K.

3.2.3.3 Deposit Products

- **INSTANT:** Instant accounts pay interest but allow for withdrawal of money at any time.
- **BOND:** Bond accounts pay a fixed rate of interest on a lump sum amount over a fixed period.
- **ISA:** ISA accounts pay tax-free returns.
- **TIME:** These are savings accounts held for a fixed term with an understanding that the depositor needs to give a minimum notice period to withdraw money.

3.2.4 London Interbank Offer Rate (LIBOR)

To test for the degree of competition in the market one needs a benchmark, against which to compare the deposit and loan rates. The present study uses LIBOR as the base rate; this represents the opportunity costs of the total assets of a bank. It is also used to measure the marginal revenue of assets and the marginal cost of liabilities. For these reasons, LIBOR is treated as a proxy for perfectly competitive deposit/loan/mortgage/credit card rates. LIBOR is obtained from the BoE website as an average rate, on a monthly basis, for the period January 1999 to April 2012. Balanced panel data are collected on a monthly basis and have the same number of observations for all products and LIBOR. The present study has a total of 187 observations for each product and a total of 2,431 observations for all products, excluding LIBOR.

Since 2008, the BoE official rate has been fixed at 0.5% and has not altered. It is reasonable to use LIBOR instead of the BoE rate, as the two rates tend to move closely together. Figure 3-2 presents a comparison of the BoE official rate and LIBOR, and demonstrates their close association, except for the year 2007. This divergence in the two rates may be due to the financial crisis, but could also be a result of the LIBOR scandal. This involved several banks misreporting their LIBOR submissions, thus

affecting its level. For example, during the 2008 financial crisis, Barclays admitted under-reporting borrowing costs. This made the bank appear to regulators and the market to be healthier than it was.

Deliberately distorted LIBOR submissions may cause several different types of economic harm. If investors rely on LIBOR submissions to assess the creditworthiness of a financial institution, fraudulent information may affect the reported stock price and interest rate on its bonds. This means that the bondholders are undercompensated for the risk of lending to the bank. Economic harm also stems from the indirect effect that a false submission has on financial instruments that have rates based on LIBOR. These instruments include commercial loans (for example, floating rate loans), consumer loans (for example, credit card balances and variable rate mortgages), and numerous derivatives (such as interest rate futures and interest rate swaps). Traditional borrowers may be harmed by manipulation that raises LIBOR. When this rate increases, the prices of lending and mortgage products also increase. Despite the scandal, LIBOR is still the rate at which banks borrow in the interbank market; similarly, derivative instruments such as 'swap' and 'swaptions' continue to use LIBOR. Another reason for using LIBOR is that after 2008 the BoE rate remained stationary till 2016, while LIBOR continued to adjust to the movement in market conditions.

LIBOR is well established as a proxy measure for PR in the empirical literature (for example, Heffernan, 2002; Ahmad et al., 2013). LIBOR is a crucial price variable in the economy; changes in LIBOR affect other short-term interest rates and long-term retail rates through various channels; important economic variables include investment, employment, output and the prices of goods and services. The problem of discreteness in the timing of changes in the PR is lessened by the use of monthly average rates obtained from the BoE electronic database.

3.3 Theoretical Background and Review of Relevant Literature

3.3.1 Introduction to Theory

In the world of perfect competition with complete information, retail prices (retail rates) should be equal to the marginal costs (LIBOR), that is MR = MC. MR is marginal revenue and MC is marginal cost. The derivative of prices with respect to marginal costs equals one: ($\frac{\delta MR}{\delta MC} = 1$). This derivative typically becomes less than one when perfect competition and information assumptions are relaxed. De Bondt (2005) presents his model of bank retail rates price setting, following the marginal cost pricing model equations of Rousseas (1985) and Ho and Sanders (1981) as follows:

$$x_{it} = A_i + C_i y_t$$

where *i* represents deposit, loan or mortgage products , $x_{it}$is the price set by banks (that is, retail rate) for *i* products, A_i is the constant *mark-up* of product *i*, C_i is elasticity of demand for product *i* and y_t is the marginal cost price approximated by LIBOR. The underlying idea is that market rates reflect the most accurate marginal costs faced by banks. This is the reason why LIBOR is the most appropriate proxy of the cost of funds.

The coefficient C_i depends on the elasticity of demand for deposits and loans in response to a change in LIBOR. A fully elastic demand means that $C_i$is equal to one (C_i= 1). It is expected to be less than one (C_i<1) if the demand for deposits and loans is not fully elastic.

The demand for deposit products is expected to be highly elastic (C_i>1) if there are close substitutes available for the product. The demand elasticity of lending products, among other factors, depends on whether borrowers have access to alternative sources of finance or not. For the loans to risk free customers, the changes are transmitted one-for-one from the cost of funds rate to the lending rates; the ratio in lending rate to cost of funds rate should be equal to 1. However, when banks are lending to the second class of borrowers, the ratio in lending rate to the cost of funds rate is greater than 1

(C_i>1), because the probability of default is higher than the increase in lending rates for the second class of borrowers. For this second class of borrower, the change in lending rates should be made greater than the change in the cost of funds to compensate for the riskiness of defaults and to reduce the probability of no repayments. Another reason can also be that when monetary contraction shrinks the supply of bank loans. The specialness of banks implies that private sector agents are unable to replace the bank borrowing without paying extra costs, with credit from a alternate sources. Since borrowers are competing for a smaller volume of bank loans, competitive pressures in the bank credit market are heightened. A rise in the bank-loan rate-over and above that in money-market rates-provides the equilibrating mechanism by which this reduced supply of loans is rationed among borrowers.

If retail banks have some degree of market power, C_i will be less than one. Market power is influenced by a wide range of factors. For instance, entry into the banking sector is restricted by regulatory agencies, creating one of the preconditions for a degree of monopoly power and administrated pricing (Niggle, 1987). According to Laudadio (1987), the retail bank interest rates in less competitive or oligopolistic segments of the retail bank market adjust incompletely and only with a delay, while bank interest rates in a fully competitive environment respond quickly and completely.

Another reason for the existence of market power and an inelastic demand for retail bank products may be attributed to the existence of *switching costs* and *asymmetric information costs* (see Sections 2.3.1 and **Error! Reference source not found.** for more details). According to switching costs theory, in the case of deposits and lending products, these costs may arise when customers consider switching from one bank to another; for example, when a household intends to transfer its savings deposits from bank A to bank B. Switching costs comprise the costs of acquiring information and associated administrative search costs. These are potentially important in markets with significant information or transaction costs. These are expected to be high in markets where customers and banks have long-term relationships and repeated transactions (Sharpe, 1997; Kim et al., 2003). If the switching costs are high in the market, then

prices will be less competitive and less elastic, and banks will have more market power.

The theory of switching costs also predicts that, if costs are low, the competitiveness of the prices offered by banks depends on the proportion of the new customers in the market. For example, if the proportion is small, the prices among the banks will be less competitive or elastic. Klemperer (1987) shows that, generally, the presence of switching costs results in market segmentation and reduces demand elasticity. Even with non-cooperative behaviour, switching costs result in a retail bank interest rate adjustment of less than one to a change in the market interest rate (Lowe and Rohling, 1992).

As regards the setting of lending rates by banks, asymmetric information costs introduce problems of *adverse selection* and *moral hazard* (Stiglitz and Weiss, 1981; see Section 2.3.1). In a market where only two types of borrower exist, namely: *risk averse* and *risk takers*, banks cannot distinguish between the two. If banks increase lending rates, it may attract riskier borrowers, who want to invest in riskier projects (adverse selection). In addition, higher lending rates may give rise to adverse incentives or encourage risk averse customers to invest in riskier projects (moral hazard). As a result, the probability of default rises for the banks, and the expected receipts may fall even if funding costs increase. Banks will, therefore, use rationing and not increase the interest rate above a certain point.

On the other hand, if C_i is greater than unity, it is translated as *overshooting*. According to Sorensen and Werner (2006), this may, for example, be due to credit risk factors reflecting the asymmetry of information between banks and their borrowers. De Bondt (2005) argues that overshooting may, among other factors, be explained by asymmetric information costs without credit rationing. Loans to risk averse borrowers are classed as *fully secured lending*, and the probability of default is zero. For risk taking borrowers, the probability of default is high; an increase in the interest rate also leads to the problems of adverse selection and moral hazard. It may be assumed that banks are able to distinguish between the two borrower types (risk free and risky

customers). Given perfect competition, they must earn the same expected return from both classes of loan. In this scenario, therefore, changes in the lending rate to risk averse customers are equal to changes in the marginal costs of funds, which are transmitted one-for-one to the changes in the lending rate on riskless loans.

However, when banks are lending to risk taking borrowers they must increase their lending rates by an amount greater than the increase in the market interest rate to compensate for the probability of default on the risky loans.

3.3.2 Review of Relevant Literature

A small number of studies related to the present study are reviewed here. A more comprehensive review of the literature can be found in Section 2.5. The selected studies relate to the UK banking industry and the most cited studies on IRPT.

The general findings from the majority of the IRPT studies can be summarised as follows. First, *LRPT* shows less than one-to-one transmission. Second, *SRAS* is sticky and incomplete. Third, the pass-through parameters are heterogeneous across Eurozone countries. Fourth, pass-through parameters are heterogeneous across different products in the short and long-run (de Haan, 2001; de Bondt, 2005; Hulseqig, 2009; Mojon, 2000).

In general, it appears that consumer lending and mortgage rates have faster *SRAS* and more complete pass-through compared to deposits. For example, Donny and Degryse (2001) and de Bondt (2005) find complete *LRPT* for short-term bank lending in the Eurozone. In addition, Aristei and Gallo (2012) find evidence that banks tend to adjust loan rates more quickly compared to deposits rates in the Eurozone. Wang and Lee (2009) find that the *SRAS* for lending rates is twice that for deposit rates, and *LRPT* is higher compared to deposits. Hofmann and Mizen (2004), in a study of UK banks, find complete pass-through for mortgage products and also find that pass-through on lending rates is more complete compared to deposit rates. Ahmad (2013) in a study on UK banks finds a higher *SRAS* for lending and mortgage products and a complete *LRPT*.

However, some studies report that overdraft, credit card, personal loan and mortgage products have very slow adjustment speeds. For example, Bredin et al. (2002) find that SPPT and *LRPT* are slower on overdrafts compared to deposit products in Ireland. Fuertes (2003) finds lending rates to be sluggish in Chile. Heffernan (1997), in a study of UK building societies, finds the *SRAS* on personal loans is the most sluggish compared to savings accounts, chequing accounts and mortgages. Hofmann (2002)

also finds that mortgage rates have incomplete pass-through compared to deposit rates in a study of UK banks. Heffernan (2009) finds the *SRAS* to be very sluggish for mortgages, credit cards and personal loans (6%, 7.2% and 6.95%, respectively) compared to savings accounts.

Overall, there appears to be no consensus or one definitive conclusion arising from IRPT studies that compare different financial products. Some studies report relatively faster adjustment speed and complete pass-through for one product, while others find opposite results.

Several studies also report the adjustment speed on deposits to be faster compared to other lending and mortgage products. Timan (2004) finds *SRPT* faster and *LRPT* higher for deposit rates in Romania and Eastern Europe. Hofmann (2002), in a study of the UK banking industry, finds the pass-through from base rates to deposit rates is complete but incomplete for mortgage products. On the other hand, some studies find that pass-through for deposit products is more sluggish compared to lending and mortgage products. Baugnet (2007) reports that saving deposits exhibit a much higher level of stickiness in short-term adjustment speed compared to other types of financial deposit products offered in Belgium. Sander and Kleimeier (2004) in an EMU study, finds over-night deposits to be much stickier compared to corporate loans and time deposits. Heffernan (1997), examining UK building societies, finds the adjustment speed on savings accounts is much more sluggish than on chequing accounts and mortgages.

There are also studies that compare IRPT for consumer products and corporate financial products. These studies find that corporate products have faster *SRPT* and more complete *LRPT,* compared to consumer products. Sander and Kleimeier (2004) observe that corporate loans are less sticky compared to overnight deposits. Sander and Kleimeier (2004a), investigating 10 EMU countries, also find that loan markets show *LRPT* is complete and *SRAS* is higher for corporate loans compared to consumer loans and deposit products. They also find that deposit products have smaller pass-through than corporate loans. De Graeve et al. (2007) report that IRPT is weaker on

consumer products, while Baugnet (2007) finds that banks price their consumer loans less competitively in both the short and long run. Heffernan (2009) finds a higher *SRAS* on business savings compared to household savings. However, Donny and Degryse (2001) find that government bonds and products for households react faster. De Graeve et al.(2007) find consumer credit to be more rigid than corporate loans for Belgian banks.

There are also studies that examine IRPT after the introduction of the Euro. These include de Bondt (2005) and Sander and Kleimeier (2007), who find hints of accelerated and more homogeneous pass-through. Similarly, Angeloni (2003) and Aristei and Gallo (2012) report faster pass-through, while Moratta (2009) observes faster *SRAS* and *LRPT*.

A number of studies report differences in pass-through parameters for products with different maturities or tier levels, or according to the type of banks (Mojon 2000). For UK households with low tier savings accounts, Heffernan (2009) observes that the longer the maturity, the higher the pass-through. For UK business instant savings accounts, he finds that high tier accounts have higher *LRPT*, suggesting a *tier effect*. In the case of 90-day savings accounts for businesses and households, the study also finds, that banks adjust retail rates faster than building societies in response to changes in PR. In addition, investigating UK banks, Heffernan (2009) reports that larger banks tend to adjust their rates for credit card and current accounts significantly more slowly compared to building societies and small banks. However, for business savings, the larger banks tend to adjust the rates more quickly. She also finds that the *mark-up* of mortgage and deposit products is significantly larger for larger banks compared to building societies and small banks. Several studies compare IRPT in different countries. For example, Mojon (2000) finds higher and more complete pass-through in the Netherlands and Germany. Donny and Degryse (2001) find evidence of complete *LRPT* for Spain, Italy, Greece and Netherlands, while Sander and Kliemier (2007) report German rates to be the least sticky. Chmielewksi (2003) finds sluggishness rates in Poland. Burgstaller (2005) observes most retail rates in Austria to be sluggish. De Greave (2006) finds incomplete and sticky pass-through in Belgium

for loan and deposit rates. Aydin (2007) reports higher *SRAS* and *LRPT* in Turkey for 2001-2005. Similarly, Ozedemir (2009) finds complete pass-through in deposit and lending rates in Turkey.

Studies also find evidence of stronger pass-through in CEE countries compared to Eurozone countries. For example, Sander and Kleimeier (2007) find evidence of more complete pass-through in CEE countries than Eurozone countries. Egert at el. (2007) also report higher pass-through in CEE countries compared to three Euro area countries. On the other hand, there is evidence that developed and stronger economies seem to have a much higher *SRAS* and more complete pass-through. Wang and Lee (2009), for instance, find complete IRPT in the US but incomplete IRPT in eight Asian countries. Similarly, Kwapil and Scharler (2010) report that IRPT is complete in the US and incomplete for Euro area countries.

A few recent studies find evidence of impaired IRPT during the financial crisis. Cihak (2009) and Hristov et al.(2012) report a slower and incomplete *LRPT* during this period. However, Jobst and Kwapil (2008) find no evidence of impaired PT. Stanisiawska (2014) finds that adjustment speed on deposit products increased slightly in the post-crisis period, but decreased on lending products, although differences were small. For *LRPT* in the post-crisis period, the pass-through was more complete for deposit products but less complete for lending products. This suggests that the speed of adjustment to deposit rates is faster than to lending rates. In the post-crisis period interest rates mostly decreased. This suggests that the slower adjustment on lending could be due to asymmetric adjustment settings; banks may want to take advantage of the increase in spreads between lending and deposit rates.

3.4 Methodology and Mechanics of Tests

This section presents the methodology, tests and variable definitions used in this paper. Section 3.4.1 presents the mechanics of the tests; Section 3.4.2 presents the empirical model and variable definitions.

3.4.1 Mechanics of Tests

This section introduces the tests used in the three papers presented in this thesis and explains their mechanics. The ARDL/Bounds approach is used in this paper. Using the ARDL model, it is possible to measure the short- and the long-run dynamics of the IRPT. The Bounds testing approach is used to measure cointegration in retail rates and LIBOR rate. The ADF test is applied for unit root testing. Sequential Bai Perron (2003) multi-break test is used to check if any break in the data is required due to shifts in data caused by the financial crisis of 2008. Lastly, we show the derivation of the Delta method which is use for the calculation of the standard error for A_i and C_i.

3.4.1.1 ARDL Model, Error Correction Method and Bounds Testing

Equation 3-1 below shows the standard ARDL model.

$$x_t = \alpha_i + \beta_1 y_t + \beta_2 x_{t-j} + \beta_3 y_{t-j} + \varepsilon_t \qquad \text{Equation 3-1}$$

where x_t represents retail rates (dependant variable), y_t is LIBOR or BoE (independent variable), and j is the lagged or previous value of y_t. The model is autoregressive because the systematic determinant of the evolution of y_t is its own past values y_{t-j}; It is also possible to specify higher order lagged values than 1.

If two time-series variables are co-integrated, they tend to move together over time. They appear *bound* together by a long-run equilibrium relationship. Possible examples in finance are the spot and future prices of currencies and commodities, the ratio of relative prices, exchange rate with company share prices and dividends, and market rates and retail rates. In each of these examples, both variables might diverge from time to time, but not by much. Even when two time-series are co-integrated, the

residuals of the level regression may still be serially correlated. If sufficient lagged terms are included, it is possible to obtain a set of residuals that are not serially correlated. If y_t and x_t are co-integrated, both specifications can easily be rearranged into an ECM model. A standard ECM model can be presented as in Equation 3-2.

Equation 3-2

$$\Delta x_{i,t} = \alpha_i + \beta_i \Delta y_t + \gamma_i x_{i,t-j} + \theta_i y_{t-j} + \sum_{l=1}^{k} \lambda_{i,l} \Delta x_{i,t-l} + \sum_{l=1}^{k} \mu_{i,l} \Delta y_{t-l} + \varepsilon_{i,t}$$

where i is represents loans, deposits and mortgage products, t is for time and k=1 to j and j represents lag. The term Δy_t represents the model's instant dynamics. It contains information about the extent to which changes in Δy_t influence changes in Δx_t (for example, Δy_t influences Δx_t). The parameter γ_i is a measure of the *SRAS* (Short Run Adjustment Speed) of $x_{i,t}$; it is a measure that presents how much of the gap in or error prevailing for x_i at month $t - j$ is closed at month t.

Following Pesaran et al. (2001), the present study uses the Wald Bounds test to analyse the co-integration between retail rates and LIBOR. The long-run cointegration is measured using following null hypothesis:

$H_0: \gamma_i = \theta_i = 0$

Where γ_i and θ_i are coefficients of retail rate and LIBOR in Equation 3-2. The Wald Bounds test detects co-movements between these two coefficients.

3.4.1.2 Bai-Perron Sequential Multi-Break Test

A structural break test is the application of a structural break to data when there is an unexpected shift in a time series. If the break is not applied, it can lead to serious forecasting errors. Tests for parameter instability and structural change in regression models have been an important part of applied econometrics, dating back to Chow (1960), who tested for regime change at *a priori* known dates using the F-statistic. To relax the requirement that the candidate break date be known, Quandt (1960) modified

the Chow framework to consider the F-statistic with the largest value over all possible break dates. Andrews (1993) and Andrews and Ploberger (1994) derived the limiting distribution of the Quandt and related test statistics. More recently, Bai (1997) and Bai and Perron (1998,) provide theoretical and computational results that further extend the Quandt framework by allowing for multiple unknown breakpoints.

The Bai Perron sequential structural break test allows you to test for the number of structural breaks and their timings, through a sequential process that starts with one break and then increases the number of breaks in steps of one. The sequential process continues until the addition of any further breaks does not significantly improve the fitted model. For any given number of breaks, the times at which they occur are determined by selecting the timings that minimise the residual sums of squares that are obtained when the sample period is split into sub-periods at each possible break date, and the model is estimated separately over each sub-period. The number of structural breaks is determined from a comparison of the minimised residual sums of squares that is obtained each time the number of breaks is increased. Eventually a point is reached at which the addition of an additional break does not significantly reduce the minimised residual sum of squares. At that point the estimation procedure stops.

The Bai-Perron (2003) multi-break test is used for l versus $l+1$ breaks to check for any unexpected shift or deviation in data due to the financial crisis in 2008. We consider the following multiple linear regression with *m* breaks (*m* + 1) regimes:

$$y_t = x'_t\beta + z'_t\delta_j + u_t, \qquad t = T_{j-1} + 1, \ldots, T_j ,$$

for $j = 1, \ldots, m+1$. In this model, y_t is the observed dependent variable at time t; x_t $(p\ x\ 1)$ and z_t (q x1)) are vectors of covariates; β and δ_t ($j = 1, \ldots, m+1$) are the corresponding vectors of the cofficients; u_t is the disturbance at time t. The indices $(T_1, \ldots, T_m)$, or break points, are explicitly treated as unknown (we use the convention that $(T_0 = 0)\ and\ (T_{m+1} = T)$). This is a partial structural change model since the parameter vector β is not subject to shifts and is estimated using the entire sample.

The present study uses the Bai-Perron multi-break test to find any breaks in the data set; the test detects multiple structural breaks in data.

3.4.1.3 Augmented Dickey-Fuller Test

The Dickey-Fuller unit root (DF) test is used to capture the dynamics of a series y_t using a first order autoregressive model plus a deterministic time trend. In some cases, a higher-order autoregressive model may be needed to capture the dynamics of y_t. If the DF test is used in such cases, the higher-order dynamics present in y_t will result in a serially correlated disturbance term in the DF auto-regression. This results in a tendency for the DF test to reject the null hypothesis of non-stationary more often than it should as it is prone to make Type I errors. In such cases, it is better to use an Augmented Dickey-Fuller (ADF) test. This works by adding a lagged term in Δy_t to the right-hand side of the autoregression in order to 'mop up' the higher-order dynamics in y_t. shows the ADF $(p-1)$ test model.

Equation 3-3

The critical values for the ADF test are the same as those for the DF test. To select the correct order (value of p, or the number of additional lags of Δy_t to include) for the DF or ADF test, one uses standard model selection criteria (AIC or SIC). It is important not to include more lagged values of Δy_t than are necessary to capture the dynamics of y_t. Using too many lags reduces the power of the unit root test: the probability that it correctly rejects the null hypothesis (non-stationary) when y_t is actually stationary.

The present study uses the ADF test to check that none of the series that we are working with is I (2). Critical values are simulated in Stata software.

3.4.1.4 Delta Method

The delta method, in principle, expands the function of a random variable about its mean, usually with a one-step Taylor Approximation. Statisticians commonly use this

procedure to obtain the estimator of the variance when it is not the simple sum of observations. (http://www.ats.ucla.edu/stat/r/faq/deltamethod.htm)

The basic idea is to use a method called Taylor Series Expansion to derive a linear function that approximates to the more complicated function. To apply the delta method, the function must be one that can be approximated by a Taylor series; in general, this means it is a smooth function. The delta method is used to calculate the standard errors for A_i and C_i. We present the derivation and calculation method for the standard error of A_i and C_i as follows:

$A_i = -\alpha_i/\gamma_i$ and $C_i = \theta_i/\gamma_i$ Equation 3-4

If A is a function of α and γ, it can be expressed as follows:

$$A_i = f(\alpha_i, \gamma_i)$$

Then variance of A can be presented as follows:

$$Var(A_i) = \left(\frac{df}{d\alpha_i}\right)^2 Var(\alpha_i) + \left(\frac{df}{d\gamma_i}\right)^2 Var(\gamma_i) + 2\left(\frac{df}{d\alpha_i}\frac{df}{d\gamma_i} cov(\alpha_i, \gamma_i)\right) \quad \text{Equation 3-5}$$

The function of A from Equation 3-4 can be written as follows:

$$f(\alpha_i, \gamma_i) = \frac{-\alpha_i}{\gamma_i} = -\alpha_i {\gamma_i}^{-1} \quad \text{Equation 3-6}$$

We then take first order derivative of Equation 3-6 with respect to α to obtain the next equation.

$$\frac{df}{d\alpha_i} = -1/\gamma_i \quad \text{Equation 3-7}$$

We also take the first order derivative of Equation 3-6 with respect to γ:

$$\frac{df}{d\gamma_i} = \alpha_i {\gamma_i}^{-2} = \alpha_i/{\gamma_i}^2 \quad \text{Equation 3-8}$$

Placing the values of first order derivative from Equation 3-7 and Equation 3-8 in Equation 3-5, the following equation is obtained:

$$Var(A_i) = \left(\frac{-1}{\gamma_i}\right)^2 Var(\alpha_i) + \left(\frac{\alpha_i}{{\gamma_i}^2}\right)^2 Var(\gamma_i) - 2\left(\frac{\alpha_i}{{\gamma_i}^3} cov(\alpha_i, \gamma_i)\right) \quad \text{Equation 3-9}$$

$$Se(A_i) = \sqrt{Var(A_i)} \quad \text{Equation 3-10}$$

Following the same method as above, the calculations used to estimate the standard error of C_i are presented below. We know that:

$$C_i = \theta_i/\gamma_i \quad \text{Equation 3-11}$$

If *C* is a function of θ and γ, it can be expressed as follows:

$$C_i = f(\theta_i, \gamma_i)$$

Variance of C can then be presented as shown in Equation 3-13:

$$Var(C_i) = \left(\frac{df}{d\theta_i}\right)^2 Var(\theta_i) + \left(\frac{df}{d\gamma_i}\right)^2 Var(\gamma_i) + 2\left(\frac{df}{d\theta_i}\frac{df}{d\gamma_i} cov(\theta_i, \gamma_i)\right) \quad \text{Equation 3-12}$$

Next, the function of *C* is derived from Equation 3-11:

$$f(\theta_i, \gamma_i) = \frac{-\theta_i}{\gamma_i} = -\theta_i {\gamma_i}^{-1} \quad \text{Equation 3-13}$$

We then take the first order derivative of Equation 3-13 with respect to α:

$$\frac{df}{d\theta_i} = -1/\gamma_i \quad \text{Equation 3-14}$$

We also take the first order derivative of Equation 3-13 with respect to γ:

$$\frac{df}{d\gamma_i} = \theta_i {\gamma_i}^{-2} = \theta_i/{\gamma_i}^2 \quad \text{Equation 3-15}$$

Placing the values of first order derivatives from Equation 3-14 and Equation 3-15 in Equation 3-12, the following equation is obtained:

$$Var(C_i) = \left(\frac{-1}{\gamma_i}\right)^2 Var(\theta_i) + \left(\frac{\theta_i}{{\gamma_i}^2}\right)^2 Var(\gamma_i) - 2\left(\frac{\theta_i}{{\gamma_i}^3} cov(\theta_i, \gamma_i)\right) \quad \text{Equation 3-16}$$

$$Se(C_i) = \sqrt{Var(C_i)} \quad \text{Equation 3-17}$$

Equation 3-10 and Equation 3-17 are used to calculate standard error for A_i and C_i

3.4.2 Empirical Model and Definitions of Dependent and Independent Variables

The study uses the ARDL Bounds testing approach to co-integration (Pesaran, Shin, and Smith, 2001). This is also known as the Bounds approach. It comprises an autoregressive distributed lagged model, which provides the short- and long-run dynamics of retail rate pass-through. The study uses the Wald Bounds test to find the long-run equilibrium rate and co-integration.

This methodology is used for the following reasons. First, the use of the ARDL approach to co-integration allows for dealing with the presence of I (0), I (1) or unit root problem; this is contrary to Engle and Granger (1987) and Johansen's (1988) procedures requiring the presence of I (1) series. The ARDL approach has the advantage of avoiding the pre-testing problems linked to the performance of unit root tests (Pesaran et al., 2001). Thus, there is no need to run unit root tests on all of the series individually before testing the series for co-integration. Second, in contrast to the two-step Engle and Granger approach, the Bounds testing approach relies on a single equation, the Unrestricted Error Correction Model (UECM; (Pesaran et al., 2001). Third, the Bounds approach is more appropriate for small samples than Engle and Granger's and Johansen's co-integration techniques (Pattichis 1999; Narayan and Peng 2007; Ozturk and Acaravci, 2010). Finally, the ARDL approach allows the selection of the lag structure of the UECM, thus enabling the choice of a different

number of lags for the variables of the model; this is in contrast to other econometric procedures (Ozturk and Acaravci, 2010).

According to Fuertes and Heffernan (2009), a retail rate cannot drift too far from the official rate over long periods: there should be a long-run equilibrium relationship between the two. The present study uses ECMs to capture the short- and long-run dynamics of interest rates, since they are useful for estimating the short- and long-term effects of one series on another time series. Using these models, it is possible to evaluate the short-term effects of changes in LIBOR on retail interest rates, long-term effects of changes in LIBOR on retail rates (i.e., the long-run multiplier), and the speed at which retail rates return to equilibrium with LIBOR after any deviation has occurred.

Following Pesaran et al. (2001), the study first establishes a modified version of the ECM equation.

Equation 3-18

$$\Delta x_{i,t} = \gamma_i\left(x_{i,t-1} - x^*_{i,t-1}\right) + \sum_{l=1}^{j-1} \lambda_{i,l}\, \Delta x_{i,t-l} + \sum_{l=1}^{j-1} \mu_l\, \Delta y_{t-l} + \varepsilon_{i,t}$$

This equation defines the retail rate of a product as a linear function of the official rate. The term $t = 1, \dots, T$ represent monthly data for 1999 to 2012; $i = 1, \dots, N$ represent the retail rates of deposit, lending and mortgage products Here, $x_{i,t}$ is the dependent variable which is the retail rate for mortgage products(TR, 2Y-FIX, 3Y-FIX, 5Y-FIX, 2Y-VR), lending products (CCL, 10K, OD), and deposit products (INSTANT, BOND, ISA, TIME). y_t represents the LIBOR rate at time t. The term $x_{i,t} - x^*_{i,t}$ is the gap or deviation of the i_{th} retail rate at time t from its (LRER) long-run equilibrium rate and $x_{i,t-1} - x^*_{i,t-1}$ is the previous period error or gap at $t - j$, defined as the deviation of the retail bank rate $x_{i,t}$ from its *LRER* (or cointegration) path represented by $x^*_{i,t}$. Parameter γ_i is the *SRAS,* which is the speed of adjustment towards its long run equilibrium. It is the error which prevailing at month $t - 1$; which is closed at month

t. It is measured by the absolute value of parameter $\gamma_i < 0$; j is the short-term lag, or the delay in the short run adjustment in months. $\Delta x_{i,t-l}$ and Δy_{t-l} are the lag terms for the dependent and independent variables. *LRER* ($x^*_{i,t}$) is given by Equation 3-19.

$$x^*_{i,t} = A_i + C_i y_t$$

Equation 3-19

A_i represents the long-run mark-up, which indicates how much a bank product rate is marked above or below the official rate in the long-run. If it is above the official rate, it is represented by $A_i > 0$; if it is below the official rate, it is represented by $A_i < 0$. Parameter C_i represents the *LRPT*, and may be defined as the fraction or multiple of an official rate change that is reflected in the retail rate over the long-run. C_i depends on the demand elasticity of deposits and loans with respect to the changes in the LIBOR rate. Ideally, for a perfectly competitive market, $C_i = 1$. However, if the demand for deposits/loans is not fully elastic, it is expected to be less than one $C_i < 1$. It can be greater than one if the change in retail rates is greater than the change in LIBOR $C_i > 1$

Equation 3-19 represents the retail rate of product *i* as the linear function of the official rate. Replacing $x^*_{i,t-j} = A_i + C_i y_{t-j}$ in Equation 3-18, the following equation is obtained:

$$\Delta x_{i,t} = \gamma_i\left(x_{i,t-1} - A_i - C_i y_{t-1}\right) + \sum_{l=1}^{j-1} \lambda_{i,l}\, \Delta x_{i,t-l} + \sum_{l=1}^{j-1} \mu_l\, \Delta y_{t-l} + \varepsilon_{i,t}$$

$$\Delta x_{i,t} = -\gamma_i A_i + \gamma_i x_{i,t-1} - \gamma_i C_i y_{t-1} \sum_{l=1}^{j-1} \lambda_{i,l}\, \Delta x_{i,t-l} + \sum_{l=1}^{j-1} \mu_l\, \Delta y_{t-l} + \varepsilon_{i,t}$$

Equation 3-20

This leads to Equation 3-20:

$$\Delta x_{i,t} = \alpha_i + \gamma_i x_{i,t-1} + \theta_i y_{t-1} + \sum_{l=1}^{j-1} \lambda_{i,l}\, \Delta x_{i,t-l} + \sum_{l=1}^{j-1} \mu_l\, \Delta y_{t-l} + \varepsilon_{i,t}$$

Pesaran et al. (2001: 296) refers to Equation 3-20 as a *'Conditional ECM'*, where θ_i is the change in retail rate in reaction to the change in LIBOR.; $\alpha_i = -\gamma_i A_i$ and $\theta_i = -\gamma_i C_i$. The long-run parameters A_i and C_i can then be obtained as follows:

$$A_i = -\alpha_i / \gamma_i \qquad \text{Equation 3-21}$$

$$C_i = -\theta_i / \gamma_i \qquad \text{Equation 3-22}$$

This means the same lagged levels are being included in Equation 3-20 as in a regular ECM, but their coefficients are unrestricted. Therefore, Equation 3-20 can be called an *Unrestricted ECM* or *Unconstrained ECM*. It can be estimated by OLS in a one-step approach, which yields unbiased and consistent measures of *mark-up* and pass-through. To identify the appropriate *lag length* j, Schwartz Information Criteria (SIC) are used, and the model with the minimum SC value is chosen. The maximum lag selected is 10. A key assumption in the ARDL/Bounds testing methodology of Pesaran et al. (2001) is that the errors of Equation 3-20 must be serially independent. This requirement may influence the final choice of the maximum lags for the variables in the model. If there is any serial correlation, one adds the difference term $\Delta x_{i,t-l}$, where $l = 1, \dots k,$. The LM test is used to test the null hypothesis that the errors are serially independent. The ECM equation assumes that the retail rate adjusts to any small or large deviation from the *LRER* and that the adjustment is the same for negative and positive gaps. The present study allows for full heterogeneity in the short- and long-run relationship between the retail bank retail rate and the official LIBOR. In contrast, the traditional random effects model treats intercepts as random and slopes as homogeneous and fixed, and all the coefficients in Equation 3-4 are treated as random. Following Pesaran et al. (2001), the present study uses the Wald Bounds test to analyse the co-integration. The null hypothesis is that there are no long-run co-movements between the retail rate and LIBOR coefficients ($H_0: \gamma_i = \theta_i = 0$) in Equation 3-20.

All the interest series are subjected to unit root tests using the ADF test to confirm that none of the variables are I (2), since such data would invalidate the methodology.

3.5 Results and Discussion

3.5.1 Introduction

This section reports descriptive and empirical results for the 13 mortgage, lending and deposit products. The descriptive analysis covers the trends in LIBOR for these products, analysed for UK banks and building societies over the period from 1999 to April, 2012. The empirical section analyses the short- and long-run parameters of interest rate pass-through for all lending and deposit products in the pre-crisis and post-crisis periods.

3.5.2 Descriptive Statistics

This section covers the trends in mortgage, lending and deposit rates quoted to households by UK banks and building societies and LIBOR. It presents the trends in average retail rates for mortgage, lending and deposit products and LIBOR.

3.5.2.1 Descriptive Statistics on Deposit and Lending Rates

Figure 3-3 shows a time series trend comparison of average mortgage, lending, deposit rates versus average LIBOR for the period 1999 to April 2012. Mortgage, lending and deposit rates all follow LIBOR, but deposit rates follow more closely than mortgage and lending rates.

The interest rate series appear un-trended and non-stationary; they appear to move up or down without any tendency to return to a specific mean value. Overall, no one specific trend is found in mortgage, deposit and lending rates. Mortgage and deposit rates decline after average rates peak in 2000, while lending rates decline from 1999, after peaking in this year. The decline in deposit and mortgage rates is found to be in line with the LIBOR. From 2003, rates for all three types of product increase following LIBOR until 2007, when they start to decline again. Figure 8-3 shows a dramatic decline in LIBOR and deposit rates and, to some extent, mortgage rates post-crisis, from 2008 to 2009. The proportional decrease in deposit rates is greater than for mortgage rates. Pre-crisis Lending rates do not move in the same direction as LIBOR.

However, there is an increase in average lending rates post-crisis. Post-crisis, there is a sharp decline in LIBOR. This decline in LIBOR is due to the BoE fixing its official rate to 0.5% in 2009, following unconventional monetary policy and QE.

Results show that average lending and mortgage rates are higher than deposit rates and LIBOR for the period investigated, with lending rates the highest. These exceptionally high lending rates raise the question of whether banks are exploiting their customers. Banks generally pay lower deposit rates than LIBOR; however, after 2009, rates are higher. This is possibly due to their desire not to lose clients. There is also a rise in lending rates for the same period, in contrast to the decline in LIBOR.

3.5.2.2 Descriptive Statistics for all Mortgage, Lending and Deposit Products

Figure 3-4 shows a trend comparison of all six mortgage products offered by banks and LIBOR in the period 1999 to 2012. It shows all mortgage products; the panels represent TR[1], 2Y-FIX, 3Y-FIX, 5Y-FIX, 3Y-VR and ST-VR and LIBOR, respectively.

Overall, the mortgage products do not show any consistent trend for the whole observation period. From 2008 to 2012, following a decline in LIBOR, all mortgage rates also show a declining trend. Figure 3-4 shows how different mortgage products are priced. 2Y-VR rates (panel E) closely follow LIBOR and have the lowest interest rates. Figure 3-4 shows the highest interest rate is on ST-VR (panel F). Post-crisis, after unconventional monetary policy, LIBOR declines sharply; 2Y-FIX, and TR mortgage products have the lowest rates in the post-crisis period; the smallest change is observed in 3Y-FIX and 5Y-FIX mortgage products.

[1] TR (tracker mortgage), 2Y-FIX (2-year fixed mortgage), 3Y-FIX (3-year fixed mortgage), 5Y-FIX (5-year fixed mortgage), 3Y-VR (3 year variable mortgage), ST-VR (standard variable mortgage).

Figure 3-5 shows a time series comparison of all three lending products; where panel A shows CCL and LIBOR; panel B shows 10K vs. LIBOR; and panel C is OD and LIBOR. All three lending products show no one specific trend for the period 1999 to 2012. Panel B shows that interest rates for the 10K product decline from 2009 to 2012; however, OD and CCL rates show an increasing trend for the same period. OD and CCL have the highest interest rates, suggesting that these are the most expensive lending products. Interest rates for 10K are higher than mortgage rates but lower than OD and CCL. Post-crisis, there is a slight decrease in 10K rates, but no sizeable difference in prices for CCL and OD. Lending rates do not move in the same direction as LIBOR. This behaviour of lending products can be explained by adverse selection and moral hazard theory. According to this theory, banks cannot reduce lending rates above or below a certain optimal level. Consequently, they apply credit rationing and decide not to reduce rates below or above certain level due to the problem of adverse selection and moral hazard. (see Section 2.3.1).

Figure 3-6 presents time-series plot trends for all deposit products and LIBOR for the period January 1999 to April 2012. The figure consists of 4 panels: A, B, C and D. Panel A shows INSTANT and LIBOR, B shows BOND and LIBOR, C shows ISA and LIBOR, and D shows TIME and LIBOR. All four products follow LIBOR movements; the interest rates are changing constantly without following any specific trend. The figure shows that in the pre-crisis period, from 1999 to 2008, banks and building societies pay the highest rates on BOND, followed by ISA, TIME and INSTANT deposits. From 1999 to 2001, ISA has higher interest rates than LIBOR, but from 2002 to 2008 BOND has higher rates than LIBOR.

Figure 3-6 also shows that during the pre-crisis period, TIME, INSTANT and ISA products have lower interest rates than LIBOR, while BOND pays slightly higher or equal rates. Post-crisis, banks pay higher rates on TIME and BOND products than LIBOR. However, INSTANT and ISA still have lower rates. Banks traditionally pay lower interest rates than LIBOR on TIME products; however, post-crisis higher interest rates than LIBOR are paid on TIME. This could be due to banks wanting to keep their customer base.

3.5.3 Result and Discussion

This section discusses and reports the results and considers their implications. Table 3.3 presents the complete ECM results for the all mortgage, lending and deposit products during the post-crisis period.

3.5.3.1 Results, Discussion and comparison of Short-run and Long-Run Parameters and Co-Integration Analysis in pre-crisis

Table 3-4, Table 3-6 and Table 3-8 presents the short-run dynamics results for all six mortgage, lending and deposit products offered by banks and building societies in the UK. Where $|\gamma|$ is short-run adjustment speed (SRAS), j is lag in months. Table 3-5, Table 3-7 and Table 3-9 shows results for long-run parameters C, A, x_t* and the results for co-integration (Wald Test) for mortgage products for ECM Equation 3-20. C is long-run pass-through (LRPT) and represents elasticity of demand for the product and a measure of competition, A is *mark-up* on the products and, $x_t*$is long-run equilibrium rate (LRER). To test co movements using Wald test, the null hypothesis is that there are no long-run co-movements between LIBOR and retail rates. The alternate hypothesis proposes that there are long-run co-movements.

Table 3-4 presents the short-run dynamics results for all six mortgage products offered by banks and building societies in the UK. Lag-length for the adjustment of retail rates in response to base rate for all products is one month, except for ST-VR. In general, all results reported for *SRAS* are incomplete. In the pre-crisis period, the analysis finds that the *lag length* for the adjustment of retail rates in response to base rate changes is one month for all products, except ST-VR. This implies that, after a change in LIBOR, banks take a minimum of one month before any adjustments are made to retail rates. It appears that the mortgage rates are very sticky, as the *SRAS* is incomplete and low. The speed of adjustment to reach long run equilibrium is found to range from 8.1% to 20.8%, with the highest values per month of 20% and 20.08% on TR and 2Y-VR, respectively. The lowest speeds of 5.2% and 8.1% are on 5Y-FIX and ST-VR, while 2Y-FIX and 3Y-FIX have speeds of 8.3% and 8.623%, respectively.

It is important to consider the significance of these adjustment speeds. If there is a change in LIBOR one month ago at time *t-j* (j=1), 20% of error that prevails in the retail rates of TR which is caused due to change in LIBOR last month (at time t-j) is closed after 1 month (at time t). Therefore, 20% of the error is closed after one month but, for the retail rate to reach the new *LRER*, 100% of the error should be closed. If 80% of the error remains, it will take about five months to achieve 100% closure and reach the *LRER*. TR and 2Y-VR products take five months to reach the new *LRER*, whereas 2Y-FIX, 3Y-FIX and ST-VR take about 13 months. 5Y-FIX take approximately 20 months. The slower the adjustment speed per month, the longer it will take to apply the 100% adjustment to retail rates.

These results imply that when the base rates are falling, the customers holding TR and 2Y-VR products will benefit more as the rates on these products will fall faster compared to other mortgage products. On the other hand, customers holding 5Y-FIX and ST-VR will benefit when PRs are rising, as the adjustment speed is slower for these rates. This means that the response to increase policy rate changes will be transferred in these products slower and over longer period of time.

Table 3-5 shows results for long-run parameters C, A, x_t* and the results for co-integration (Wald Test) for mortgage products. In the pre-crisis period, out of six mortgage products, only two, TR and 2Y-VR, show long-run co-movements, as the F value is greater than the upper bound critical value of 4.78 for Wald test co-integration. The P values for these two products are lower than the 0.05 significance level, so the Wald test results are highly significant. For the other four products our test fail to detect any co-movements as the F values for these products are smaller than the 4.04 lower bound critical value for Wald test co-integration.

Results for *LRPT* and mark-up/down are examined to see if there are any trends in the price setting of mortgage products. The *LRPT* ranges from 0.238 to 0.808 and *mark-up* ranges from 0.970 to 4.515. We find that products which have the slowest adjustment speeds have the highest mark-ups. For instance, the adjustment speed on 2Y-FIX, 3Y-FIX, 5Y-FIX and ST-VR is 8.3%, 8.6%, 5.25%, and 8.1% and the *mark-*

up is 3.164, 3.763, 4.515 and 3.121, respectively. It is also observed that the *LRPT* of these four products is the lowest0.442, 0.376, 0.238, and 0.697. TR and 2Y-VR, which show the highest adjustment speed of 20% and 20.8%, also have the lowest *mark-up* values of 1.957 and 0.970, respectively. These two products also have the highest *LRPT*, 0.759 and 0.808, respectively. TR and 2Y-VR products also show co-movements with LIBOR, while the other products do not.

Most of the products with slow adjustment speeds and high mark-ups are fixed rate products. Banks offer a fixed rate for these products, which could be another reason why these rates are stickiest. A fixed rate reflects expectations of what the variable rate will be over the whole duration. A movement in the daily rate today should have a smaller impact on the fixed rate over a long duration than on a fixed rate over a short duration or a variable rate mortgage. Also, fixed rate products may be offered to high risk customers, and banks may charge high mark-ups to cover the probability of default. However, in the case of TR and 2Y-VR, as these products follow the LIBOR rate, the adjustment speed is higher. In addition, as these products have lower mark-ups, banks may offer them only to customers with very high credit rating. Since the risk associated is lower, mark-ups are therefore also lower. This indicates that products with the stickiest rates are the ones for which banks charge the highest mark-ups. In times of falling LIBOR, they adjust these rates the slowest and make more profits on these products. The lowest *LRPT* is found on fixed rate mortgage products: 5Y-FIX, 3Y-FIX and 2Y-FIX products. Competition on fixed rate mortgage products is relatively low in the market compared to other mortgage products. It can be argued that not enough banks are offering the same fixed rate mortgage products, or they offer different fixed rate products as there are 2Y-FIX, 3Y-FIX and 5Y-FIX products and these products have less competitive market.

According to de Bondt (2005), *LRPT* is expected to be less than one if the demand for a product is not fully elastic; means that the change increase or decrease of the rates does not impact on the demand on the products much. It is possible that only the banks exercise market power in setting these interest rates as the demand for mortgages is very high. This could be an indication of banks exercising market power for these

products (Laudadio,1987). A wide range of factors influences market power; for instance, entry into the banking sector is restricted by regulatory agencies, creating one of the pre-conditions for a degree of monopoly power and administrated pricing (Niggle, 1987). According to Rousseas (1985), the *mark-up* will be higher in less competitive markets and lower in more competitive markets. The average adjustment speed for all the mortgage products is only 11.16% and the average for C_i is 0.553. On average, only 11.16% of the error closes in one month, while 88.83% prevails. This means it will take approximately nine months to apply 100% adjustment and close the error, to reach full *LRER*.

Table 3-6 results for γ are significant for all three products. The average γ of all lending products is only 5.47% per month. All three of the lending products are unsecured and have very high risk associated with them. In the pre-crisis period, the study finds that *lag length* for the adjustment of retail rates in response to base rate changes is one month for all products. The lending products also have very sticky rates. The adjustment speed on CCL, 10K and OD is 5.2%, 3.1% and 8.1%, respectively. This means it takes about 20 months to close 100% of the error and reach *LRER*. 10K and OD products take about 32 and 12 months, respectively, to achieve this. It implies that, when the base rate falls, the retail rate adjustment is passed extremely slowly to these products. Average adjustment speed for all the lending products is only 5.47% per month, with a 94.53% error prevailing. It will take approximately 18 months to apply 100% adjustment to close the error and reach *LRER*. R-squared is the highest for CCL (11.6%) and lowest for OD (8.5%). All three lending products show long-run co-movements with LIBOR.

Table 3-7 shows results for long-run parameters and co-integration test results for lending products. *LRPT* for the three lending products ranges from 1.270 to 2.948, with an average of 1.897. The *LRPT* on these three credit products is much higher than 1. Ideally, it is expected that *LRPT* will equal unity, which is representative of perfect completion. This scenario can be explained by the asymmetric information costs hypothesis without rationing, as proposed by De Bondt (2005). According to this theory, in the case where FI's are lending to high risk customers, in times of excess

demand and rising base rates, the change in lending rates adjustment speed is greater than the changes in cost of funds, which is to compensate for the probability of default and for expected losses. This explains that the banks are lending relentlessly to safe as well as risky customers, and, to compensate for expected losses, the change in adjustment speed is much higher than the change in the LIBOR. In the case of lending products, they all exhibit very sticky retail rates but the *LRPT* is much higher than unity, in contrast to mortgage products, where slow adjustment speed is associated with low *LRPT*. This could be because the attributes of lending products are completely different from mortgage products. Another reason can also be that when monetary contraction shrinks the supply of bank loans. The specialness of banks implies that private sector agents are unable to replace the bank borrowing costlessly with credit from alternative sources. Since borrowers are competing for a smaller volume of bank loans, competitive pressures in the bank credit market are heightened. A rise in the bank-loan rate-over and above that in money-market rates-provides the equilibrating mechanism by which this reduced supply of loans is rationed among borrowers.

Traditionally banks charge high rates on OD and credit cards because both these products are high risk products. Banks are also lending unsecured loan products to risky customers and charge high rates due to the high risk nature of the product. The analysis finds that CCL and OD have high mark-ups, implying that banks are earning higher revenues on these products. The *mark-up* on lending products ranges from -6.032 to 9.712, with CCL having the highest value, followed by OD. 10K products show a negative sign, indicating a mark-down. However, due to high S.E, this result will be ignored. CCL and OD also have the slowest adjustment speeds of all the lending products. This is in line with the previous finding for mortgage products, where the adjustment speed is slower for products with higher mark-ups. This suggests that in times of decreasing LIBOR prices banks can make more revenue when the adjustment speed of retail rates on these products is the slowest. The *LRER* values for the three lending products are quite far from the $y_{i,t}$ (4.87). This is due to the high margins that banks charge on lending products.

Table 3-8 presents the results of γ for the deposit products. The average adjustment speed for all four deposit products is 7.08% per month. This implies that it will take approximately 14 months for 100% adjustment. In the pre-crisis period, the *lag length* for applying adjustment in response to LIBOR is 1 month on all deposit products except for ISA (2 months). This implies that, after a change in LIBOR, banks take a minimum of a month before any changes are made to retail rates to deposit products. The highest adjustment speed of, 9%, is found on BOND, closely followed by 8.3% on INSTANT. The slowest speed is 4.2% on ISA, followed by 6.8% on TIME. This suggests that the customers holding BOND and INSTANT accounts will benefit from a faster adjustment speed when the LIBOR is rising, while customers with ISA will benefit from slow adjustment when LIBOR is falling. For example, if LIBOR rises, retail rates for BOND will adjust 9% in response to the LIBOR change in the next month compared to just 4.2% for ISA, suggesting a 4.8% faster increase. For all deposit products, the Wald test finds no co-movements.

Table 3-9 presents mark-up/down results for all the deposit products. The negative sign on '*A'* presents a mark-up/down; a positive sign represents a mark-up. The mark-up/down is -0.633, 0.791, -2.126 and -2.171 for INSTANT, BOND, ISA and TIME, respectively. Three deposit products show a mark-down; only one shows a mark-up. The highest mark-down is on TIME, followed by ISA; the lowest mark-down is on INSTANT. These results are consistent with the theory that banks pay lower interest rates on deposits than LIBOR. The *mark-up* for BOND suggests that banks pay higher interest rates on this product; this is in contrast to all other deposit products and is an incentive for customers to invest in BOND and to keep their money longer with the banks as these are fixed rate long-term bonds.

The average *LRPT* for the four deposit products is 0.91. *LRPT* on TIME is 1.154, which is complete pass-through and implies perfect competition in the UK financial market for these products. ISA has a *LRPT* value of 1.525, which is representative of a very high level of competition. Generally, for ISA and TIME accounts, customers have to keep their money with banks for longer period. Banks need a strong deposit base and want customers to leave their money in their accounts for as long as possible.

All banks, therefore, try to offer attractive terms to gain more customers and this could be the reason for a higher level of competition on these products. Fuertes and Heffernan (2009) suggest a pass-through of greater than one means that there is tight competition among banks and the product has close substitutes available. *LRPT* for INSTANT and BOND is partial, at 0.481 and 0.486, respectively, which suggests a relatively low level of competition in favour or oligopolistic market behaviour. Consumers can withdraw their money any time on INSTANT accounts, so this makes them a less attractive option for banks compared to ISA and TIME deposits. In the case of BOND, customers keep their deposits longer with banks but the difference between ISA and BONDS is that banks usually have to pay a fixed and higher interest rate compared to ISA. De Bondt (2005) suggests the partial pass-through could be because of less than elastic demand for deposits in the market. According to Laudadio (1987), the pass-through can be incomplete because banks have some degree of market power.The presence of switching costs leads towardsresulting of interest rate adjustment of <1 to a change in the market interest rate (Lowe and Rohling, 1992).

Traditionally deposit rates are lower than the cost of funds (LIBOR). As a result, a mark-down on deposit products is expected. Three of the four deposit products in the analysis follow this trend, but one shows a mark-up. The highest mark-down is on TIME, followed by ISA; the smallest mark-down is on INSTANT. These results are consistent with the theory that banks pay lower interest rates on deposits than LIBOR. The *mark-up* for BOND suggests that banks pay higher interest rates on this product in contrast to all others products. This offers an incentive for customers to leave their money with the banks for longer periods, as these are fixed rate long-term bonds.

In general, the adjustment speed is extremely slow for all three types of products (deposit, mortgage and lending). However, it is marginally faster for mortgage products compared to lending and deposit products. Heffernan (2009) also finds a very sluggish adjustment speed on mortgages compared to other products. The C_i for mortgage products is lower than for the other two products. These results for the *LRPT* are in line with Hoffman (2002), who finds, in a study on UK banks, that mortgages have lower levels of pass-through compared to other products. However, our results

are in contrast to those of Hoffmann (2004), who finds complete pass-through on mortgage products in a later study on the UK banking industry.

The current study also finds that the adjustment speed for lending products is marginally slower compared to deposit products. Heffernan (2009) finds *SRAS* to be very sluggish for credit cards and personal loans compared to savings accounts. Heffernan (1997) also finds the adjustment on personal loans is the most sluggish compared to savings accounts and chequing accounts. Brending and Fitzpatrick (2002) finds the slowest *SRAS* on overdrafts. However, this result is in contrast to the findings of Aristiei and Gallo (2012) and Wong and Lee (2009), who find the *SRAS* on lending rates is faster compared to deposit rates. The *LRPT* on the lending rate is >1, and also higher than for other products. This result is in line with Donny and Degryse (200 1), de Bondt (2005), Wang Lee (2009), Aristei and Gallo (2012) and Ahmad (2013).

The present study does not find complete pass-through for all four deposit products. However, Fuertes & Heffernan (2009) and Ahmad et al. (2013) find complete *LRPT* for all lending and deposit products in the UK. Nevertheless, this paper's results are consistent with those of most previous studies. Fuertes and Heffernan (2009) also find incomplete and very slow adjustment speed for all lending and deposit products under analysis. The *SRAS* for mortgage, credit cards, personal loans, current accounts and high-tier savings accounts is 6%, 7.2%, 7%, 8% and 12.3%, respectively. These results are very similar to those presented here. The *lag length* for most products is close to one month. Ahmad et al. (2013) also find incomplete short-term adjustment speeds of only 23.5% and 14.6% on TIME and INSTANT deposits, respectively. Their results suggest a slightly higher adjustment speed for deposit products but it is still very sticky and incomplete. For lending and mortgage products, they find adjustment speeds of 25.7% and 27.6 %, respectively. These figures are again higher than our values for these products but the speed is incomplete, in line with our results. De Bondt (2005) finds that the *SRAS* is slightly higher for deposit products compared to lending products. However, it is very slow and incomplete. The adjustment speed on overnight deposits, deposits with up to 3 months' notice, deposits with over 3 months' notice,

deposits with maturity up to 2 years, and deposits with maturity over 2 years is 4%, 27%, 8%, 3% and 31%, respectively.

The adjustment speed on lending products up to 1 year, over 1 year, lending to consumers and lending for house purchases is 7%, 11%,12% and 21%, respectively. These findings are in line with our results for deposits, lending and mortgage products. However, in contrast to de Bondt (2005), the current study finds the highest *SRAS* on mortgage products. Sorensen and Werner (2006), in a study on IRPT in the Euro area, find incomplete and slow adjustment speeds for financial products. The lowest average adjustment speed is on current accounts, followed by mortgage rates and consumer loans. The highest adjustment speed is on TIME deposits. De Bondt (2002) finds that the immediate pass-through of market interest rates to retail bank interest rates for the Euro area is incomplete. The proportion of a given market interest rate change that is passed through within one month is found, at its highest, to be around 50%, which is much higher than our results. Hofmann and Mizen (2004), in a study on UK financial institutions, find the same results as the current study for deposit and mortgage products. They find values of between 5% and 9% for adjustment to disequilibrium per month in deposit rates and 15% to 28% in mortgage rates. These figures also indicate that mortgage rates have faster adjustment compared to deposits. This result is in line with our findings. Hulsewig et al. (2009) finds short-run pass-through in the Euro area to be 54%, indicating an incomplete pass-through. Marotta (2009) reports that short-run pass-through ranged from 12% to 107% before the introduction of the Euro, and from 15% to 89% after it was introduced. In line with our study, all these studies observe heterogeneities in the *SRAS* for different financial products. Stanisiawska (2014) analyses the IRPT before and after the financial crisis experienced by the Polish banks, and finds differences in adjustment speed among different financial products. In contrast to our findings, Baugnet et al. (2007) suggest Belgium banks adjust their retail interest rates to changes in market rates relatively rapidly. However, similar to our results, they find significant heterogeneity across products. Also, in line with the present study, they find that, even though Belgian banks adjust interest rates relatively rapidly, the reaction is only partial. The results

that to price less competitively on consumer-oriented loans both in the short-run is same as this paper's findings. However, we find an overshooting scenario for competition among lending products, in contrast to Baugnet et al. (2007), who find that the *LRPT* is less competitive for these products. However, their finding that interest rates offered on overnight deposits, which represent the banks' liability, tend to react less completely compared to time and redeemable deposits is in line with our finding that INSTANT deposits react much more slowly compared to TIME deposits. Moreover, we find a high level of stickiness for bonds, which is similar to their finding that savings deposits exhibit much more stickiness in adjustment speed compared to other types of deposit.

These slow adjustment speeds on deposit and lending rates can be explained, among factors, by asymmetric information costs (adverse selection, moral hazard and rationing, collusive pricing behaviour, switching costs, and menu costs). Additionally, the level of change in PR can also determine whether commercial banks will react to such changes. As noted by Mahadeva and Sinclair (2005: 19), "…there may also be a narrow range within which official rates can move while provoking no retail interest rate response". Heffernan (2002) and Fuertes, Heffernan, and Kalotychou (2010) argue that the stickiness and heterogeneities in retail rates in the UK banks are the result of menu costs and administrative costs involved in informing the customers. It should be noted that menu costs have been one of the key arguments for retail interest rate stickiness in bank lending and deposit rates.

The implications of these slow adjustment speed results for financial institutions are that in periods when LIBOR decreases banks will still charge higher interest rates and will benefit from the increase in spreads between deposit and lending rates. The products with the slowest adjustment speed are also the products with the highest average interest rates; that is, CCL, 10K, OD and ST-VR. This implies that banks tend to adjust rates for products with the highest interest rates more slowly than other products.

3.5.3.2 Results, Discussion and comparison of Short-run and Long-Run Parameters and Co-Integration Analysis in post-crisis

Table 3-10, Table 3-12 and Table 3-14 presents the short-run dynamics results for all six mortgage, lending and deposit products offered by banks and building societies in the UK. Where $|\gamma|$ is short-run adjustment speed (SRAS), j is lag in months. Table 3-11, Table 3-13, and **Error! Reference source not found.** shows results for long-run parameters C, A, x_t* and the results for co-integration (Wald Test) for mortgage products for ECM Equation 3-20. C is long-run pass-through (LRPT) and represents elasticity of demand for the product and a measure of competition, A is *mark-up* on the products and, x_t*is long-run equilibrium rate (LRER). To test co movements using Wald test, the null hypothesis is that there are no long-run co-movements between LIBOR and retail rates. The alternate hypothesis proposes that there are long-run co-movements.

Table 3-10 presents post-crisis short-term adjustment speed results for mortgage products. In the post-crisis period, we find *lag length* for all the mortgage products ranges between one to six months. Results indicate that mortgage rates are very sticky, as the *SRAS* is incomplete and very low, ranging from 3.7% to 23.6%. The highest adjustment speeds of 79.3%, 58.1% and 23.6%, are found on products 3Y-FIX, ST-VAR and 5Y-FIX respectively. The slowest speeds of 7.4%, 16.4% and 19.7% on 2Y-VR, 2Y-FIX and TR respectively. The adjustment speed for mortgage products in the post-crisis period is higher at 34.1% per month compared to 11.83% per month in the period 1999 to 2008. This indicates when it comes to the change of retail rates to follow PR mortgage market responds the slowest

Table 3-11 shows long-run parameters C and 'A', x_t* and the results for co-integration (Wald Test) for mortgage. For the post-crisis period, only two of the six products, TR and 2Y-VR, show long-run co-movements. Wald test fails to detect any co-movements for the other 4 mortgage products. The *LRPT* values are -0.929, -0.0275, -3.563, -4.414, 4.917 and 0.561 for TR, 2Y-FIX, 3Y-FIX, 5Y-FIX, 2Y-VR and ST-VR, respectively. Out of six mortgage products, four show negative pass-through.

Negative sign shows that the change in retail rates is in the opposite direction of change in LIBOR post-crisis. After a sharp decline in LIBOR in 2009, there is increase in LIBOR but the increase is very low. However, the mortgage products cannot immediately reduce the rates proportionate to LIBOR immediately so banks reduce the prices slowly even when LIBOR is rising banks at still lowering the rates to bring it in line with PR. That's why four mortgage products do not follow the LIBOR rate strictly. In fact, the changes in the prices of these products are in opposite direction to the changes in the LIBOR rate, as can be seen in Figure 3-4 (A, B, C and D). For the products which show negative pass-through, their retail interest rates are in the process of declining to bring the rates in line with a huge drop is PR, instead of increasing against the direction of LIBOR, which means they are moving in the opposite direction. Post-crisis, the decline in LIBOR is substantial and the subsequent increase is very minimal. As noted by Mahadeva and Sinclair (2005: 19), "….there may also be a narrow range within which official rates can move while provoking no retail interest rate response". TR has almost complete pass-through which is to be expected as the TR follow PR closely; for ST-VR, there is a partial or incomplete pass-through (0.561); 2Y-VR has a coefficient of 4.917, which is very high. However, this result will be ignored as it shows a high S.E. Figure 3-4 shows that the only two products that seem to follow the LIBOR rate are ST-VR and 2Y-VR. These are also the only two products that have positive pass-through (see Figure 3-4 D and F). 5Y-FIX and 2Y-VR products shows higher than 1 pass-through (-3.563, -4.414) which can suggest that the changes in the rates for these fixed products are higher than changes in base rate to compensate for the higher risk.

It is expected that margins will increase, since the reduction in the cost of funds (LIBOR) is substantial. The resultant change in the retail rate is proportionally less. The A_i is 4.102, 3.713, 6.555, 7.629, -0.055 and 3.669 on TR, 2Y-FIX, 3Y-FIX, 5Y-FIX, 2Y-VR and ST-VR, respectively. Overall the margins have increased on all the mortgage products post-crisis, except for 2Y-VR, which actually shows a mark-down rather than a mark-up. The highest *mark-up* is 7.629 and 6.555 on 5Y-FIX and 3Y-FIX products, respectively. The increase in margins is because of a considerable

decline in LIBOR in 2009 and less than proportionate decline in mortgage prices. Banks cannot reduce the mortgage prices in line with huge reductions in LIBOR, to keep them profitable and to compensate for the probability of default for the mortgage products.

Theoretically, *LRER* should not be too far from the average LIBOR for the period. The average LIBOR($y_{i,t}$), for the pre-crisis period is 0.69. *LRER* is given in the Table 3-11 for mortgage products. The *LRER* values for TR, 2Y-FIX, 3Y-FIX, 5Y-FIX, 2Y-VR and ST-VR are 3.458, 3.522, 4.084, 4.568, 3.355 and 4.058, respectively.

Table 3-12 presents short-term adjustment speed results for lending products. All three of the lending products are unsecured and have a very high level of associated risk. In the post-crisis period, the *lag length* for the adjustment of retail rates in response to base rate for all the products is one month. Post-crisis, there is a significant increase in adjustment speed on lending products and retail rates are found to be less sticky. The adjustment speed in post-crisis per month on CCL, 10K and OD (62.7%, 40.2% and 32.8%) is significantly higher compared to pre-crisis (5.2%, 3.1% and 8.1%), respectively. The product CCL takes just over one month to close 100% error and reach *LRER*. 10K and OD products take about 2.5 months and 3 months, respectively. The average adjustment speed per month pre-crisis for these three products is 5.5%, compared to 45.3% after the crisis. R-squared values are 59.9%, 56.8% and 49.7% for OD, CCL and 10K, respectively. Of these products, OD is found to have the highest value (59.9%).

Table 3-13 shows results for long-run variables and co-integration for the three lending products. All products show long-run co-movements with LIBOR as the F values from the Wald test are higher than the upper bound critical value. The *LRPT* post-crisis is 2.365, -5.467 and 2.415 for CCL, 10K and OD, respectively, with an average value of 1.897 for the three products. C_i values for CCL and OD are higher than unity. The value is negative on 10K products but the S.E is high so this result will be ignored. The values for C_i on CCL and OD are much higher than 1. The situation where *LRPT* is higher than unity can be termed overshooting. This indicates that the FIs are lending

to high risk customers; the demand of these unsecured lending products is high and risk associated is also high. Banks are making higher changes in the lending rate than the changes in the cost of funds, which is to compensate for the probability of default and expected losses. In the case of lending products, they all exhibit significantly less sticky retail rates post-crisis, but the *LRPT* is much higher than unity. This is in contrast to mortgage products, where rates, although less sticky post-crisis, remain very sticky compared to lending products and competition is almost non-existent. This could be because of the fact that the attributes of lending products are completely different from mortgage products.

We find that the *mark-up* has increased significantly on all three lending products. We find CCL and OD have high mark-ups. This may be because banks are lending these credit products to risky as well as safe customers. The high *mark-up* implies that banks are earning higher revenues on these products. In the post-crisis period, the *mark-up* on lending products ranges from 12.438 to 17.720 compared to -6.032 to 9.712 pre-crisis. OD has highest *mark-up* of all these products, followed by CCL and 10K. The *LRER* values for the three products are quite far from the $y_{i,t}$ (0.694) due to the high margins that bank charge on lending products.

Table 3-14 presents the empirical short-term pass-through results for the four deposit products. Of these, $|\gamma|$ results are insignificant for INSTANT but highly significant for the other three deposit products. The *lag length* for all the deposit products is one month. The highest adjustment speed per month is 50.5% on ISA and 26.9% on TIME deposits. The lowest adjustment speed per month is 16.2% and 18.2% on INSTANT and BOND deposits, respectively. In other words, for ISA and TIME, 50.5% and 26.9%, respectively, of the error is closed in one month. It takes about 2 months for ISA and approximately 4 months for TIME to close the error 100% and reach *LRER*. However, it will take about 6 months and 5.5 months for BOND and INSTANT products to achieve *LRER*. Post-crisis all four deposit products show on average a 28% adjustment speed compared to 7.08% in the pre-crisis period. This means that to close 100% of the error prevailing at time t-j, it will take approximately less than 4 months.

Error! Reference source not found. shows results for long-run variables and co-integration for deposit products. For deposit products, the Wald test finds no co-integration for ISA only. The average *LRPT* for the four deposit products is 0.91. TIME has the highest *LRPT* 0.659, which is still less than one. The *LRPT* on deposit products post-crisis is 0.150, -0.055, 0.482 and 0.659 for CCL, BOND, 10K and OD, respectively. TIME has the highest *LRPT* of 0.659, although this is still below 1; the lowest value is -0.055 on BOND. The *LRER* values for INSTANT, BOND, ISA and OD are 0.252, 2.581, 0.550 and 1.155, respectively. These values are quite far from the $y_{i,t}$, which is only 0.69. This is due to the high margins that banks charge on lending products.

For the deposit products, the findings are in contrast to the pre-crisis period, as all the products show mark-ups instead of mark-downs. This is due to the fact that banks are paying higher interest rates than LIBOR. Theoretically and traditionally, banks pay lower interest rates on deposit products compared to LIBOR. This could be because banks do not want to lose their deposit base, so they continue to pay higher prices than LIBOR for deposit products to avoid this. Ideally, in the perfectly competitive market, the marginal costs are equal to marginal rates. Here, once again, banks seem to exercise market power and dictate price settings for deposits. Ahmad et al. (2013) suggests that banks are paying higher interest rates than expected because they do not want to lose their deposit base. Banks want to keep their depositors and also attract new customers in case of shortage of liquidity due to credit crunch. Of the deposit products analysed, BOND has the highest mark-up, followed by TIME; the lowest mark-ups are found on INSTANT and ISA products.

These results are in contrast with Hristov (2012), who analyses interest rate transmission in the Euro area and finds that IRPT during the financial crisis becomes less complete for both deposit and lending rates. The increasing incompleteness of IRPT in the course of the financial crisis implies that the transmission mechanism of monetary policy is severely distorted. Cihák (2009) also finds that the pass-through mechanism in EMU as a whole becomes slower during the crisis. He argues that monetary policy impulses have been less effective during recent years. Stanisławska

(2014), who analyses the IRPT before and after the financial crisis for Polish banks. He finds that the adjustment speed for lending products decreases slightly, with small differences. On the other hand Jobst and Kwapil (2008) report no change in the degree of pass-through over the crisis period. Investigating the pass-through to loan rates in Austria, they do not detect any striking differences in the pass-through process during the financial crisis, and do not support the view that the mechanism is impaired by the crisis.

In general, the current study finds that the *SRAS* for UK mortgage, lending and deposit products increases but remains incomplete after the financial crisis. However, the products CCL, 10K and OD show significantly faster, although incomplete, adjustment speeds post-crisis. The implications of slow adjustment speed results for financial institutions is that, in periods when LIBOR rates decrease, banks will still charge higher interest rates and will benefit from the increase in profit margins. Post-crisis, we find that the lending products with the highest adjustment speeds are also the products with the highest average mark-ups; namely: CCL, 10K, and OD. This result is the reverse of pre-crisis findings, as banks tend to adjust products with high interest rates the slowest in this period. We find that *LRPT* for products is still higher than one but the magnitude is smaller post-crisis. On the other side for the deposit side we find a reduction in *LRPT* which is basically due to the fact that *LIBOR* rates alone are not dictating deposit rates but banks are market power to keep the rates above the PR in order to keep their customers and secure the deposit base.

3.6 Conclusion

In pre-crisis the study finds a very slow *SRAS* pre-crisis for both deposit and lending products, and *SRAS* is heterogeneous across products. *LRPT* is incomplete for most products. Among mortgage products we find more complete pass-through for variable rate products (TR, 2Y-VR and ST-VR). Among mortgages banks exercise market power as a result the products which have the slowest adjustment speeds have the highest mark-ups and lowest competition. In case of lending products, evidence of banks exercising market power is found, similar to mortgage, as the products with highest mark-ups have the lowest *SRAS*. In addition, we detect that banks increase prices for unsecured lending products (CCL, 10K and OD) more than proportionate to the changes in PR, which is due to high demand and risk associated to these unsecured lending products (de Bondt, 2005). *LRPT* is complete for TIME, suggesting perfect competition, and pass-through is greater than one for ISA, suggesting the availability of substitute products and indicating high competition in the market.

Post crisis study finds that the adjustment speed towards the Long run equilibrium for UK lending and deposit products increases significantly but still remains incomplete. Banking system has become more efficient in case of Lending and deposit products responding to PR. However, we find that mortgage products rates still stay very sticky post-crisis except for 3Y-FIX and ST-VR. Banks are more efficient in changing the retail rates as the adjustment speed is the highest of unsecured lending products which have the highest mark-up. This result is the reverse of pre-crisis findings, as banks tend to adjust products with high interest rates the slowest in pre-crisis period. For the deposit side we find a reduction in *LRPT* which is basically due to the fact that *LIBOR* rates alone are not dictating deposit rates but banks are exercising market power to keep the rates above the PR in order to keep their customers and secure the deposit base.

The study covers a range of financial products offered by the banking industry. However, it uses aggregated data, so fails to capture the whole picture for individual banks. With bank level data, it is possible to go further for a more detailed analysis,

and investigate whether the banks that show co-integration also show higher pass-through or *SRAS*, or below average mark-up. We can find the ranges of adjustment speed, *mark-up* and *LRPT*. These findings are only possible with a bank level data (see next study).

APPENDIX OF FIGURES AND TABLES

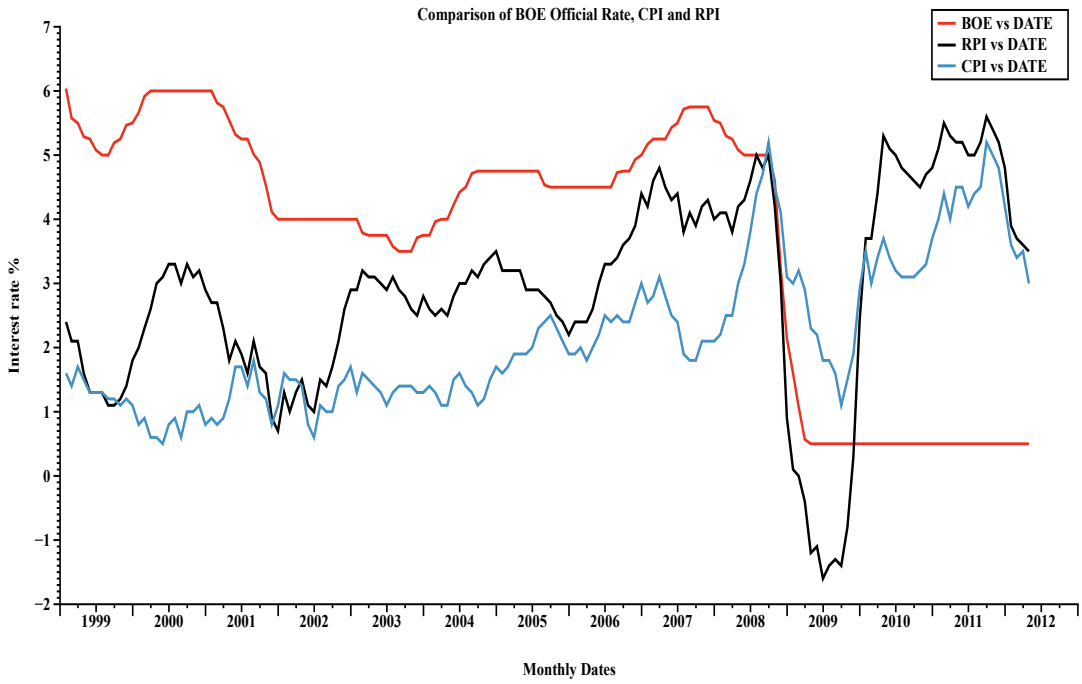

Figure 3-1. Time series comparison of BoE official rate RPI and CPI from 1999 to 2012.

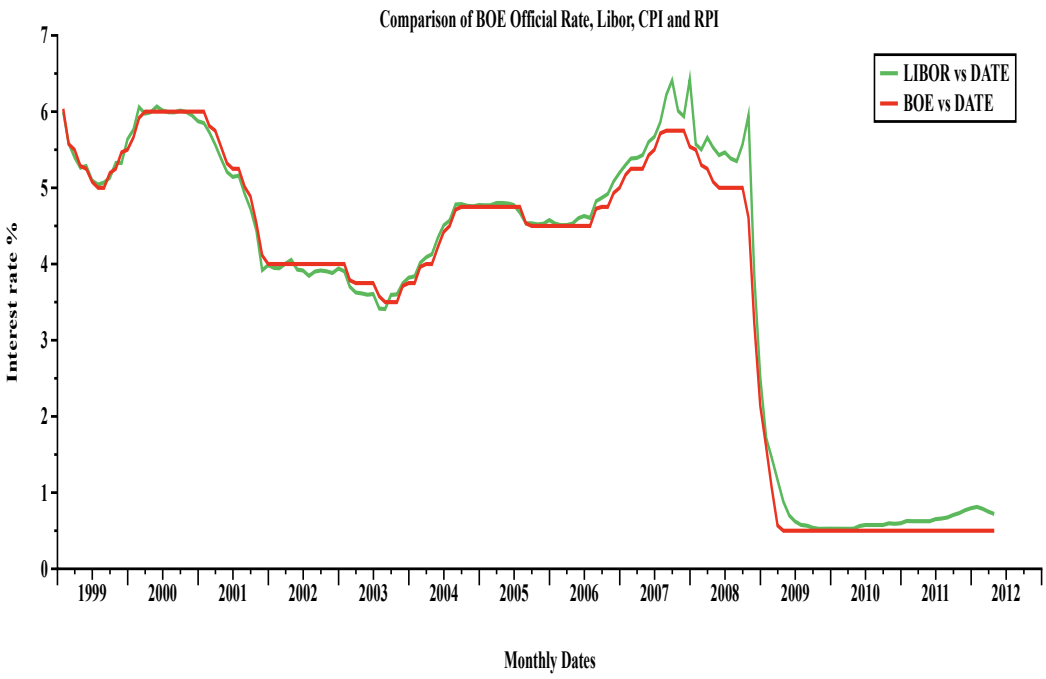

Figure 3-2. Time series comparison of the BoE official rate and LIBOR for 1999-2012.

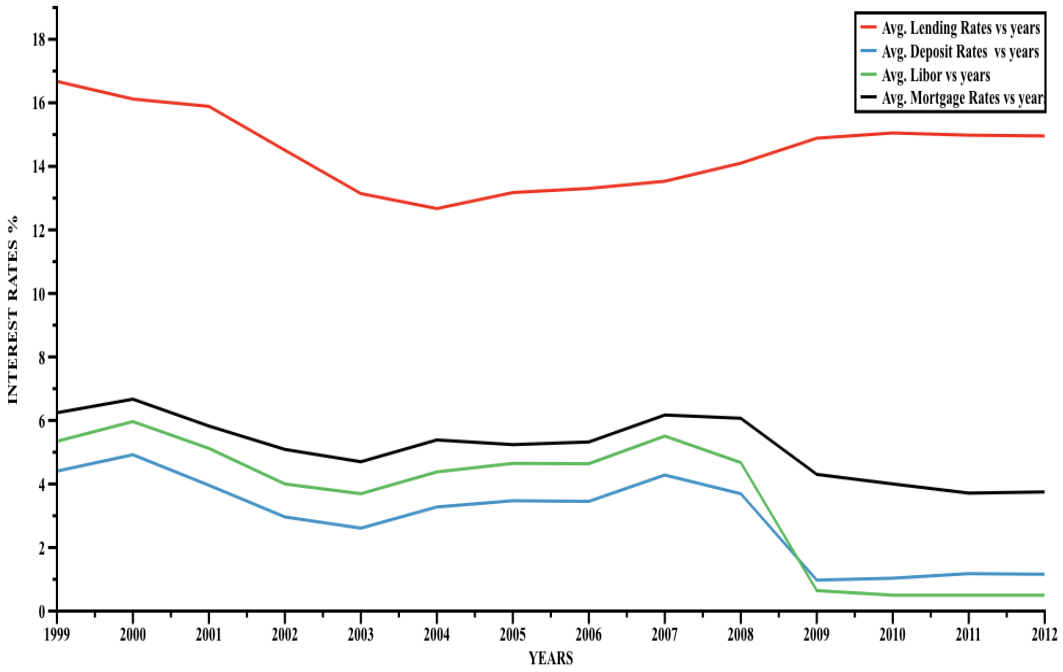

Figure 3-3. Time-series plot comparison of lending, deposit, mortgage rates and LIBOR for 1999-2012.

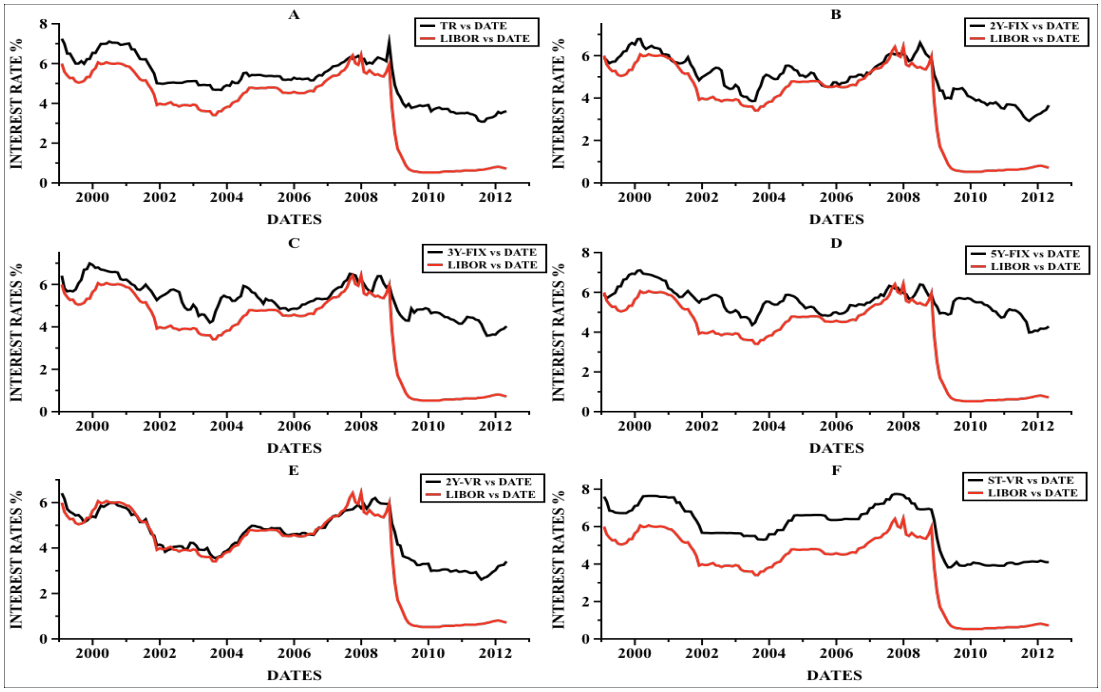

Figure 3-4.Time series plot comparison of all mortgage and LIBOR for 1999-2012

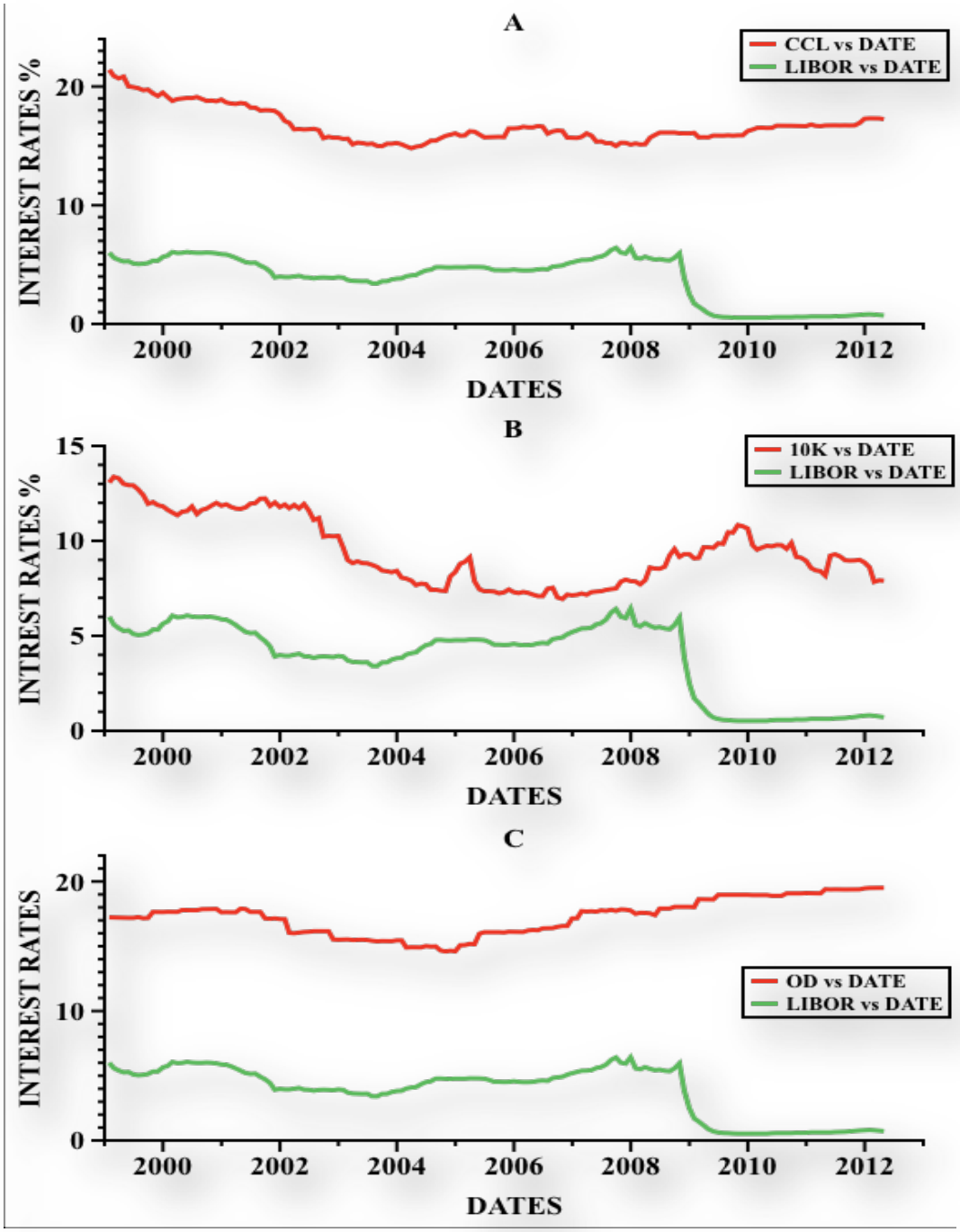

Figure 3-5. Time series comparison of CCL, 10K, OD and LIBOR for 1999-2012.

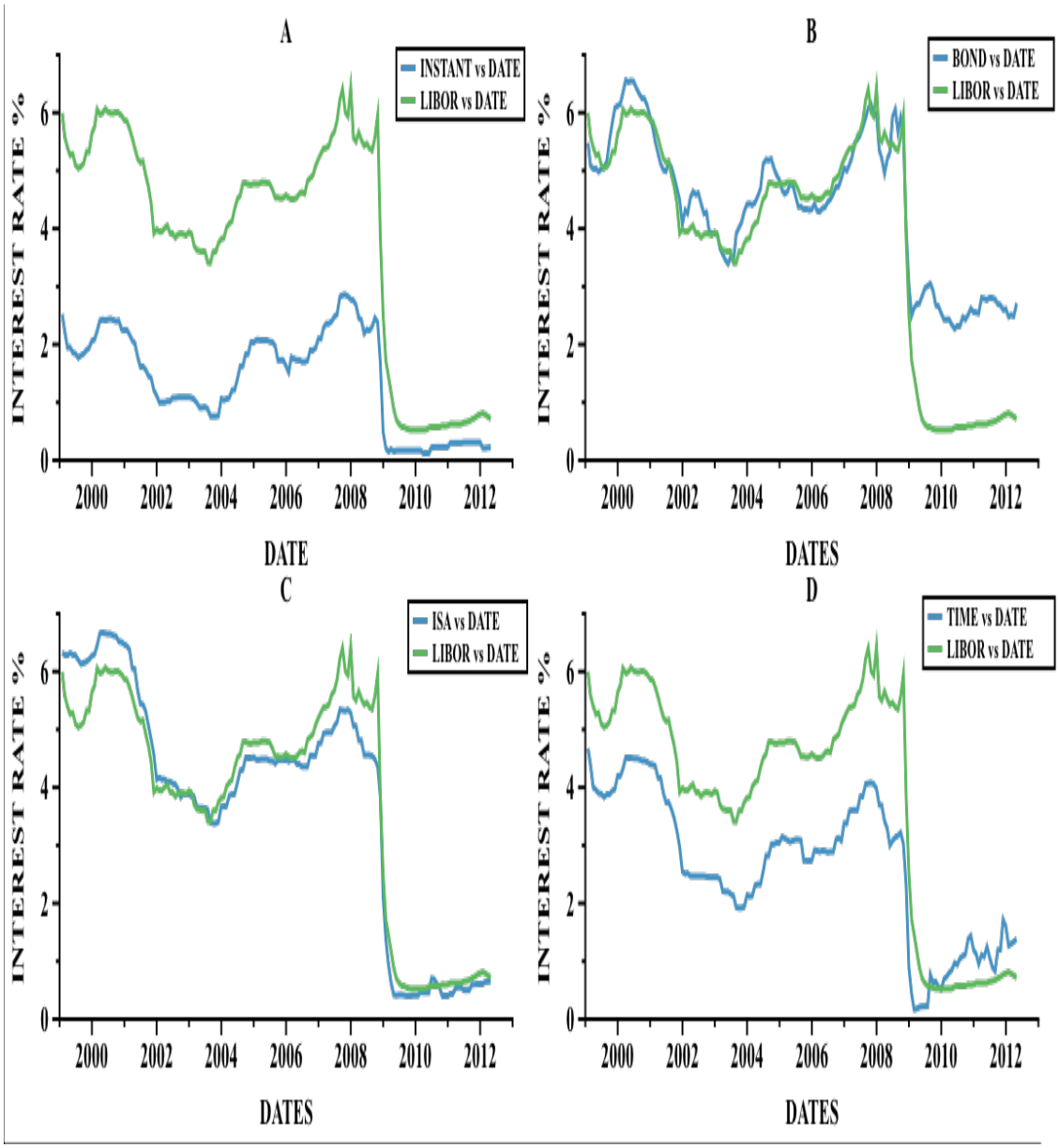

Figure 3-6. Time series trend comparison for all deposit and LIBOR for 1999-2012.

Table 3-2. ECM results for all 13 lending and deposit products pre-crisis

	MORTGAGE						*LENDING*					*DEPOSIT*	
	TR	2Y-FIX	3Y-FIX	5Y-FIX	2Y-VR	ST-VR	CCL	10K	OD	INSTANT	BOND	ISA	TIME
α	0.391**	0.262**	0.324**	0.237**	0.202**	0.254	0.503**	-0.189	0.772**	-0.053	0.072*	0.090	0.148
	(0.151)	(0.126)	(0.142)	(0.122)	(0.090)	(0.217)	(0.210)	(0.177)	(0.342)	(0.116)	(0.135)	(0.076)	(0.095)
$x_{i,t-1}$	-0.200**	-0.083*	-0.086**	-0.052*	-0.208***	-0.081	-0.052***	-0.031**	0.081***	-0.083	-0.090	0.042*	0.068
	(0.064)	(0.044)	(0.041)	(0.032)	(0.067)	(0.094)	(0.014)	(0.012)	(0.028)	(0.061)	(0.068)	(0.022)	(0.045)
$y_{i,t-1}$	0.152***	0.037	0.032	0.012	0.168***	0.057	0.066**	0.092***	0.119***	0.044	0.044	-0.064**	-0.079*
	(0.057)	(0.038)	(0.033)	(0.025)	(0.062)	(0.086)	(0.028)	(0.032)	(0.038)	(0.066)	(0.066)	(0.028)	(0.043)
$\Delta x_{i,t-1}$	-0.405***	0.422***	0.376***	0.408***	0.246**	0.103	-0.028	0.029	-0.009	0.324***	0.526***	0.214*	0.274**
	(0.121)	(0.099)	(0.094)	(0.092)	(0.103)	(0.101)	(0.089)	(0.091)	(0.091)	(0.118)	(0.129)	(0.119)	(0.110)
$\Delta x_{i,t-2}$	-	-	-	-	-	0.218**	-	-	-	-	-	0.223	-
						(0.090)						(0.115)	
Δy_{t-1}	0.469***	-0.009	0.030	0.012	0.031	0.318***	-0.015	-0.081	-0.077	0.303***	-0.008	0.537***	0.444***
	(0.100)	(0.071)	(0.066)	(0.055)	(0.074)	(0.071)	(0.080)	(0.097)	(0.078)	(0.061)	(0.115)	(0.056)	(0.065)

The stars show the significance level of the coefficients. One * means results are significant at the 10% level; two mean results are significant at the 5% level; and three mean results are significant at the 1% level.$x_{i,t-1}$ is the SRAS, which is the speed of adjustment towards its long run equilibrium.$y_{i,t-1}$ is the change in retail rate in reaction to the change in LIBOR.. The lag-length and best-fit model are chosen by the minimum value of SC and further lag terms of Δx_i are added to remove autocorrelation. Results captured from.Equation 3-20 given below.

$$\Delta x_{i,t} = \alpha_i + \gamma_i x_{i,t-1} + \theta_i y_{t-1} + \sum_{l=1}^{j-1} \lambda_{i,l} \Delta x_{i,t-l} + \sum_{l=1}^{j-1} \mu_l \Delta y_{t-l} + \varepsilon_{i,t}.$$

Table 3-3. ECM results for all 13 lending, mortgage and deposit products post-crisis

	MORTGAGE						*LENDING*				*DEPOSIT*		
	TR	2Y-FIX	3Y-FIX	5Y-FIX	2Y-VR	ST-VR	CCL	10K	OD	INSTANT	BOND	ISA	TIME
α	08.08** (0.351)	0.611 (0.713	5.201*** (1.484)	1.803*** (0.696)	-0.004*** (0.446)	2.133** (0.765)	9.569*** (1.962)	5.004*** (1.962)	5.812*** (1.922)	0.024 (0.025)	0.477** (0..234)	0.109** (0.049)	0.188 (0.144)
xi,t-1	-0.197** (0.087)	-0.164 (0.124)	-0.793*** (0.218)	-0.236*** (0.084)	-0.074 (0.118)	-0.581*** (0.211)	-0.627*** (0.627)	-0.402*** (0.129)	-0.328*** (0.107)	-0.163 (0.099)	-0.182** (0.081)	0.505*** (0.127)	0.269** (0.120)
yi,t-1	-0.183*** (0.142)	-0.045 (0464)	-2.827*** (0.878)	-1.043** (0.475)	0.365* (0.200)	0.326 * (0.163)	1.482*** (0.370)	-2.200** (0.879)	0.792*** (0.243)	0244 (0.046)	-0.010 (0.118)	0.244* (0.126)	0.177 (0.272)
Δxi,t-1	0.014. (0.167)	0.367* (0.199)	0.765*** (0.227)	0.348** (0.158)	0.104 (0.165)	0.341 (0.224)	0.291* (0.151)	0.176 (0.091)	0.010 (0.176)	-0.021 (0.099)	0.183 (0.174)	0.423** (0.142)	-0.009 (0.166)
Δxi,t-2	-	-	0.675*** (0.177)		-0.091 (0.195)	0.262 (0.212)	-	-	-	-	-		-
Δxi,t-3			0.418*** (0.148)			0.162 (0.186)							
Δxi,t-4			0.232 (0.136)			0.313** (0.139)							
Δxi,t-5			0.136 (0.423)			0.018 (0.127)							
						0.241** (0.099)							
Δyt-1	-0.260 (0.406)	-1.519 (1.306)	0.806 (0.989)	-0.506 (1.286)	0.430 (0.652	0.192 (0.457)	-0.754 (1.147)	-0.0419 (3.349)	-0.432 (0.078)	0.087 (0.106)	-0.008 (0.115)	0.391** (0.185)	1.156 (0.799)

Δyt-2	0.188 (1.281)	-1.251 (0.899)		-0.101 (1.168)	3.521 (3.512)	-1.339** (0.699)
Δyt-3	1.097 (1.158)			1.108 (1.061)	-6.665** (3.221)	1.507** (0.718)
Δyt-4	-0.146 (1.153)			0.072 (0.956)	8.232** (3.216)	0.267 (0.406)
Δyt-5	-0.653 (0.742)			-0.546 (0.962)	-6.328*** (1.847)	
Δyt-6				1.802** (0.688)		

The stars show the significance level of the coefficients. One * means results are significant at the 10% level; two mean results are significant at the 5% level; and three mean results are significant at the 1% level.$x_{i,t-1}$ is the SRAS, which is the speed of adjustment towards its long run equilibrium.$y_{i,t-1}$ is the change in retail rate in reaction to the change in LIBOR.. The lag-length and best-fit model are chosen by the minimum value of SC and further lag terms of Δx_i are added to remove autocorrelation. Results captured from.Equation 3-20 given below.

$$\Delta x_{i,t} = \alpha_i + \gamma_i x_{i,t-1} + \theta_i y_{t-1} + \sum_{l=1}^{j-1} \lambda_{i,l} \Delta x_{i,t-l} + \sum_{l=1}^{j-1} \mu_l \Delta y_{t-l} + \varepsilon_{i,t}.$$

Table 3-4. Pre-crisis short-run ECM results for mortgage products

Variable	α	P-Value	|γ|	P-value	Θ	P-Value	(J)	R2	F-stat
TR	0.391	0.011	0.200	0.002	0.152	0.008	1.000	0.317	13.116
2Y-FIX	0.262	0.040	0.083	0.062	0.037	0.343	1.000	0.177	6.073
3Y-FIX	0.324	0.025	0.086	0.039	0.032	0.322	1.000	0.176	6.015
5Y-FIX	0.237	0.055	0.052	0.100	0.012	0.622	1.000	0.179	6.140
2Y-VR	0.202	0.027	0.208	0.002	0.168	0.008	1.000	0.226	8.251
ST-VR	0.254	0.244	0.081	0.389	0.057	0.511	2.000	0.457	18.703

Results are taken from Equation 3-20. $|\gamma|$ is the adjustment speed; which is the speed of adjustment towards its long run equilibrium. It is the error which prevailing at month *t-1*; which is closed at month *t* It is measured by the absolute value of parameter $\gamma|<0; j$ is Adjustment delay shown as the number of lags per month. TR is tracker mortgage, 2Y-FIX is 2 years fix mortgage, 3y-FIX is 3 year fix mortgage, 5y-FIX 5 years fix mortgage, 2y-VR 2 year variable mortgage and ST-VR is standard variable mortgage.

Table 3-5. Pre-crisis long-run parameter results and Wald Bounds test values for mortgage products for the period 1999 – 2008

Variable	$A=-\alpha/\gamma$ Mark-up/down	S.E (A)	$C=-\theta/\gamma$ LRPT	S.E (C)	$x_t^* = A + C_t$ LRER	F-Value (Wald test)	P-Value (Wald Test)
TR	1.957	0.137	0.759	0.006	5.655	5.060	0.008
2Y-FIX	3.164	1.009	0.442	0.043	5.317	2.558	0.082
3Y-FIX	3.763	0.800	0.376	0.409	5.594	2.831	0.063
5Y-FIX	4.515	1.787	0.238	0.074	5.675	1.984	0.142
2Y-VR	0.970	0.086	0.808	0.474	4.904	5.512	0.005
ST-VR	3.121	0.955	0.697	0.043	6.516	1.076	0.345

x_t^* is calculated using Equation 3-19; *A* is long-run mark–up, which indicates how much a bank product rate is set above or below the official rate in the long term; it is calculated using Equation 3-21. *C* is represents the competition; it is defined as the fraction or the multiple of an official rate change that is reflected in the retail rate over the long-run; it is calculated using Equation 3-22. Standard error of *A* and *C* is calculated using Equation 3-10 and Equation 3-17 respectively. $(y_t=4.87)$, the average value of LIBOR for the period 1999-2008, which is used to Calculate x_t^*.

Table 3-6. Pre-crisis short-run ECM results for lending products

Variable	α	p-value	|γ|	p-value	Θ	p-value	(J)	R2	F-stat
CCL	0.503	0.018	0.052	0.000	0.066	0.023	1.000	0.116	3.701
10K	-0.189	0.289	0.031	0.011	0.092	0.005	1.000	0.110	3.492
OD	0.772	0.026	0.081	0.005	0.119	0.002	1.000	0.085	2.627

Results are taken from Equation 3-20|γ| is the adjustment speed; which is the speed of adjustment towards its long run equilibrium. It is the error which prevailing at month *t-1*; which is closed at month *t* It is measured by the absolute value of parameter *γ|<0; j* is Adjustment delay shown as the number of lags per month. CCL is credit card lending, 10k is 10k loans and OD is overdrafts.

Table 3-7. Pre-crisis long-run parameter results and Wald Bounds test values for lending products

Variable	$A=-\alpha/\gamma$ Mark-up/down	S.E (A)	$C=-\theta/\gamma$ LRPT	S.E (C)	$x_t^* = A + C\,y_t$ LRER	F-value (Wald test)	p-value (Wald Test)
CCL	9.712	3.080	1.270	0.121	15.897	7.004	0.001
10K	-6.032	25.005	2.948	0.947	8.325	6.293	0.003
OD	9.537	1.229	1.472	0.051	16.703	5.175	0.007

x_t^* is calculated using Equation 3-19; *A* is long-run mark–up, which indicates how much a bank product rate is set above or below the official rate in the long term; it is calculated using Equation 3-21. *C* is represents the competition; it is defined as the fraction or the multiple of an official rate change that is reflected in the retail rate over the long-run; it is calculated using Equation 3-22. Standard error of *A* and *C* is calculated using Equation 3-10 and Equation 3-17 respectively. $(y_t = 4.87)$, the average value of LIBOR for the period 1999-2008, which is used to Calculate x_t^*.

Table 3-8. Pre-crisis short-run ECM results for deposit products

Variable	α	P value	|γ|	p-value	Θ	p-value	(J)	R2	F-stat
INSTANT	-0.053	0.651	0.083	0.174	0.040	0.361	1	0.468	24.867
BOND	0.072	0.099	0.090	0.184	0.044	0.510	1	0.230	8.458
ISA	0.090	0.242	0.042	0.064	-0.064	0.022	2	0.602	33.640
TIME	0.148	0.120	0.068	0.131	-0.079	0.069	1	0.493	27.499

Results are taken from Equation 3-20. $|\gamma|$ is the adjustment speed; which is the speed of adjustment towards its long run equilibrium. It is the error which prevailing at month *t-1*; which is closed at month *t* It is measured by the absolute value of parameter $\gamma|<0; j$ is Adjustment delay shown as the number of lags per month. INSTANT is instant deposits, BOND is 10 year govt bond, ISA is ISA savings, TIME is time deposits.

Table 3-9. Pre-crisis long-run parameter results and Wald Bounds test values for deposit products

Variable	$A=-\alpha/\gamma$ Mark-up/down	S.E (A)	$C=-\theta/\gamma$ LRPT	S.E (C)	$x_t^* = A + C\,y_t$ LRER	F-value (Wald test)	p-value (Wald test)
INSTANT	-0.633	0.564	0.481	0.025	1.712	1.623	0.202
BOND	0.791	2.045	0.486	0.090	3.158	1.946	0.148
ISA	-2.126	2.193	1.525	0.103	5.301	2.708	0.071
TIME	-2.171	0.948	1.154	6.174	3.450	1.787	0.172

x_t^* is calculated using Equation 3-19; *A* is long-run mark–up, which indicates how much a bank product rate is set above or below the official rate in the long term; it is calculated using Equation 3-21. *C* is represents the competition; it is defined as the fraction or the multiple of an official rate change that is reflected in the retail rate over the long-run; it is calculated using Equation 3-22. Standard error of *A* and *C* is calculated using Equation 3-10 and Equation 3-17 respectively. $(y_t=4.87)$, the average value of LIBOR for the period 1999-2008, which is used to Calculate x_t^*.

Table 3-10: Post-crisis short-run parameters on Mortgage products

Variable	α	P-Value	|γ|	P-Value	θ	P-value	(J)	R-sqrd	F-stat
TR	0.808	0.028	0.197	0.031	0.183	0.206	1.000	0.227	2.421
2Y-FIX	0.611	0.400	0.164	0.196	-0.045	0.923	1.000	0.351	1.693
3Y-FIX	5.201	0.002	0.793	0.001	-2.827	0.004	5.000	0.442	2.472
5Y-FIX	1.803	0.015	0.236	0.009	-1.043	0.036	1.000	0.444	4.946
2Y-VR	-0.004	0.993	0.074	0.536	0.365	0.077	2.000	0.240	1.960
ST-VR	2.133	0.011	0.581	0.011	0.326	0.058	6.000	0.556	3.195

Results are taken from Equation 3-20$|\gamma|$ is the adjustment speed; which is the speed of adjustment towards its long run equilibrium. It is the error which prevailing at month *t-1*; which is closed at month *t* It is measured by the absolute value of parameter $\gamma|<0; j$ is Adjustment delay shown as the number of lags per month. TR is tracker mortgage, 2Y-FIX is 2 years fix mortgage, 3y-FIX is 3 year fix mortgage, 5y-FIX 5 years fix mortgage, 2y-VR 2 year variable mortgage and ST-VR is standard variable mortgage.

Table 3-11: Post-crisis long-run parameter results and Wald Bounds test values for Mortgage products

Variable	$A=-\alpha/\gamma$ Mark-up/down	S.E (A)	$C=-\theta/\gamma$ LRPT	S.E (C)	$x_t^* = A + C\,y_t$ LRER	F-value (Wald test)	P-value (Wald test)
TR	4.102	0.100	-0.929	0.249	3.458	2.719	0.081
2Y-FIX	3.713	1.499	-0.275	3.515	3.522	2.636	0.091
3Y-FIX	6.555	0.017	-3.563	0.043	4.084	7.371	0.003
5Y-FIX	7.629	0.224	-4.414	0.534	4.568	4.021	0.028
2Y-VR	-0.055	18.536	4.917	46.588	3.355	3.756	0.035
ST-VR	3.669	0.005	0.561	0.013	4.058	3.920	0.034

x_t^* is calculated using Equation 3-19; *A* is long-run mark–up, which indicates how much a bank product rate is set above or below the official rate in the long term; it is calculated using Equation 3-21. *C* is represents the competition; it is defined as the fraction or the multiple of an official rate change that is reflected in the retail rate over the long-run; it is calculated using Equation 3-22. Standard error of *A* and *C* is calculated using Equation 3-10 and Equation 3-17 respectively. $(y_t = 4.87)$, the average value of LIBOR for the period 1999-2008, which is used to Calculate x_t^*.

Table 3-12: Post-crisis short-run parameters on pass-through on Lending products

Variable	α	P-Value	|γ|	P-Value	Θ	P-value	(J)	R-sqrd	F-stat
CCL	9.569	0.000	0.627	0.000	1.482	0.001	1.000	0.568	3.363
10K	5.004	0.003	0.402	0.002	-2.200	0.019	1.000	0.497	3.090
OD	5.812	0.005	0.328	0.005	0.792	0.003	1.000	0.599	5.766

Results are taken from Equation 3-20. $|\gamma|$ is the adjustment speed; which is the speed of adjustment towards its long run equilibrium. It is the error which prevailing at month *t-1*; which is closed at month *t* It is measured by the absolute value of parameter $\gamma|<0; j$ is Adjustment delay shown as the number of lags per month. CCL is credit card lending, 10k is 10k loans and OD is overdrafts.

Table 3-13: Post-crisis long-run parameter results and Wald Bounds test values for lending products

Variable	$A=-\alpha/\|\gamma\|$ Mark-up/down	S.E (A)	$Ci=-\theta/\gamma$ LRPT	S.E (C)	$x_t^* = A + C\,y_t$ LRER	F-value (Wald test)	P-value (Wald test)
CCL	15.272	0.019	2.365	0.048	16.912	7.046	0.004
10K	12.438	0.467	-5.467	1.159	8.646	6.265	0.006
OD	17.720	0.033	2.415	0.088	19.395	5.477	0.010

x_t^* is calculated using Equation 3-19; *A* is long-run mark–up, which indicates how much a bank product rate is set above or below the official rate in the long term; it is calculated using Equation 3-21. *C* is represents the competition; it is defined as the fraction or the multiple of an official rate change that is reflected in the retail rate over the long-run; it is calculated using Equation 3-22. Standard error of *A* and *C* is calculated using Equation 3-10 and Equation 3-17 respectively. $(y_t = 4.87)$, the average value of LIBOR for the period 1999-2008, which is used to Calculate x_t^*.

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Table 3-14: Post-crisis short-run parameters on pass-through on deposit products

Variable	α	P-Value	|γ|	P-Value	Θ	Prob.	(J)	R-sqrd	F-stat
INSTANT	0.024	0.354	0.162	0.112	0.024	0.598	1.000	0.092	0.838
BOND	0.477	0.049	0.182	0.032	-0.010	0.933	1.000	0.213	2.229
ISA	0.109	0.034	0.505	0.000	0.244	0.063	1.000	0.644	14.907
TIME	0.188	0.202	0.269	0.032	0.177	0.519	1.000	0.155	1.507

Results are taken from Equation 3-20. $|\gamma|$ is the adjustment speed; which is the speed of adjustment towards its long run equilibrium. It is the error which prevailing at month *t-1*; which is closed at month *t* It is measured by the absolute value of parameter $\gamma|<0; j$ is Adjustment delay shown as the number of lags per month. INSTANT is instant deposits, BOND is 10-year govt bond, ISA is ISA savings, TIME is time deposits.

Table 3-15: Post-crisis long-run parameter results and Wald Bounds test values for Deposit products

Variable	$A=-\alpha/\gamma$ Mark-up/down	SE (A)	$C=-\theta/\gamma$ LRPT	SE C	$x_t^* = A + C\, y_t$ LRER	F-Value (Wald test)	P Value (Wald test)
INSTANT	0.148	0.012	0.150	0.030	0..252	1.430	0.254
BOND	2.620	0.086	-0.055	0.208	2.581	2.531	0.095
ISA	0.216	0.006	0.482	0.015	0.550	10.053	0.000
TIME	0.698	0.170	0.659	0.383	1.155	2.816	0.074

x_t^* is calculated using Equation 3-19; *A* is long-run mark–up, which indicates how much a bank product rate is set above or below the official rate in the long term, it is calculated using Equation 3-21. *C* is represents the competition; it is defined as the fraction or the multiple of an official rate change that is reflected in the retail rate over the long-run; it is calculated using Equation 3-22. Standard error of *A* and *C* is calculated using Equation 3-10 and Equation 3-17 respectively. $(y_t=4.87)$, the average value of LIBOR for the period 1999-2008, which is used to Calculate x_t^*.

4 INTERBANK AND INTRA-BANK ANALYSIS OF PASS-THROUGH FOR SAVINGS ACCOUNTS IN DIFFERENT TYPES OF FIRM IN THE UK

4.1 Introduction

4.1.1 Motivation for study

In Chapter 3, the study used aggregated data, collected from the BoE website. The data comprises aggregated monthly retail rates of different financial products offered to households in the UK by banks and building societies combined. There were two reasons for using the aggregated data set. First, it includes a wide variety of deposit, lending and mortgage accounts; this made possible a comparison of price setting on these three types of account. Second, the data set covers a long period, which facilitated a comparison of the industry pre- and post-crisis period. The study examined the stickiness of competition and heterogeneities among different financial accounts. However, we were unable to investigate whether there are differences in stickiness, competition, and price setting among the different types of firm for the same product or different products. This is due to the limitations of using aggregated data.

Most interest rate transmission studies rely on aggregated data. This rules out the possibility that the dynamic relationship between changes in the BoE official rate and the retail rate can vary significantly across individual banks and building societies. Different types of financial firm can have different objectives, characteristics and costs. This can lead these firms to have differences in their response to policy rate changes. For example, in the UK, it is frequently argued that high street banks answer to shareholders. Building societies, however, as mutual organisations with substantial reserves, can opt to protect their depositors/borrowers by smoothing their responses or delaying passing on changes in the central bank rate. Moreover, smaller firms may offer customers keener prices (interest rates) than larger ones or alter their prices more quickly. In view of these potential differences in behaviour, the results based on

aggregated data may suffer from aggregation bias. There is an extensive literature available on the problem of aggregation bias (Imbs et al., 2005, Pesaran et al., 2006). For example, if all the banks and building societies show a high adjustment speed, the aggregated values would also do so and there would be no bias. In reality, some banks and building societies show a high adjustment speed, while others have a slower speed. The aggregation bias comes precisely from the heterogeneity in the dynamics (Imbs et al., 2005). To measure the IRPT differences between firms, there are very few studies on interest rate transmission in the UK financial market which use disaggregated data. Those studies that use such data are also confined to very few firms and accounts, and cover a very short observation period. To the author's best knowledge, only four studies have been conducted using disaggregated data for the UK (namely: Hefferman, 1997; Hofmann and Mizen, 2004; Ashton, 2007; Fuertes and Heffernan, 2009).

In light of the limited literature available, the current study uses disaggregated interest rate data at the bank level for UK savings accounts. The research covers the period from Jan 1999 to Dec 2011. The heterogeneities in the IRPT parameters are investigated for the three different types of firm; high street banks (HSB), building societies (BS) and small banks (SB) (see Section 4.4), each offering two savings products. Differences in price setting behaviour within each type of firm for different saving accounts is also analysed. Having three types of firm allows comparison to identify which type is more efficient. We also consider whether the *Law of One Price* exists for the same product in different types of firm in the UK market, and whether, within each type of firm, the price adjustment behaviour for different accounts is the same. In addition, the group mean t-test is used to formally investigate inter-bank and intra-bank heterogeneities among different firms.

This study contributes to the existing literature in six respects. First, it uses a larger data set. Second, by grouping the individual FIs by type (high street bank, building society and small bank), the study tests the effectiveness of the monetary policy mechanism for three types of firm. Third, the inter-bank (among firms) heterogeneities in IRPT parameters are formally tested for the three types of firm. Fourth, intra-bank heterogeneities in IRPT parameters are also formally tested for these firms. Fifth,

using aggregated data allows investigation of the *Law of One Price* in the UK savings accounts industry. Six, the study adds to literature by examining the deposit-tier effects on IRPT parameters.

4.1.2 Research Question and Objectives of the Study and Hypothesis Development

Different types of financial firm can have different objectives, characteristics and costs. This can lead these firms to have differences in their response to policy rate changes. For example, in the UK, it is frequently argued that high street banks answer to shareholders. Building societies, however, as mutual organisations with substantial reserves, can opt to protect their depositors/borrowers by smoothing their responses or delaying passing on changes in the central bank rate. Moreover, smaller firms may offer customers keener prices (interest rates) than larger ones or alter their prices more quickly. In view of these potential differences in behaviour, the results based on aggregated data may suffer from aggregation bias.

Since it is argued that banks exhibit some degree of market power (oligopolist market) because the typical retail market is "...dominated by a few large banks of national and international character" (Rousseas, 1985, p.136).

Hannan and Prager (2004) speculate that large banks have greater access to wholesale funds. This implies that larger banks do not need to offer as high a retail deposit rate as small banks, and that smaller, single market banks tend to offer lower deposit rates, the greater the presence of large multimarket banks in their local areas. This explanation is consistent with the findings of Kiser (2004) and Schuller and Heinemann (2002) in a paper that explicitly models the relationship between the cost of wholesale funds and the interest rate offered on retail deposit accounts.

This study uses a large sample of disaggregated data to shed light on how high street banks (HSB), building societies (BS) and small banks (SB) adjust retail rates for savings accounts in response to changes in the PR (policy Rate). The main goals of the study are to analyse the dynamic adjustment of savings account interest rates by different types of UK firm in response to PR changes; to investigate the existence of

heterogeneous behaviour in interest rate setting among different types of firm; and to examine the impact of aggregation bias.

The main question to be explored in this study is whether there are differences in the monetary policy transmission mechanism, competition, and price setting behaviour among the different type of firm for the same product; or different products. Accordingly, the study focuses on the following questions:

- Do inter-bank heterogeneities in SRAS and competition for IAS and MTS accounts exist among firms? (which type of firm is more efficient; which firm has the highest competition for IAS and MTS accounts?)?
- Do inter-bank heterogeneities exist among firms for mark-up/down for IAS and MTS accounts? (Does the *Law of One Price* exists in UK market)
- Do intra-bank heterogeneities exist for *SRAS* and competition (tier effect) exist within firm itself for adjustment speed for IAS and MTS accounts? (Difference in adjustment speed and competition in the same firm type and product, but among different deposit tiers?)

4.1.3 Structure of the paper

Section 4.1 describes the study's motivation, research questions and objectives; the structure of the paper; and discusses aggregation bias and the *Law of One Price*. Section 4.4 describes data sources and the process of data collection. It also provides definitions and abbreviations of the financial products. Section 4.5 comprises a brief literature review, focussing on those studies that are closest to the present study. Section 4.6 describes the methodology used in this paper; it explains the econometric model, provides definitions of variables, and explains the mechanics of the tests used. Section 4.7 presents results and discussion; it presents descriptive statistics and discusses the empirical results and their interpretation for both IAS and MTS products. Finally, Section 4.8 reports the most important findings and provides concluding remarks.

4.1.4 Aggregation Bias

As mentioned previously (see Section 4.1.) , many studies are based on aggregate level data that consists of a simple sum or weighted average of the bank-level data. However, aggregating the data of the micro units, according to Theil (1957) and Zellner (1962), may lead to aggregation bias. The theoretical basis of the aggregation bias is that the individual (micro) units from which the aggregated data is composed may be individuals with different (heterogeneous) behavior. Consequently, by estimating the economic relations with aggregated data, the individual behavior of each unit is suppressed. Differences may, therefore, be hidden in the disturbances of the model, which may result in biased estimates. According to Theil (1957), Zellner (1962) and Lee et al. (1990), the derivation of the aggregation bias, based on simple (bivariate) time series regression, is as follows:

The general disaggregated model for each unit may be presented as:

$$y_{it} = \beta_i x_{it} + u_i; i = 1,2,3, \ldots . n \qquad \text{Equation 4-1}$$

Where y is the dependent variable; x is an independent variable; β is a coefficient to be estimated; u is white noise residuals; i and t are unit and time specific subscripts. The same equation derived for the aggregated data would be as follows:

$$\sum_{i=1}^{n} y_{it} = \sum_{i=1}^{n} \beta_i x_{it} + \sum_{i=1}^{n} u_i = \qquad \text{Equation 4-2}$$

However, in the empirical research based on aggregated data, the economic relations are estimated as follows:

$$\sum_{i=1}^{n} y_{it} = \beta_i \sum_{i=1}^{n} x_{it} + v_i \qquad \text{Equation 4-3}$$

Equation 4-2 and Equation 4-3 would be equal if the residuals of both equations are equal ($u = v$), for which the following condition (H_0) must be satisfied:

$$H_0 = \sum_{i=1}^{n} \beta_i x_{it} + \beta \sum_{i=1}^{n} x_{it} = 0 \qquad \text{Equation 4-4}$$

or in a simplified form (Zellner, 1962):

$$H_0 = \beta_1 = \beta_2 = \beta_3 = \cdots = \beta \qquad \text{Equation 4-5}$$

Condition H_0 actually indicates that the β parameter from Equation 4-2 must be equal for each individual unit, implying homogeneous behavior among the units from which the aggregated data are derived. Otherwise, if the condition H_0 is not satisfied, then it implies that the units have heterogeneous behavior that is hidden in the error term of Equation 4-3 and would result in biased estimates.

In the case of the banking sector, de Graeve et al. (2004) argue that estimating the pass-through multipliers with aggregate data may also lead to aggregation bias arising from the heterogeneous nature of the data. This argument is empirically supported by their findings for Belgium, where pass-through estimates based on aggregate data are lower compared to estimates based on individual (bank-level) data.

4.1.5 Law of One Price

As discussed above, using disaggregated data is required for the study of whether the *Law of One Price* is valid. To study price convergence from a theoretical perspective, it is necessary to consider the *Law of One Price*. This serves as a clear benchmark. According to this law: "In an efficient market all identical goods must have only one price". This means, in a single market, prices should converge thanks to arbitrage (Affinito and Farabullini, 2006). Several researchers have used the law for measuring homogeneity in interest rates. If the law holds, it means there should not be any market segmentation. However, the existence of differences in price levels means that barriers to entry in the industry are causing price differences. In reality, many researchers on various grounds have criticized the law. The test of its validity is especially complex in the banking market because several banking products are not similar and cannot be substituted for each other. This suggests the law may not hold within countries even if the markets are integrated (Affinito and Farabullini, 2009). On the other hand, arbitrage should be easier in financial markets compared to goods markets because of the absence of transportation costs. For this reason, the law might be expected to hold instantaneously.

Nonetheless, the *Law of One Price* remains a useful theoretical reference when one analyzes price convergence. First, financial theorists have used the law as an uncontroversial minimal condition, on which they have built the edifice of modern financial theory, including the Modigliani-Miller capital structure propositions and the Black-Scholes option-pricing formula (for example, Lamont and Thaler, 2003). Second, the ECB considers the law a natural way to assess the state of European financial integration (for example, Trichet, 2006). Third, several scholars indicate that, even with its imperfections, the law is the sole theory for measuring integration (Adam et al., 2002; Adjaouté and Danthine, 2003; Baele et al., 2004; Kok Sorensen and Lichtenberger, 2007; Gropp and Kashyap, 2010). The *Law of One Price* will therefore be used as a theoretical benchmark to check for price convergence among firms for both types of savings account product in the present study.

4.2 Hypothesis Development

Different types of financial firms can have different objectives, characteristics and costs. This can lead these firms to have differences in their response to policy rate changes. For example, in the UK, it is frequently argued that high street banks answer to shareholders. Building societies, however, as mutual organisations with substantial reserves, can opt to protect their depositors/borrowers by smoothing their responses or delaying passing on changes in the central bank rate. Moreover, smaller firms may offer customers keener prices (interest rates) than larger ones or alter their prices more quickly when PR is going up. In view of these potential differences in behaviour, the results based on aggregated data may suffer from aggregation bias hence the use of disaggregated data helps us study these differences in firm behaviour.

Since it is argued that banks exhibit some degree of market power (oligopolist market) because the typical retail market is "...dominated by a few large banks of national and international character" (Rousseas, 1985, p.136). So we expect banks to exercise market power. According to the market power hypothesis of Berger (1995), banks with a larger market share tend to react less rapidly when base rates are rising and less completely to changes in market conditions. In addition, less liquid banks adjust interest rates on loans and deposits more quickly. So we expect that larger banks will have lower adjustment speed and smaller banks building societies to have lower adjustment speed. However larger banks can exercise market power and delay the adjustment of the deposits with higher maturity which costs them more. Because all the banks are in the race for attracting customers their aim is to increase deposit base. Due to this all banks and building societies tend to offer higher rates of higher deposits as an incentive. They also try to take advantage of keeping the adjustment speed changes lower on higher deposit products so in times of rising PRs they pay less interest. As Heffernan 2005 notices that the higher the tier size of the deposits the lower the adjustment speed.

Larger banks enjoy economies of scale and have access to cheaper cost of funds. We expect to see that larger banks offer lower prices for deposits and will have relatively faster adjustment speed when PR is falling as larger banks answer to shareholders and profit maximizing is their main target. Large banks enjoy economies of scale and pay lower deposit rate compared to building societies and the small banks. On the other hand because large banking have higher market power they can intentionally pay higher deposits rates to create barriers to entry and also to keep their deposit base. Due to the economies of scale and market power we expect that the law of one piece may not hold in the UK banking market. Martin et al. (2005b) finds for the Spanish that the Law of One Price does not apply for similar products. Author argues that it is due to the market power of larger banks. Larger banks also enjoy economies of scale which enables them to operate on lower costs and pay lower deposits.

Because larger banks have easier access to cheaper cost of funds compared to smaller banks and building societies; we expect the competition in smaller banks to be higher due to the fact that they have to work harder to attract customers and higher deposit base. Hannan and Prager (2004) speculate that large banks have greater access to wholesale funds. This implies that larger banks do not need to offer as high a retail deposit rate as small banks, and that smaller, single market banks tend to offer lower deposit rates.

Building societies, however, as mutual organisations with substantial reserves, can opt to protect their depositors/borrowers by smoothing their responses or delaying passing on changes in the central bank rate. For example, Heffernan (2004) finds that converted building societies are far more likely to rapidly respond to a change in current LIBOR than the building societies. The results show that the new converts offer predominantly rip-off products, providing evidence to support the expectation that, in an imperfectly competitive environment, they become more responsive to shareholders post-conversion.

4.4 Data Collection, Definitions and Abbreviations of IAS and MTS

The study uses disaggregated data for deposit savings accounts offered by UK financial institutions for the period Jan 1999 to Dec 2011. The data is collected from MoneyFacts, a company that gathers and publishes interest rate data for UK financial institutions. The data are unbalanced panel bank level data collected on a monthly basis. Disaggregated data facilitates division of the data into three groups on the basis of the type of firm: namely, HSB, BS and SB. The data set includes data for a total of 78 banks and building societies, comprising 9 HSB, 52 BS and 17 SB.

In terms of savings accounts, there are two main product categories: Instant access savings (IAS) and Medium term savings (MTS). IAS accounts are those for which no notice period or only 0 days of notice are required to withdraw savings. The IAS product is further classified into 7 tiers, according to deposit levels, namely: 1K, 2.5K, 5K, 10K, 25K, 50k and 100k. In total, therefore, there are 7 IAS accounts, which are named 1K-IAS, 2.5K-IAS, 5K-IAS, 10K-IAS, 25K-IAS, 50K-IAS and 100K-IAS.

MTS accounts are those for which 30 to 90 days of notice period is required to withdraw money. As the interest rate paid on savings accounts changes with the amount of funds deposited, MTS accounts are classified according to 7 representative deposit levels: namely, 1K, 2.5K, 5K, 10K, 25K, 50k and 100k. In total, there are 7 deposit tiers for these accounts: namely, 1K-MTS, 2.5K-MTS, 5K-MTS, 10K-MTS, 25K-MTS, 50K-MTS and 100k-MTS.

The deposit tiers are further grouped to form three main levels: low tier (LT), mid tier (MT) and high tier (HT). 1K-IAS and 2.5K-IAS are classed as low tier accounts, 5K-IAS and 10K-IAS as mid tier and 25K-IAS, 50K-IAS AND 100K-IAS as high-tier accounts to find any tier effect associated. Table 4-1 presents deposit tiers, definitions and Abbreviations of IAS and MTS.

Table 4-1: Deposit tiers, Definitions and Abbreviations of IAS and MTS

	IAS Accounts	MTS Accounts	Deposit levels
Low Tier	1K-IAS	1K-MTS	up to £1000
	2.5K-IAS	2.5K-MTS	up to £2,500
Mid Tier	5K-IAS	5K-MTS	up to £5000
	10K-IAS	10K-MTS	up to £10,000
High Tier	25k-IAS	25K-MTS	up to £25,000
	50K-IAS	50KMTS	up to £50,000
	100K-IAS	100KMTS	up to £100,000

4.4.1 Selecting the Base Rate

In this paper, the BoE rate is selected as the base rate. This rate is set by the BoE on a daily basis for inflation targeting. It also represents the opportunity costs of the total assets of a bank, and is used to measure the marginal revenue of assets and marginal cost of liabilities. For these reasons, the BoE official rate is treated as a proxy for the perfectly competitive deposit/loan/mortgage/credit card rates. The BoE rate is obtained from the Central Bank of England website. It is calculated as an average monthly rate from Jan 1999 to Dec 2011. Figure 4-1 presents a comparison of LIBOR and the BoE official rate.

4.5 Theoretical Background and Review of Relevant Literature

A small number of studies that are most closely related to the present study are reviewed in detail here. A broader review of the literature, with slightly less technical detail, can be found in Section 2.7. The studies discussed in this section are those focused on the UK banking industry, as well as those most cited with regard to IRPT research. Comparison of our findings with these studies will be made throughout the paper's empirical analysis.

One of the first studies conducted in the UK on this topic was Heffernan (1993). The study investigates whether the Law of One Price exists in British retail banking. The research focuses on a sample of nine banks and seven building societies offering deposit and loan products for the period 1985 to 1989. LIBOR is used as a benchmark to measure competition among the banks. Heffernan (1993) reports that the UK retail banking market is characterised by complex imperfect competition, with sluggish loan and deposit rate adjustments to changes in the LIBOR. Empirical values of coefficients for deposit rates are 43.5% to 61% less than 100%, which is against the perfect competition. For loans, the sum of coefficients is 1.70, which suggests that the prices of loans are 70% higher than perfect competition. In a later study, Heffernan (2001) analyses the retail pricing behaviour of five generic products offered by British financial institutions, for the period of 1993 to 1999. The study finds considerable price dispersion among the financial products offered by banks and building societies and the absence of any Law of One Price. Furthermore, evidence of increased competition is found for some products in British markets in the 1990s compared to 1980s. In another study, Heffernan (2004) compares the pricing behaviour of building societies and mutuals. The study finds that converted building societies are far more likely to rapidly respond to a change in current LIBOR than the building societies. Deposit products are permanently lower, and mortgage rates permanently higher. The results show that the new converts offer predominantly rip-off products, providing further evidence to support the expectation that, in an imperfectly competitive environment, they become more responsive to shareholders post-conversion. Martin et al. (2005b) uses a sample of bank-level data for the Spanish banks to study IRPT in

Spain. After controlling for product differentiation, the study finds that the Law of One Price does not apply for similar products, pointing towards the existence of price dispersion and a non-integrated Spanish loan market. Martin et al. (2005b) argue that this dispersion reflects bank specific effects owing to different credit policies, including relationship lending. In addition, they find that bank market power affects the speed of adjustment of bank interest rates to changes in market rates.

Hannan and Prager (2004) report two findings that are relevant to multimarket bank pricing. First, single market banks tend to offer higher deposit interest rates than multimarket banks in the same local market; second, the deposit interest rates offered by single market banks are lower if the presence of multimarket banks is greater in their local market. This second finding casts doubt upon a commonly offered explanation for the first – that large multimarket banks can offer lower deposit rates because they provide a higher quality of service – since it does not seem plausible that single market banks would offer lower rates in response to the better service provided by their multimarket rivals.

In an attempt to better understand individual bank responses to policy rate changes of the UK retail banking market Heffernan (2005, 2009) analyses IRPT) on a wide range of products credit, deposit and mortgage products Tests reveal marked heterogeneities across FIs in both the short-run speed of retail rate adjustment to PR changes and long-run mark-up. For the vast majority of FIs, *LRPT* is higher for PL and CC, compared to mortgages, which provides evidence of a collateral effect. Author finds that higher the deposit level and maturity more complete is the *LRPT* indicating a tier effect and term effect. FIs differ widely in the character of their responses. Some FIs match the PR quickly for certain products, whereas others let the gaps build up before changing their deposit or loan rates. Thus, as far as this aspect of the transmission mechanism is concerned, the repercussions of monetary policy changes are slower, less uniform and more complex than typically modelled. Ahmad, Aziz and Rummun (2013) analyse accounts offered by UK banks and building societies for the period from Jan 1999 to July 2007 using aggregated data for instant deposits, time deposits, lending rates and mortgage rates. LIBOR is used as the base rate. A short-run adjustment speed (SRAS) of 20.7% is found on instant deposit accounts, 14.7% on time deposits, 25.7% on

lending rates and 27.6% for mortgage rates. They find co-integration for all four retail rates. They also report complete pass-through (C=1) for time deposits, lending rates and mortgage rates, whereas pass-through for instant deposits is high but not complete. They find a mark-down for deposit accounts, indicated with a negative sign. This is consistent with the theory that banks usually pay lower rates than LIBOR for deposit accounts. There are positive mark-ups for lending and mortgage accounts as banks charge higher prices on lending and mortgage accounts than LIBORs. Overall, Ahmad, Aziz and Rummun (2013) argue that adjustment speed is slow in the short-run in the UK banking industry, the *LRPT* is complete, and there is co-integration in the long run.

4.6 Methodology

4.6.1 Empirical Model and Definition of Dependent and Independent Variables

The empirical approach used in the study is the ARDL/Bounds testing approach which is described previously (see Section 3.4.2).

ECMs are useful for estimating both the short- and long-term effects of one series on another time series. Using these models, the study can evaluate the short-term effects of changes in LIBOR on retail interest rates, long-term effects of changes in LIBOR on retail rate (long-run multiplier), and the speed at which retail rates return to equilibrium with LIBOR after any deviation has occurred. Following Pesaran et al., (2001), the model is specified as follows:

Equation 4-6

$$\Delta x_{i,h,t} = \gamma_{i,h}\left(x_{i,h,t-1} - x^{*}_{i,h,t-1}\right) + \sum_{l=1}^{j-5} \lambda_{i,h,l}\, \Delta x_{i,h,t-l} + \sum_{l=1}^{j-5} \mu_{i,h,l}\, \Delta y_{t-l} + \varepsilon_{i,h,t}$$

This equation defines the retail rate of a product as a linear function of the official rate. In it, $x_{i,h,t}$, the dependent variable, represents bank retail rates for the low tier accounts (1K, 2.5K), mid-tier accounts (5K,10K), and high tier accounts (25K ,50K,100K), for the IAS and MTS. y_t presents the BoE rate at time t. The term $i = 1, \dots, N$ represent the retail rates; $t = 1, \dots, T$ (which is monthly, Jan 1999 to Oct 2011) represents time; and $h = 1, \dots, N$ represents banks. The term $x_{i,t} - x^{*}_{i,t}$ is the gap or deviation of the i_{th} retail rate at time t from its (LRER) long-run equilibrium rate and $x_{i,h,t-1} - x^{*}_{i,h,t-1}$ is the previous period error or gap at $t - j$, defined as the deviation of the retail bank rate $x_{i,h,t}$ from *LRER*(or cointegration) path represented by $x^{*}_{i,h,t}$. Parameter $\gamma_{i,h}$ is the *SRAS,* which is the speed of adjustment towards its long run equilibrium. It is the error which prevailing at month $t - 1$; which is closed at month t. It is measured by the absolute value of parameter $\gamma_i < 0$; j is the short-term lag, or the delay in the short

run adjustment in months; and $\Delta x_{i,h,t-l}, \Delta y_{t-l}$ are the lag terms for the dependent and independent variables. *LRER* ($x^*_{i,h,t}$) is given by Equation 4-7

:

$$x^*_{i,h,t} = A_{i,h} + C_{i,h} y_t \qquad \text{Equation 4-7}$$

$A_{i,h}$ represents the long-run mark–up, which indicates how much a bank product rate is set above or below the official rate in the long term. If it is above the official rate, it is represented by $A_{i,h} > 0$; if it is below, it is represented by $A_{i,h} < 0$. Parameter $C_{i,h}$ represents the *LRPT*. $C_{i,h}$ is defined as the fraction or the multiple of an official rate change that is reflected in the retail rate over the long-run. $C_{i,h}$ depends on the elasticity of the demand for deposits and loans with respect to the changes in the LIBOR rate. Ideally, for a perfectly competitive market, $C_{i,h}$=1. If the demand for deposits and loans is not fully elastic, $C_{i,h}$ is expected to be less than one. Deposit/loan demand is expected to be relatively more elastic with respect to changes in LIBOR when close substitutes for deposits/loans exist. (See Section 2.4 for more details of IRPT dynamics.)

The equation below represents the retail rate of product *i* as the linear function of the official rate. Replacing $x^*_{i,h,t-j} = A_{i,h} + C_{i,h} y_{t-j}$ in Equation 4-6, one gets:

$$\Delta x_{i,h,t} = \gamma_{i,h}\left(x_{i,h,t-1} - A_{i,h} - C_{i,h} y_{t-1}\right) + \sum_{l=1}^{j-5} \lambda_{i,h,l}\, \Delta x_{i,t-l} + \sum_{l=1}^{j-5} \mu_{i,h,l}\, \Delta y_{t-l} + \varepsilon_{i,h,t}$$

or

$$\Delta x_{i,h,t} = -\gamma_{i,h} A_{i,h} + \gamma_{i,h} x_{i,h,t-1} - \gamma_{i,h} C_{i,h} y_{t-1} \sum_{l=1}^{j-5} \lambda_{i,h,l}\, \Delta x_{i,h,t-l} + \sum_{l=1}^{j-5} \mu_{i,h,l}\, \Delta y_{h,t-l} + \varepsilon_{i,h,t}$$

This leads to Equation 4-8:

Equation 4-8

$$\Delta x_{i,h,t} = \alpha_{i,h} + \gamma_{i,h} x_{i,h,t-1} + \theta_{i,h} y_{t-1} + \sum_{l=1}^{j-5} \lambda_{i,h,l} \Delta x_{i,h,t-l} + \sum_{l=1}^{j-5} \mu_{i,h,l} \Delta y_{t-l} + \varepsilon_{i,h,t}$$

(Pesaran et al., 2001, p. 296) calls Equation 4-8 a *"Conditional ECM"*., where $\theta_{i,h}$ is the change in retail rate in reaction to the change in LIBOR; $\alpha_{i,h} = -\gamma_{i,h} A_{i,h}$ and $\theta_{i,h} = -\gamma_{i,h} C_{i,h}$. The long-run parameters $A_{i,h}$ and $C_{i,h}$ can be obtained as follows:

$$A_{i,h} = -\alpha_{i,h} / \gamma_{i,h}$$ Equation 4-9

$$C_{i,h} = -\theta_{i,h} / \gamma_{i,h}$$ Equation 4-10

In Equation 4-8, lagged levels the same as those used in a regular ECM are included, but their coefficients are not restricted. Equation 4-8, also known as an *Unrestricted ECM* or *Unconstrained ECM*, can be estimated by OLS in a one-step approach; this yields unbiased and consistent measures of *mark-up* and pass-through. To identify the appropriate *lag length* j, Schwartz Information Criteria SIC are used, and the model with the minimum SC value is chosen. The maximum lag selected is 10. A key assumption in ARDL/Bounds testing methodology of Pesaran et al. (2001) is that the errors of Equation 4-8 must be serially independent. This requirement may influence the final choice of the maximum lags for the variables in the model. If there is any serial correlation, one adds the difference term $\Delta x_{i,h,t-l}$, where $l = 1,2, \ldots k$. The LM test is used to investigate the null hypothesis that the errors are serially independent. The ECM equation assumes that the retail rate adjusts to any deviation, whether small or large, from the *LRER*, and that the adjustment is the same for negative and positive gaps. The present study allows for full heterogeneity in the short- and long-run relationship between bank retail rates and the official LIBOR. In contrast, the traditional random effects model treats intercepts as random and slopes as homogeneous and fixed, while all the coefficients in Equation 3-4 are treated as

random. Following Pesaran et al. (2001), the present study uses the Wald Bounds test to analyse the co-integration. The null hypothesis is: there are no long-run co-movements between the retail rate (γ) and BoE (θ); it can be presented as follows:

$$H_0: \gamma_{i.h,l} = \theta_{i,h,l} = 0 \qquad \text{Equation 4-11}$$

All the interest series are subjected to unit root tests using the ADF test to make sure that none of the variables are I (2) (such data would invalidate the methodology).

The simplest way to measure the short- and long-run dynamics is to estimate Equation 4-8 by OLS for all the banks individually for $i = 1,...,N$ products, constructing an average for all the short- and long-run variables. The study's empirical analysis provides prima facie evidence of heterogeneities among FIs regarding their short- and long-run responses to PR changes.

The question of whether inter-bank and intra-bank heterogeneities exists is formally addressed by using two sample mean-difference t-tests. To test for inter-bank heterogeneities for each product, retail rate behavior is compared for HSB, BS and SB for all tiers of IAS and MTS accounts. The analysis tests for discrepancies in the way different types of FI react to changes in the official rate in terms of the short-term adjustment speed, long-run mark-up, *LRPT* and *LRER*.

The hypotheses tested for inter-bank heterogeneities are given below:

- Hypothesis 1 = the adjustment speed is the same for the same accounts for all firms.
- Hypothesis 2 = the *LRPT* is the same for the same accounts for all firms.
- Hypothesis 3 = the *LRER* is the same for the same accounts for all firms.
- Hypothesis 4 = the long-run *mark-up* is the same for the same accounts for all firms.

Each of the above hypotheses is tested for all possible pairs of firm types (HSB = BS, HSB = SB, BS = SB, HSB = BS, HSB = SB, BS = SB, HSB = BS, HSB = SB, BS = SB) for all tiers of IAS and MTS.

To test for intra-bank heterogeneities within each bank for different types of products and tiers, retail rate behavior is compared for LT, MT and HT accounts. The analysis tests for discrepancies in the way different tiers of IAS and MTS react to changes in the official rate in terms of the short-term adjustment speed, long-run mark-up, *LRPT* and *LRER*. The hypotheses tested for intra-bank heterogeneities are as followa:

- Hypothesis 1 = all the accounts within the same type of firms have the same adjustment speed (tier effect).
- Hypothesis 2 = all the accounts within the same type of firms have the same *mark-up* (tier-effect).
- Hypothesis 3 = all the accounts within the same type of firms have the same *LRPT* (tier-effect).
- Hypothesis 4 = all the accounts within the same type of firms have the same *LRER* (tier-effect).

Each of the above hypotheses is tested for all possible pairs of tiers for IAS and MTS (LT = MT, LT = HT, MT = HT, LT = MT, LT = HT, MT = HT, LT = MT, LT = HT, MT = HT).

A significantly positive t-statistics shows the first variable in the pair has larger mean value. If the t-statistics is negative it shows that the first product in the pair has the smaller mean.

4.7 Results and Discussion of ECMs for IAS and MTS Accounts

4.7.1 Introduction

This section presents the results and discussion. Section 4.7.1.1 provides a summary of ECM and Wald test results. In this section 4.7.1.2 presents the results and discussion for short-run and long-run parameters for IAS. Section 4.7.1.3 presents the results and discussion for short-run and long-run parameters for MTS.

4.7.1.1 Summary of Co-Movement Results of Wald Test and Significant γ Results for IAS and MTS (All Tiers)

Table 4-2 shows the total number of ECMs run for IAS and MTS accounts for all deposit tiers for the whole industry and all three types of firm. It also presents the number of ECMs that show co-movements, no co-movements, inconclusive co-movements, and ECMs that have significant results for γ. The total number of ECMs for low, mid and high tier IAS accounts are 156, 156 and 234, respectively, while the number with significant values of γ are 105, 116 and 183. ECMs that show co-movements are 25, 36 and 66; those with no co-movements are 122, 111 and 141. The number with inconclusive results are 9, 9 and 27. The bivariate model exclusively excludes other exogenous variables that may influence banks savings rates. The R^2 which is the goodness of fit value for IAS ranges between 5% to 84%, 4% to 89% and 4% to 95%. These values of R^2 suggest that ECMs captures the time-variation in retail rates reasonably good. The total number of ECMs for low, mid and high tier MTS accounts are 148, 148 and 222, respectively, and those with significant values of γ are 108, 107 and 174. ECMs that show co-movements are 45, 49 and 89, while 95, 100 and 119 show no co-movements, and 8, 11 and 21 provide inconclusive results. The R^2 values for MTS ranges between 2% to 84%, 3% to 86% and 4% to 86%. These values of R^2 suggest that ECMs captures the time-variation in retail rates reasonably good. The statistics for each firm are also presented in Table 8-13.

4.7.1.2 Short-Run and Long-Run Parameters for IAS

Table 4-3 shows the average values for $|\gamma|$ and j for low tier instant access savings (IAS) offered by all three types of firm and the industry. Where $|\gamma|$ is short-run adjustment speed (*SRAS*), j is *lag length* in months. Table 4-4 present the t-test results for inter-bank heterogeneities for the parameters $|\gamma|$ and j for IAS accounts. Table 4-5 shows t-test results for intra-bank product heterogeneities in the same firm type for IAS accounts. Figure 4-2 represents a comparison of $|\gamma|$, $|\gamma|/J$ and j for the IAS accounts offered by all three types of firm and the industry as a whole. Figure 4-3 presents a comparison of C for all firms and industry for IAS. Figure 4-4 presents a comparison of A for all firms and industry.

For the industry, the average *SRAS* for low tier (LT), mid-tier (MT) and high tier (HT) accounts is sluggish and sticky (11.0%, 12.8%, and 13.09%, respectively), although for building societies (BS) and small banks (SB) there is an increasing trend for *SRAS* with an increase in the deposit tier. In contrast, high street banks (HSB) does not show any trend. Trend can be seen in Figure 4-2.

Moreover, the results of t-tests for intra-bank heterogeneities (see Table 4-5) indicate that *SRAS* is homogeneous for all three tiers of HSB accounts. The results are also homogeneous for LT vs MT and MT vs HT for BS and SB. However, the finding that *SRAS* is significantly lower for low tier products compared to high tier products for BS and SB is similar to that of Heffernan (2007; 2009). He also finds an increase in *SRAS* with the increase in tier size. This is also known as the tier effect, which suggests that the adjustment speed is faster for the higher tier products. This result is consistent with the tier effect literature.

Results from Table 4-3 suggest that the *SRAS* for HSB is above the industry average on all IAS deposit tiers (43.5%, 43%, 43.6% for LT, MT and HT respectively). However, the *SRAS* values for BS (7.5%,9%,9.33%) and SB (5%,8%,8.67%) are below the industry average (11%,12.8%,13.09%). In addition, *SRAS* is lowest on SB; BS has a marginally higher adjustment speed compared to SB. These results suggest that the adjustment speed is stickier on SB and BS products compared to HSB. The t-

test results for inter-bank heterogeneity (see Table 4-4) support the finding that average *SRAS* for all three deposit tiers (LT, MT, HT) of IAS offered by HSB is significantly higher than the value for BS and SB. Inter-bank heterogeneity results also verify that the *SRAS* for BS for low tier IAS accounts is higher compared to SB. However, results for mid tier and high tier accounts are homogeneous for these two types of firm. The spread in *SRAS* is 1%-114%, 1%-50% and 0%-49% for HSB, BS and SB, respectively. This indicates the existence of aggregation bias. This is in line with Degreave (2004) and Hefernan (2009). Once 100% adjustment is applied and after accounting for the mark-up/downs, the rate reaches its new equilibrium level, the *LRER*.

The industry values for *lag length* for LT, MT and HT accounts are 1.82, 1.74 and 1.63, respectively. For HSB, *j* (1.44, 1.5, and 1.56) is smaller than the industry average on all deposit tiers on IAS However, for BS and SB it is higher compared to the value for the industry as a whole. These results suggest that, following a change in the base rate, HSB has the smallest lag in changing the retail rates on all tiers of IAS accounts, followed by BS and SB. HSB also make the highest adjustment speed in retail rates following a change in LIBOR. Hence this type of firm is the most efficient in transmitting LIBOR rate changes for IAS on all deposit tiers. These results are further verified by inter-bank heterogeneity (see Table 4-4) results. IAS accounts show that HSB have lower average *lag length* values compared to SB for all deposit tiers. HSB also has lower *lag length* than BS on low tier accounts. Results for mid tier and High tier accounts are insignificant. However, results for lag length are largely homogeneous for BS and SB on all deposit tiers, as the results are insignificant for all tiers of BS and SB accounts. This is in contrast to Ashton (2007) and Heffernan (2009) find statistically significant differences in the different type of firms' pricing patterns for deposit interest rates in the UK banking industry.

The t-test results for intra-bank heterogeneities (Table 4-5) for parameter *j* are insignificant for all three IAS product types for HSB, BS and SB. Which suggests there is no enough evidence for the existence of heterogeneities for *lag length* between deposit tiers within same type of firm.

These results verify that not only is price setting behaviour in the UK banking industry sticky but also that inter-bank and intra-bank heterogeneities exist in the short-term. Results show that heterogeneities for *SRAS* not only exist within different types of firm offering the same products, but also within the same firm type offering different products, since different deposit tiers have different adjustment speeds. This is in contrast to the findings of Ashton (2001) and Heffernan (1997), who find homogeneous adjustment for the all the accounts offered by the same firm.

	Product	High Street Banks (HSB)		Building Societies (BS)		Small Banks (SB)	
Long-run	IAS	Mean	St Dev	Mean	St Dev	Mean	St Dev
C	Low-tier	0.26 (-0.14, 0.68)	33.5	0.36 (-2.41, 0.93)	46.5	0.79 (0.11, 4.44)	49
C	Mid-tier	0.31 (-0.13, 0.82)	34	0.45 (-2.14, 1.44)	41.5	0.65 (0.12, 2.44)	44
C	High-tier	0.35 (-0.13, 0.86)	38.7	0.50 (-2.32, 1.02)	46	0.71 (0.34, 1.95)	35.3
A	Low-tier	1.67 (-0.14, 7.15)	1.67	0.49 (-0.80, 13.34)	1.91	-0.17 (-11.87, 4.38)	3.01
A	Mid-tier	1.74 (-0.24, 6.06)	1.83	0.42 (-0.74, 8.87)	1.36	0.04 (-5.82, 1.02)	1.2
A	High-tier	1.66 (-0.44, 4.07)	1.47	0.5 (-0.61, 8.64)	1.35	0.13 (-3.95, 1.17)	1.01
x_t^*	Low-tier	2.65 (1.03, 8.26)	1.55	1.87 (0.44, 4.44)	1.05	2.82 (0.86, 9.77)	2.28
x_t^*	Mid-tier	2.93 (1.17, 7.32)	1.46	2.14 (0.44, 4.83)	1.03	2.49 (1.02, 4.24)	1.11
x_t^*	High-tier	2.94 (1.20, 4.17)	1.08	2.4 (-0.74, 5.12)	1.05	2.85 (1.28, 4.24)	0.89

Table 4-9 shows the average results for parameters *C*, *A* and x_t* for the industry for the three tiers of IAS accounts. *C* is long-run pass-through (LRPT) and represents elasticity of demand for the product and a measure of competition, *A* is *mark-up* on the products and, x_t*is long-run equilibrium rate (*LRER*). Table 4-10 shows the inter-bank results for the three tiers for *C* and *A*. Table 4-11 shows t-test results for intra-bank product heterogeneities within the same firm type for IAS accounts.

Figure 4-3 below represents a comparison of *C (LRPT)* for the three firm types and the industry for three tiers of IAS accounts. *LRPT* values for IAS accounts are found

to be less than one for the industry and all three types of firm. For the industry, the average *LRPT* for LT, MT and HT accounts is 0.44, 0.48 and 0.53, respectively. This implies the elasticity of demand of IAS products on all deposit tiers is low or relatively inelastic. The study finds partial and incomplete *LRPT* for HSB, BS and SB on all deposit tiers. The *LRPT* for SB (0.79, 0.65, and 0.71) is above the industry average (0.44, 0.48, and 0.53) on all deposit tiers. However, the average values for BS (0.36, 0.45, and 0.50) and HSB (0.26, 0.31, and 0.35) are below the industry average on all the deposit tiers. The lowest values of *LRPT* are observed on HSB and the highest on SB, on low, mid and high tier accounts. The t-test results for inter-bank heterogeneity (see Table 4-10) verify these findings, as HSB and BS are found to have significantly smaller *LRPT* values than SB on all deposit tiers. However, results are homogeneous between HSB and BS on all three tiers. The smallest range is found in HSB (-0.13 to 0.86), compared to BS (-2.41 to 1.44) and SB (0.11 to 4.44). These results suggest that there are differences in competition for the same accounts among different types of firm.

For the industry, results for *LRPT* for all IAS deposit tiers reveal that the accounts which have higher *LRPT* also have higher *mark-up* and *SRAS*. An increasing trend in *LRPT* is found for HSB, BS and the industry with an increase in tier size. However, SB shows no such trend. The only significant t-test finding for intra-bank heterogeneity is that the *LRPT* is significantly lower on LT than HT accounts for SB. The results are largely homogeneous for all the other comparisons between the deposit tiers, as no significant differences were found.

Figure 4-4 shows comparison for *A* in all firms and the industry. The average *A* represents the mark-up/down on IAS products and results are analysed to investigate whether the *Law of One Price* exists in the UK financial market. For the industry, the *A* on IAS is 0.48, 0.50 and 0.55 on LT, MT and HT products, respectively. Generally, on deposit accounts expected sign on *A* is negative, representing a mark-down. The reason for the positive values of *A* in the current study is the fall in the BoE official rate to 0.5% from 2009. For the banks to survive and maintain a healthy deposit base and retain their existing customers, they need to pay higher interest rates than BoE.

This explains why there is a *mark-up* instead of a mark-down on IAS and MTS accounts.

For HSB, the A (2.5, 2.6 and 3.99) on all IAS deposit tiers is above the industry average (0.48, 0.50 and 0.55) for all deposit tiers. However, the average *mark-up* on BS (0.25, 0.38 and 1.03) and SB (0.24, 0.92 and 0.94) is below the industry average for all deposit tiers. A values are lowest for SB (0.24) and highest for HSB (3.99) on all IAS tiers. The t-tests for inter-bank (see Table 4-10) heterogeneity verify these findings, as they suggest that BS and SB have significantly lower *mark-up* values than HSB on all deposit tiers. Results also suggest that the A on BS is significantly higher than SB for high tier products. However, the results are homogeneous between BS and SB on low tier and mid tier accounts. The smallest variation is found in HSB (-0.44 to 7.15) compared to BS (-0.80 to 13.34) and SB (-11.87 to 4.38). Results indicate an increasing trend in *mark-up* for all three types of FI and the industry with an increase in tier size. Moreover, the *mark-up* is different on all deposit tiers within the same type of firm. The increasing trend in SB and the industry can be clearly seen in Figure 4-4 However, t-test results for intra-bank heterogeneity do not detect any significant differences among tiers within same firm type.

4.7.1.3 Short-Run and Long-Run Parameters for MTS

Table 4-6 shows the average values for $|\gamma|$ and j for low tier Medium term savings (MTS) offered by all three types of firm and the industry. Where $|\gamma|$ is short-run adjustment speed (SRAS), j is lag in months. Table 4-7 present the t-test results for inter-bank heterogeneities for the parameters $|\gamma|$ and j for IAS accounts. Table 4-8 shows t-test results for intra-bank product heterogeneities in the same firm type for IAS accounts. Figure 4-5 presents a comparison of $|\gamma|$, $|\gamma|/J$ and j for the IAS accounts offered by all three types of firm and the industry as a whole. Figure 4-6 presents a comparison of C for all firms and industry for MTS. Figure 4-7.presents a comparison of A for all firms and industry.

For the industry, the average *SRAS* for low tier (LT), mid tier (MT) and high tier (HT) accounts is sluggish and sticky (12.5%, 13%, 14.67%) for MTS accounts, although an

increasing trend is found with an increase in deposit tier. This is similar to the finding for IAS accounts. Literature on developed countries shows a higher adjustment speed in contrast to our results. An increasing trend is also found for BS and SB, also similar to the findings for IAS accounts. However, no such trend is found for HSB, while IAS shows a decreasing trend. The trend can be seen in Figure 4-5.

Table 4-6 result suggest that the *SRAS* for HSB (29.5%, 29.5% and 29.3%) is above the industry average (12.20%, 13.4% and 14.70%) for MTS for all deposit tiers. However, the *SRAS* for BS (11.5%, 12.5%, 14%) and SB (8%, 10% and 11.7%) is below the industry average. Results also suggest that the *SRAS* values are highest on all HSB tiers compared to BS and SB, while the lowest value is found on SB accounts. The t-test results for inter-bank heterogeneity (see Table 4-7) verify that the average MTS *SRAS* for HSB on all deposit tiers is significantly higher compared to BS and SB. The t-test results for intra-bank heterogeneities reveal that the HSB *SRAS* is lower for MT compared to HT accounts, while results are homogeneous for LT vs MT and LT vs HT. Results for intra-bank heterogeneities for BS show that *SRAS* values are significantly lower for MT compared to HT accounts, but the results are homogeneous for LT vs MT and LT vs HT. For SB, the results reveal significantly lower *SRAS* for low tier compared to high tier accounts, but values are found to be homogeneous for LT vs MT and MT vs HT. For the industry as a whole, *lag length* for LT, MT and HT MTS accounts is 1.81, 1.91, and 1.97, respectively. For HSB, *lag length* is lower than the industry average for all deposit tiers. However, for BS and SB it is higher than average of the industry as a whole.

These results suggest that in the UK banking industry, following a change in the base rate, HSB shows the smallest lag in changing the retail rates on MTS accounts, followed by BS and SB. HSB also makes the highest adjustment in retail rates following a change in BoE. Hence this type of bank is the most efficient in following BoE rate changes for all deposit tiers for both IAS and MTS accounts.

The industry values for *lag length* for LT, MT and HT accounts are1.81, 1.90 and 1.97 respectively. HSB average *lag length* (1.86, 1.58 and 1.48) is smaller than the industry average on all deposit tiers. However, for BS (1.87, 1.95, 3.08) *lag length* is larger

compared to industry and HSB. SB average *lag length* (1.56, 1.86 and 1.94) is smaller for LT, MT and HT compared to industry. *Lag length* on BS is smaller than HSB on LT and smaller than BS on tiers. These results suggest that, following a change in the base rate, HSB has the smallest delay in changing the retail rates on all tiers of MTS accounts, followed by SB and BS. HSB also make the highest *SRAS* in retail rates following a change in BoE. Hence this type of firm is the most efficient in transmitting BoE rate changes for IAS on all deposit tiers. The results for HSB are same as the results for IAS products however, for MTS products we find that SB show lesser lag than BS in contrast to our finding for IAS where BS shows smaller lag compared to small banks. The inter-bank heterogeneity results for the average *lag length* for MTS accounts are homogeneous for all the deposit tiers. In addition, for the industry, there is a positive relationship between *lag length* and the deposit tier size for MTS accounts, but an inverse relationship is observed for IAS. In contrast, for HSB, the relationship is inverse for MTS, but positive for IAS. BS and SB show an increasing trend for *lag length* for MTS accounts but a decreasing trend for IAS.The range on j for HSB is 1–3, 1–4 and 1–4; for BS is 1–5, 1–6 and 1–6 and for SB is 1–5, 1–6 for LT, MT and HT respectively.

Table 4-12 shows the average results for parameters *C*, *A* and x_t* for the industry for the three tiers of IAS accounts. *C* is long-run pass-through (LRPT) and represents elasticity of demand for the product and a measure of competition, *A* is *mark-up* on the products and, x_t*is long-run equilibrium rate (LRER). Table 4-13 shows the inter-bank results for the three tiers for *C* and *A*. Table 4-14 shows t-test results for intra-bank product heterogeneities within the same firm type for IAS accounts.

The comparison of *LRPT* for all three types of firm and deposit tiers can be seen in Figure 4-6. For the industry and all three firm types, *LRPT* values for MTS accounts are less than one. The industry average for LT, MT and HT accounts is 0.55, 0.58 and 0.53, respectively. The industry *LRPT* is partial and incomplete for all firms, although it is higher on MTS compared to IAS accounts. For SB, *LRPT* (0.57, 0.54, 0.63) is above the industry average on low and high tier accounts, but below it for mid tier accounts. For BS, the average *LRPT* (0.61, 0.66 and 0.6) is above the industry average for all three deposit tiers. However, for HSB, the value is below industry average on

all tiers. In fact, the lowest values of *LRPT* are observed on all HSB tiers. BS has the highest *LRPT* for Low- and mid tier accounts, but SB has the highest *LRPT* for high tier products. The results for inter-bank heterogeneity verify these findings, as they suggest that HSB has significantly lower *LRPT* than BS and SB on all deposit tiers. The results also reveal that SB has significantly lower *LRPT* than BS only for mid tier MTS accounts. However, the results are homogeneous for SB and BS on low tier and mid tier accounts. The smallest variation is found in SB (0.98 to 3.83), compared to HSB (-7.40 to 0.79) and BS (-8.57 to 2.33).

It is worth noting that SB experiences the highest level of competition in the market for IAS accounts on all deposit tiers and for high tier MTS accounts, but BS has the highest *LRPT* level for Low- and mid tier MTS accounts.

For the industry as a whole, *LRPT* results for all MTS deposit tiers reveal that the accounts which have a higher *LRPT* also have higher *mark-up* and *SRAS*. These results are similar to the findings for IAS accounts. Results also indicate an increasing trend in *LRPT* for SB and the industry with an increase in tier size, but HSB and BS do not show any such trend. However, t-test results for intra-bank heterogeneity do not detect any significant differences between low, mid and high tier MTS products, which are found to be largely homogeneous.

These results suggest that in UK banking industry there are differences in the level of competition for the same accounts among different types of firm for both types of account. In general, *LRPT* is less than one for all three types of firms in the industry. The level of competition (LRPT) for HSB is much lower compared to that for the other two firms for both types of savings accounts. This can be because HSB are large banks and can exercise market power. Generally, this type of FI has a much more substantial deposit base compared to SB. Moreover, the demand for deposits from HSB customers is less than elastic (LRPT <1) , which could be because of switching and information costs. De Bondt (2005) suggests that partial pass-through could be the result of a less elastic demand for deposits in the market.According to Laudadio (1987), the pass-through may be incomplete because banks have some degree of market power. The presence of switching costs results in market segmentation and reduces demand

elasticity. Even with non-cooperative behaviour, switching costs may result in a retail bank interest rate adjustment of less than one to a change in the market interest rate. As highlighted above, SB experiences the highest degree of competition in the market for IAS accounts on all deposit tiers. That is becausef SB have to fight harder to gain their deposit base, hence the level of competition is the highest for this type of firm.

Figure 4-7 shows the *A* comparison and trends for all firm types and the industry for MTS products. The average *mark-up* on MTS accounts for the industry is 0.46, 0.71 and 1.29 on low tier, mid tier and high tier products, respectively. The *mark-up* is higher on MTS than IAS accounts.

For HSB, the *mark-up* (1.67, 1.74 and 1.66) on all IAS deposit tiers is above the industry average for all deposit tiers. However, for BS (1.91, 1.36 and 1.35 and SB (-0.17, 0.04 and 0.13), the average *mark-up* is below the industry average for all tiers. *mark-up* is the lowest for SB and highest for HSB on all MTS tiers. The results for inter-bank heterogeneity verify these findings as they suggest that BS and SB have significantly lower *mark-up* than HSB on all deposit tiers. Results also suggest that the *mark-up* on BS is significantly lower than SB for MT products. However, the results are homogeneous between BS and SB for low tier and high tier accounts. The smallest variation is found in HSB (-0.01 to 6.43) compared to BS (-6.75 to 3.99) and SB (-16.44 to 6.29). These results suggest that there are differences in *mark-up* for the same account among different firm types. This also implies that the *Law of One Price* does not apply in the savings accounts market.

In general, *mark-up* is higher on high tier accounts than lower tiers, suggesting banks pay higher rates on higher levels of savings. An increasing trend is found in the *mark-up* settings with an increase in tier level. This trend is observed for all three types of FI and the industry as a whole. The *mark-up* is different for all deposit tiers within the same type of firm. The increasing trend for SB and the industry can be clearly seen in Figure 8-13. However, t-test results for intra-bank heterogeneity do not detect any significant differences among tiers within any firm type.

4.8 Conclusion

This paper investigates the stickiness of interest rate pass-through, level of competition, and the *Law of One Price* for three types of FIs (HSB, BS and SB) offering the same IAS and MTS products. The average *SRAS* for the industry as a whole show that adjustment is sluggish and sticky for low tier, mid-tier and high tier IAS and MTS accounts. The results verify that inter-bank and intra-bank heterogeneities exist in the short- and long-run variables. Results show that heterogeneities for *SRAS* not only exist within different types of firm offering the same products, but also within the same firm offering different products. Moreover, t-test results for intra-bank heterogeneities find that *SRAS* is significantly lower for low tier products compared to high tier products in the industry for both IAS and MTS accounts. Banks exercise market power and adjustment speed is slower on high deposit tiers, where banks pay higher interest rates. This is called tier effect. The results indicate that the *SRAS* for HSB is above the industry average on all IAS and MTS deposit tiers. On the other hand, *SRAS* is lowest for SB on both products. We find that SB and BS protect their depositors/borrowers by smoothing their responses or delaying passing on changes in the central bank rate. For the whole UK industry we find the competition and adjustment speed is higher for the products with high deposit tiers, because for banks higher deposit tiers are more attractive so competition is higher for these products and banks offer higher prices for these accounts to attract customers. Due to the fact that SB have lower market power and don't enjoy economies of scale we find that competition is higher on for SBs for both products, while HSB face the lowest competition. All firms want to attract high depositor so Results indicate an increasing trend in *mark-up* for all three types of FI and the industry with an increase in tier size for both IAS and MTS products. The inter-bank results for mark-up shows clearly that HSB exercise market power and pay higher deposit rates on low-, mid- and high tier IAS and MTS which is to create barriers to entry for smaller banks and to maintain a higher customer base. Significant differences in mark-up also exist between SBs and BSs which this implies that the Law of One Price does not exist in the UK market for IAS and MTS products.

APPENDIX OF FIGURES AND TABLES

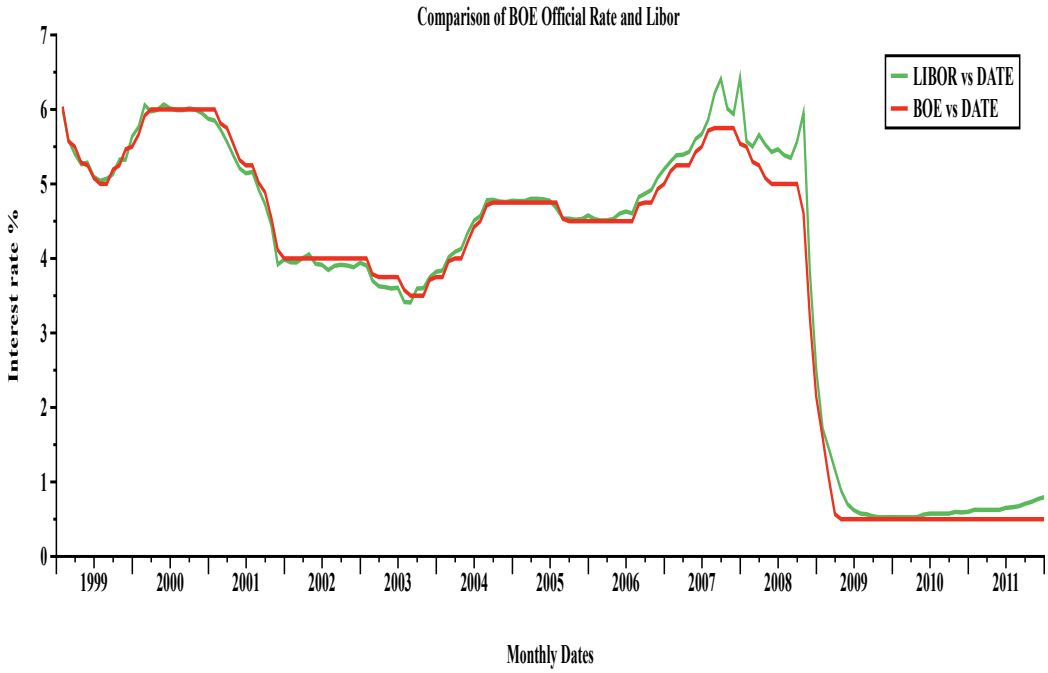

Figure 4-1: comparison of BoE rate and Libor

Table 4-2 ECM summary statistis for co-movements and no co-movements and significant results for IAS and MTS

		IAS				MTS			
STATISTICS	DEPOSIT-TIERS	IND	HSB	BS	SB	IND	HSB	BS	SB
Number of ecms	Low-tier	156	18	104	34	148	14	102	32
Number of ecms	Mid-tier	156	18	104	34	148	14	102	32
Number of ecms	High-tier	234	27	156	51	222	21	153	48
Significant ecm results	Low-tier	105	16	71	18	108	11	77	20
Significant ecm results	Mid-tier	116	16	77	23	107	11	76	20
Significant ecm results	High-tier	183	24	122	37	174	16	122	36
Co-movements	Low-tier	25	13	12	0	45	8	28	9
Co-movements	Mid-tier	36	14	19	3	49	11	32	9
Co-movements	High-tier	66	19	41	6	89	10	59	20
No co-movements	Low-tier	122	4	84	34	95	5	67	23
No co-movements	Mid-tier	111	4	77	30	100	6	62	19
No co-movements	High-tier	141	4	97	40	119	11	82	26
In- conclusive	Low-tier	9	1	8	0	8	1	7	0
In- conclusive	Mid-tier	9	0	8	1	11	0	9	4
In- conclusive	High-tier	27	4	18	5	21	0	12	2

The table above presents a summary of number of ECM ran for each deposit-tier, for both savings accounts for industry and three firms. Its shows the number significant ECM results. It shows number of wald-test results that show long-run co-movement; results that doesn't show co-movements; results that are in-conclusive.

Table 4-3 Short-run estimator results for the Industry for IAS

	High Street Banks (HSB)		Building Societies (BS)		Small Banks (SB)		Industry (Ind)	
Product	% Error closed (100|γ|)	Adjustment delay (j)	% Error closed (100|γ|)	Adjustment delay (j)	% Error closed (100|γ|)	Adjustment delay (j)	% Error closed (100|γ|)	Adjustment delay (j)
IAS	Mean%	Mean	Mean%	Mean	Mean%	Mean	Mean%	Mean
Low tier	43.5 (0, 114)	1.44 (1,3)	7.5 (1,50)	1.87 (1,6)	5.00 (0, 23)	1.91 (1, 6)	11 (0,114)	1.82 (1, 6)
Mid tier	43 (0, 110)	1.5 (1,4)	9 (1,41)	1.79 (1,6)	8.00 (1, 49)	1.68 (1,6)	12.8 (1, 110)	1.74 (1,6)
High tier	43.6 (1,108)	1.56 (1,4)	9.33 (1,41)	1.63 (1,6)	8.67 (1, 49)	1.65 (1, 6)	13.09 (1, 108)	1.63 (1,6)

The results are obtained from the Equation 4-8. . 100|γ| is the adjustment speed in percentage; which is the speed of adjustment towards its long run equilibrium. It is the error which prevailing at month *t-1*; which is closed at month *t.* It is measured by the absolute value of parameter |γ|*<0; j* is Adjustment delay shown as the number of lags per month. Table presents the average results of HSB, BS, and SB and the range mean values of firms. Minimum and maximum values are given in parenthesis under the mean values. IAS means Instant Access Savings. MTS means Mid-tier Savings. Low tier accounts = average of 1k-MTS and 2.5k-MTS, Mid-tier = average of 5k-MTS, High-tier = 10k-MTS, High-tier = average of 25k-MTS, 50k-MTS, 100k-MTS.

Table 4-4 Inter-bank group heterogeneity analysis for IAS

		% Error closed ($100|\gamma|$)		Adjustment delay (j)	
Null Hypothesis (H_0)	PRODUCT	T-VALUE	P-VALUE	T-VALUE	P-VALUE
HSB = BS	Low-tier	3.92	0.001	-1.96	0.056
HSB = SB	Low-tier	3.7	0.002	-5.45	0
BS = SB	Low-tier	0.065	0.065	-0.15	0.882
HSB = BS	Mid-tier	3.68	0.002	-1.19	0.242
HSB = SB	Mid-tier	3.7	0.002	-5.43	0
BS = SB	Mid-tier	0.34	0.733	0.43	0.667
HSB = BS	High-tier	4.62	0	-0.34	0.734
HSB = SB	High-tier	4.68	0	-6.22	0
BS = SB	High-tier	0.56	0.576	-0.09	0.927

For each firm, a t-test for significant differences is deployed for several pair wise combinations of the three deposit-tier IAS accounts available for all three firms and industry. A significantly positive t-statistics shows the first product in the pair has higher, adjustment speed or Lag

Table 4-5 Intra-Bank product heterogeneity analysis for IAS

		% Error closed ($100|\gamma|$)		Adjustment delay (j)	
Null Hypothesis (H_0)	Firm Type	T-VALUE	P-VALUE	T-VALUE	P-VALUE
LT = MT	HSB	0.06	0.956	-0.21	0.833
LT = HT	HSB	0.07	0.948	-0.44	0.66
MT = HT	HSB	0	0.997	-0.2	0.841
LT = MT	BS	-1.47	0.144	0.41	0.686
LT = HT	BS	-2.07	0.04	1.42	0.159
MT = HT	BS	-0.4	0.692	0.97	0.335
LT = MT	SB	-1.52	0.134	0.66	0.514
LT = HT	SB	-2.08	0.041	0.79	0.432
MT = HT	SB	-0.11	0.91	0.1	0.919

For each firm, a t-test for significant differences is deployed for several pair wise combinations of the three deposit-tier IAS accounts available for all three firms and industry. A significantly positive t-statistics shows the first product in the pair has higher, adjustment speed or Lag.

Table 4-6: Short-run estimator results for the all firms and Industry for MTS

	High street		Building Societies		Small		Industry	
Product	% Error closed (100|γ|)	Adjustment delay (j)	% Error closed (100|γ|)	Adjustment delay (j)	% Error closed (100|γ|)	Adjustment delay (j)	% Error closed (100|γ|)	Adjustment delay (j)
MTS	Mean%	Mean	Mean%	Mean	Mean%	Mean	Mean%	Mean
Low-tier	29.5 (3, 91)	1.86 (1,6)	11.5 (2, 82)	1.87 (1,5)	8 (1, 24)	1.56 (1,5)	12.20 (1, 91)	1.81 (1,6)
Mid-tier	29.5 (3, 91)	1.58 (1,5)	12.5 (2, 74)	1.95 (1,6)	10 (2, 43)	1.86 (1,6)	13.4 (2, 91)	1.90 (1,6)
High-tier	29.3 (0,89)	1.48 (1,5)	14 (0, 88)	3.08 (1,6)	11.7 (2, 35)	1.94 (1,6)	14.70 (0, 89)	1.97 (1,6)

The results are the average results for all the individual banks and are obtained from the Equation 4-8. $100|\gamma|$ is the adjustment speed in percentage; which is the speed of adjustment towards its long run equilibrium. It is the error which prevailing at month *t-1*; which is closed at month *t*. It is measured by the absolute value of parameter $|\gamma|<0$; *j* is Adjustment delay shown as the number of lags per month. Table presents the average results of HSB, BS, and SB and the range mean values of firms. Minimum and maximum values are given in parenthesis under the mean values. IAS means Instant Access Savings. MTS means Mid-tier Savings. Low tier accounts = average of 1k-MTS and 2.5k-MTS, Mid-tier = average of 5k-MTS, High-tier = 10k-MTS, High-tier = average of 25k-MTS, 50k-MTS, 100k-MTS.

Table 4-7 Inter-bank group mean difference t-test among three types of firms for MTS

	PRODUCT	% Error closed ($100\|\gamma\|$)		Adjustment delay (j)	
Null Hypothesis (H_0)	MTS	T-VALUE	P-VALUE	T-VALUE	P-VALUE
HSB = BS	Low-tier	1.94	0.075	-0.86	0.402
HSB = SB	Low-tier	2.27	0.041	-0.03	0.974
BS = SB	Low-tier	1.76	0.082	-0.71	0.481
HSB = BS	Mid-tier	1.87	0.083	0.61	0.552
HSB = SB	Mid-tier	2.07	0.059	-1.49	0.142
BS = SB	Mid-tier	0.93	0.354	-2.23	0.034
HSB = BS	High-tier	2.21	0.038	-0.01	0.994
HSB = SB	High-tier	2.49	0.021	0.5	0.615
BS = SB	High-tier	1.17	0.246	1.31	0.196

For each firm, a t-test for significant differences is deployed for several pair wise combinations of the three deposit-tier MTS accounts available for all three firms and industry. A significantly positive t-statistics shows the first product in the pair has higher, adjustment speed or Lag.

Table 4-8 Intra-Bank product heterogeneity analysis for MTS

	Product	% Error closed ($100\|\gamma\|$)		Adjustment delay (j)	
Null Hypothesis (H_0)	Firm Type	T-VALUE	P-VALUE	T-VALUE	P-VALUE
LT = MT	HSB	-1.51	0.133	-1.08	0.279
LT = HT	HSB	-0.93	0.356	-0.6	0.552
MT = HT	HSB	-1.88	0.063	-1.32	0.19
LT = MT	BS	0.02	0.98	0.76	0.456
LT = HT	BS	-0.99	0.329	-0.92	0.359
MT = HT	BS	1.87	0.084	0.24	0.815
LT = MT	SB	-0.56	0.576	-0.43	0.669
LT = HT	SB	-1.87	0.084	0.52	0.609
MT = HT	SB	-0.64	0.523	-0.18	0.854

For each firm, a t-test for significant differences is deployed for several pair wise combinations of the three deposit-tier MTS accounts available for all three firms and industry. A significantly positive t-statistics shows the first product in the pair has higher, adjustment speed or Lag.

Table 4-9 *LRPT* (*C*), *Mark-up/down* (*A*) and *LRER* (x_t*) comparison among three firms and industry for IAS

	Product	High Street Banks (HSB)		Building Societies (BS)		Small Banks (SB)		Industry (IND)	
Long-run	IAS	Mean	St Dev	Mean	St Dev	Mean	St Dev	Mean	St Dev
C	Low-tier	0.26 (-0.14, 0.68)	33.5	0.36 (-2.41, 0.93)	46.5	0.79 (0.11, 4.44)	49	0.44 (-2.41, 4.44)	0.63
C	Mid-tier	0.31 (-0.13, 0.82)	34	0.45 (-2.14, 1.44)	41.5	0.65 (0.12, 2.44)	44	0.48 (-2.14, 2.44)	0.42
C	High-tier	0.35 (-0.13, 0.86)	38.7	0.50 (-2.32, 1.02)	46	0.71 (0.34, 1.95)	35.3	0.53 (-2.32, 1.95)	0.44
A	Low-tier	1.67 (-0.14, 7.15)	1.67	0.49 (-0.80, 13.34)	1.91	-0.17 (-11.87, 4.38)	3.01	0.48 (-11.87, 4.38)	2.21
A	Mid-tier	1.74 (-0.24, 6.06)	1.83	0.42 (-0.74, 8.87)	1.36	0.04 (-5.82, 1.02)	1.2	0.5 (-5.82, 1.02)	1.46
A	High-tier	1.66 (-0.44, 4.07)	1.47	0.5 (-0.61, 8.64)	1.35	0.13 (-3.95, 1.17)	1.01	0.55 (-3.95, 8.64)	1.35
x_t^*	Low-tier	2.65 (1.03, 8.26)	1.55	1.87 (0.44, 4.44)	1.05	2.82 (0.86, 9.77)	2.28	2.17 (0.44, 9.77)	1.51
x_t^*	Mid-tier	2.93 (1.17, 7.32)	1.46	2.14 (0.44, 4.83)	1.03	2.49 (1.02, 4.24)	1.11	2.31 (0.44, 7.32)	1.125
x_t^*	High-tier	2.94 (1.20, 4.17)	1.08	2.4 (-0.74, 5.12)	1.05	2.85 (1.28, 4.24)	0.89	2.56 (-0.74, 5.12)	1.03

x_t* long run equilibrium rate; is calculated using Equation 4-7 and y_t=3.81%; *A* is long-run mark–up, which indicates how much a bank product rate is set above or below the official rate in the long term; it is calculated using Equation 4-9. *C* represents the competition; it is defined as the fraction or the multiple of an official rate change that is reflected in the retail rate over the long-run; it is calculated using Equation 4-10.

Table 4-10 Inter-bank group mean difference t-test among three types of firms for IAS

	Product	A		C	
Null Hypothesis (H_0)	IAS	T-VALUE	P-VALUE	T-VALUE	P-VALUE
HSB = BS	LT	2.62	0.02	-1.08	0.291
HSB = SB	LT	2.81	0.007	-2.81	0.007
BS = SB	LT	1.22	0.229	-2.43	0.02
HSB = BS	MT	2.95	0.008	-1.56	0.131
HSB = SB	MT	3.59	0.001	-3.04	0.004
BS = SB	MT	1.55	0.125	-2.26	0.028
HSB = BS	HT	3.74	0.001	-1.83	0.075
HSB = SB	HT	4.79	0.002	-4.17	0
BS = SB	HT	2.12	0.036	-3.51	0.001

For each firm, a t-test for significant differences is deployed for several pair-wise combinations of the three deposit tiers for IAS available for all three firms and industry as a whole. A significantly positive t-statistic shows the first product in the pair has higher adjustment speed or lag.

Table 4-11 Intra-bank product heterogeneity analysis for IAS

	Product	A		C	
Null Hypothesis (H_0)	IAS	T-VALUE	P-VALUE	T-VALUE	P-VALUE
LT = MT	HSB	-0.12	0.903	-0.44	0.661
LT = HT	HSB	0.14	0.889	-0.83	0.409
MT = HT	HSB	0.28	0.782	-0.37	0.712
LT = MT	BS	0.3	0.768	-1.47	0.143
LT = HT	BS	-0.05	0.96	-2.37	0.018
MT = HT	BS	-0.46	0.647	-0.9	0.37
LT = MT	SB	-0.38	0.707	0.76	0.45
LT = HT	SB	-0.56	0.578	0.4	0.692
MT = HT	SB	-0.35	0.728	-0.78	0.438

For each firm, a t-test for significant differences is deployed for several pair wise combinations of the three deposit tiers of IAS available for all three firms and industry as a whole. A significantly positive t-statistic shows the first product in the pair has higher adjustment speed or lag.

Table 4-12: Pass-through (C), Mark-up/down (A) and *LRER* (x_t*) comparison among three firms and industry for MTS

		High Street Banks		Building Societies		Small Banks		Industry	
Long-run variables	Deposit-tiers	Mean	St Dev	Mean	St Dev	Mean	St Dev	Mean	St Dev
C	Low-tier	-0.01 (-0.62, 0.63)	0.43	0.61 (-0.07, 2.33)	0.32	0.57 (-0.98, 3.83)	0.83	0.55 (-0.98, 3.83)	0.51
C	Mid-tier	0.03 (-0.62, 0.69)	0.45	0.66 (-0.26, 1.59)	0.28	0.54 (-0.98, 3.83)	0.37	0.58 (-0.62, 1.59)	0.36
C	High-tier	-0.2 (-7.4, 0.79)	1.31	0.6 (-8.57, 1.54)	0.96	0.63 (-0.062, 0.99)	0.29	0.53 (-8.57, 1.54)	0.97
A	Low-tier	2.5 (-0.01, 4.69)	1.85	0.25 (-.6.75, 3.04)	1.35	0.24 (-16.44, 5.8)	3.92	0.46 (-16.44, 5.8)	2.275
A	Mid-tier	2.6 (0.02, 4.86)	1.97	0.38 (-4.4, 3.59)	1.25	0.92 (-1.03, 3.88)	1.41	0.71 (-4.4, 4.86)	1.495
A	High-tier	3.99 (0.24, 6.43)	5.4	1.03 (-4.34, 3.99)	3.3	0.94 (-0.24, 6.29)	1.16	1.29 (4.34, 6.34)	3.48
x_t^*	Low-tier	2.47 (1.60, 3.66)	0.76	2.59 (0.55, 4.06)	0.77	2.44 (-1.82, 4.06)	1.22	2.55 (-1.82, 4.16)	0.875
x_t^*	Mid-tier	2.70 (1.81, 2.89)	0.74	2.91 (1.26, 4.20)	0.65	2.95 (1.48, 4.11)	0.66	2.90 (1.26, 4.20)	0.66
x_t^*	High-tier	3.21 (2.12, 4.42)	0.75	3.31 (-1.89, 4.46)	0.78	3.35 (2.26, 4.26)	0.52	3.31 (-1.89, 4.39)	0.72

x_t* long run equilibrium rate; is calculated using Equation 4-7 and y_t =3.81%; A is long-run mark–up, which indicates how much a bank product rate is set above or below the official rate in the long term; it is calculated using Equation 4-9. C represents the competition; it is defined as the fraction or the multiple of an official rate change that is reflected in the retail rate over the long-run; it is calculated using Equation 4-10.

Table 4-13 Inter-bank group mean difference t-test among three types of firms for MTS

		A		C	
Null Hypothesis (H_0)	Deposit-tiers	T-VALUE	P-VALUE	T-VALUE	P-VALUE
HSB = BS	LT	4.54	0.000	-5.4	0.001
HSB = SB	LT	2.68	0.010	-5.51	0.001
BS = SB	LT	0.02	0.986	0.26	0.796
HSB = BS	MT	4.28	0.001	-3.19	0.003
HSB = SB	MT	3.01	0.007	-2.21	0.039
BS = SB	MT	-1.93	0.059	1.83	0.074
HSB = BS	HT	1.93	0.067	-2.08	0.035
HSB = SB	HT	2.02	0.057	-2.21	0.039
BS = SB	HT	0.28	0.782	-0.35	0.724

For each firm, a t-test for significant differences is deployed for several pair wise combinations of the three deposit-tier MTS accounts available for all three firms and industry. A significantly positive t-statistics shows the first product in the pair has higher, adjustment speed or Lag.

Table 4-14 Intra-Bank product heterogeneity analysis

		A		C	
Null Hypothesis (H_0)	Firm types	T-VALUE	P-VALUE	T-VALUE	P-VALUE
LT = MT	HSB	-0.16	0.877	-0.22	0.830
LT = HT	HSB	-0.95	0.352	0.50	0.66
MT = HT	HSB	-0.88	0.389	0.59	0.563
LT = MT	BS	-0.71	0.479	-1.20	0.233
LT = HT	BS	-2.45	0.015	0.19	0.850
MT = HT	BS	-2.07	0.004	0.73	0.466
LT = MT	SB	-0.99	0.332	0.27	0.792
LT = HT	SB	-0.92	0.365	-0.37	0.717
MT = HT	SB	-0.10	0.923	-1.25	0.216

For each firm, a t-test for significant differences is deployed for several pair wise combinations of the three deposit-tier MTS accounts available for all three firms and industry. A significantly positive t-statistics shows the first product in the pair has higher, adjustment speed or Lag.

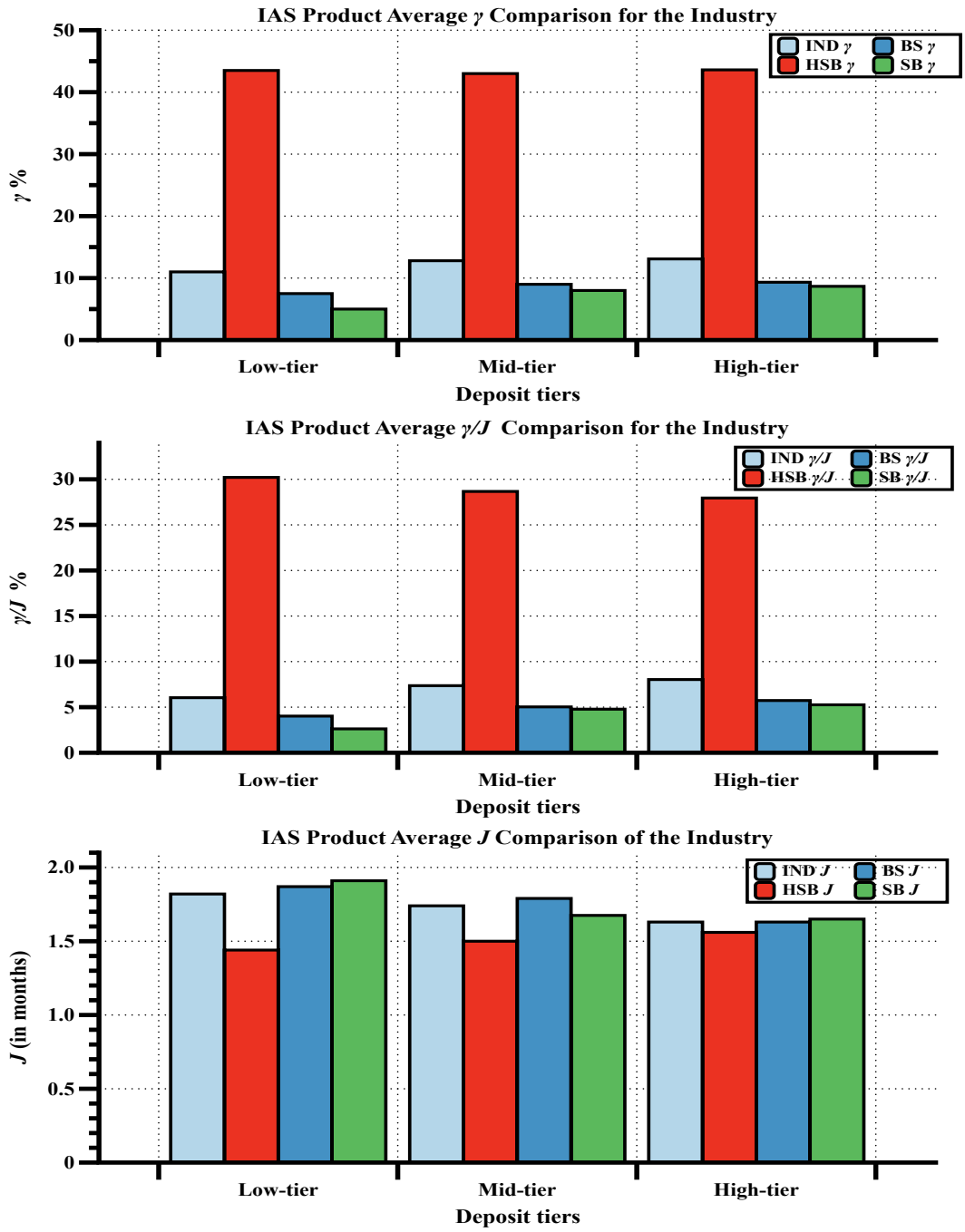

Figure 4-2 Comparison of $|\gamma|, \frac{|\gamma|}{j}, and\ j$ for IAS for Industry

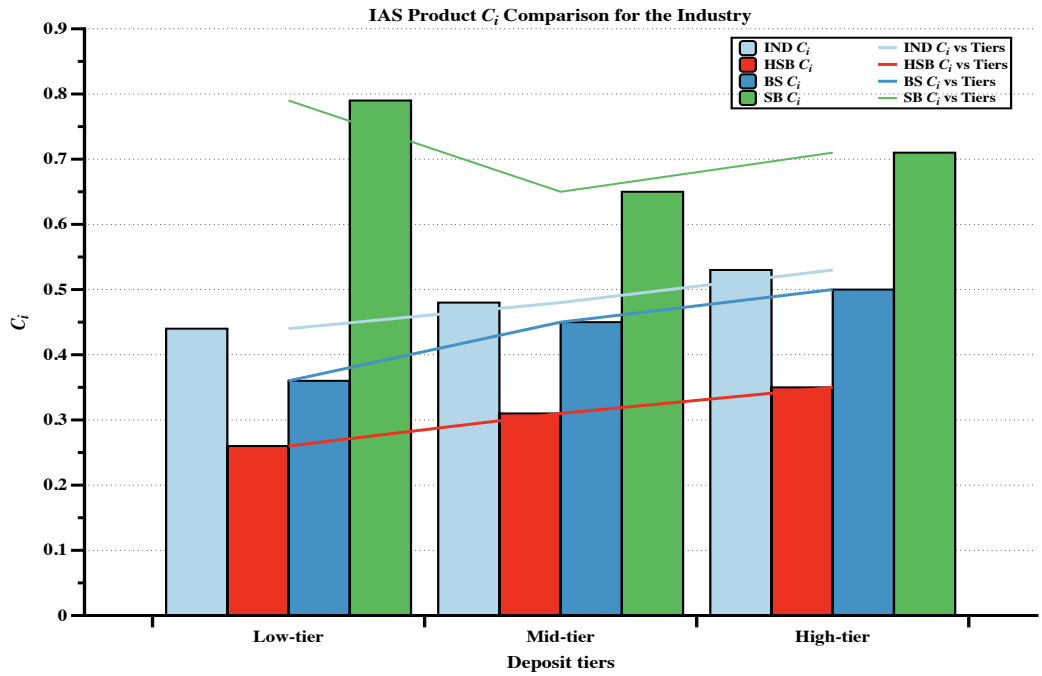

Figure 4-3 Comparison of *C* for industry for IAS

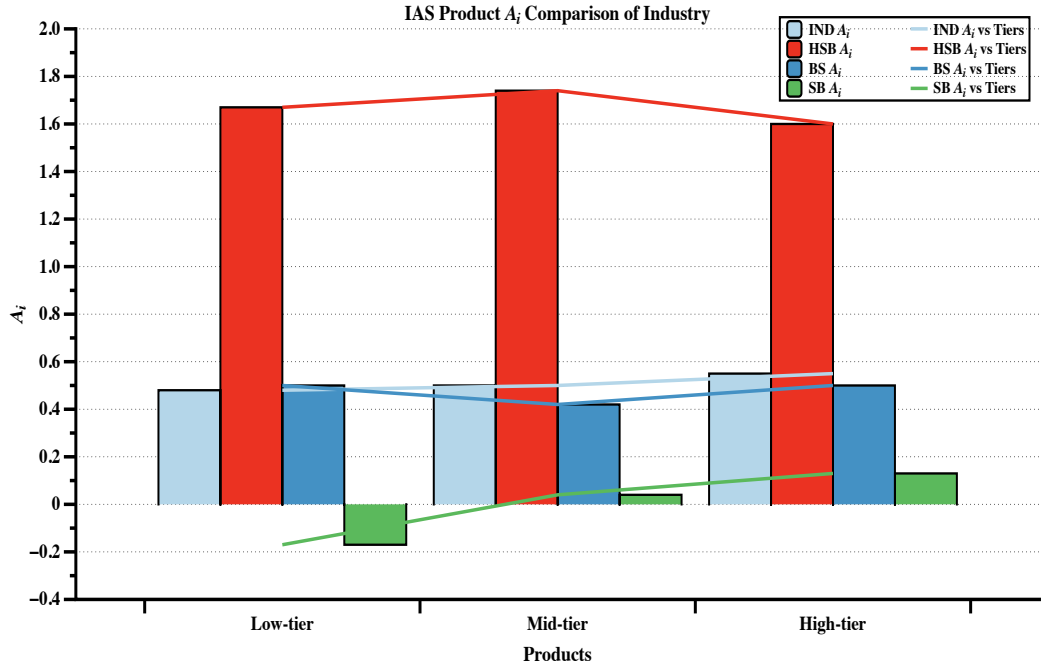

Figure 4-4 Comparison of A for industry for IAS

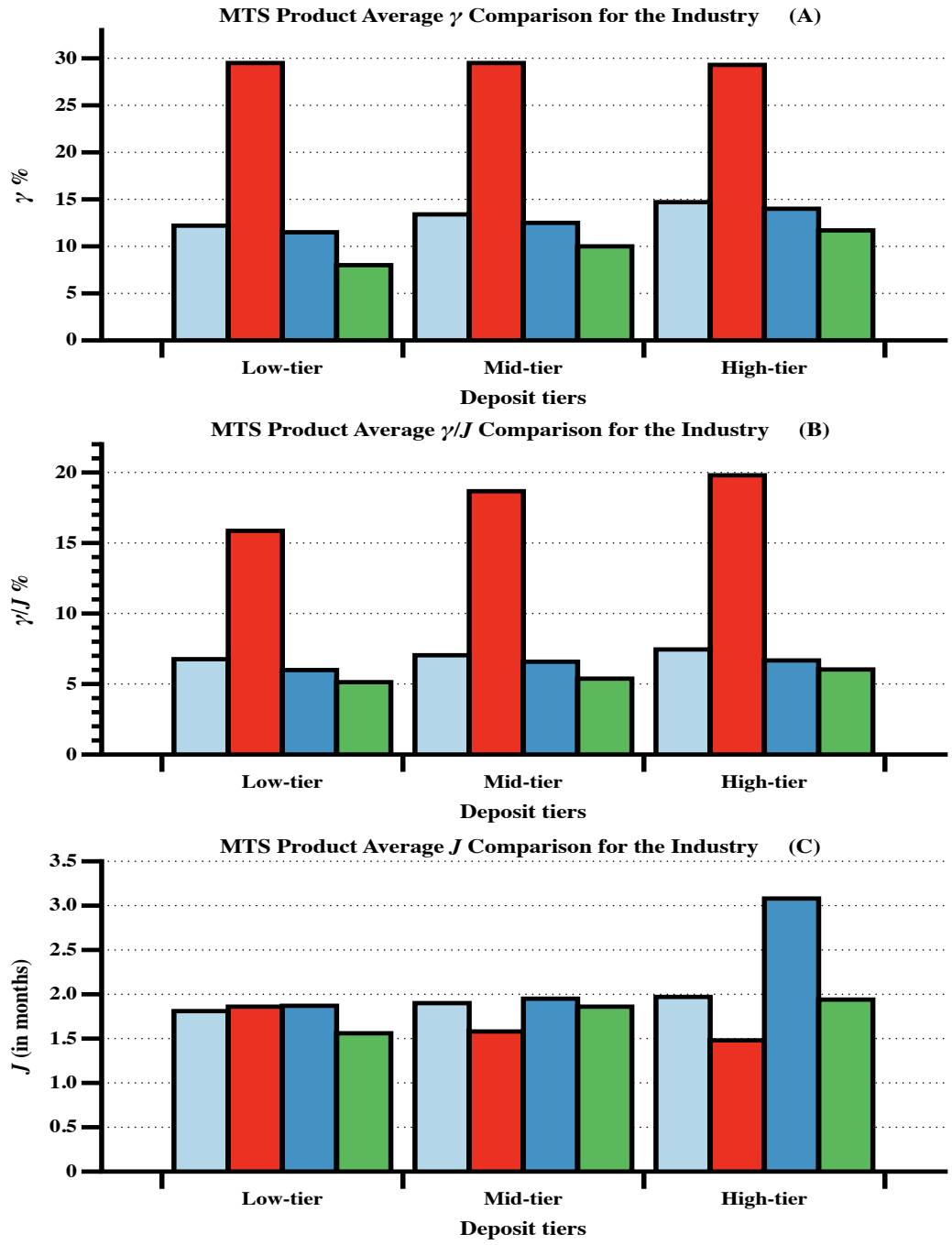

Figure 4-5 Comparison of $|\gamma|, \frac{|\gamma|}{j}, and\ j$ for MTS for Industry

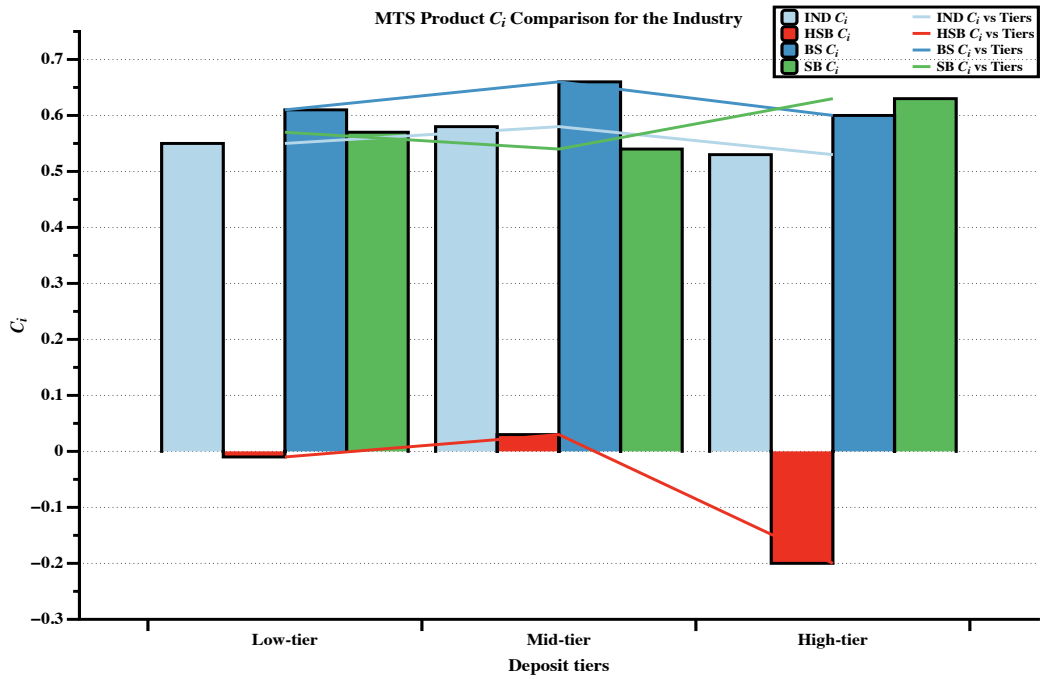

Figure 4-6 Comparison of C for industry for MTS

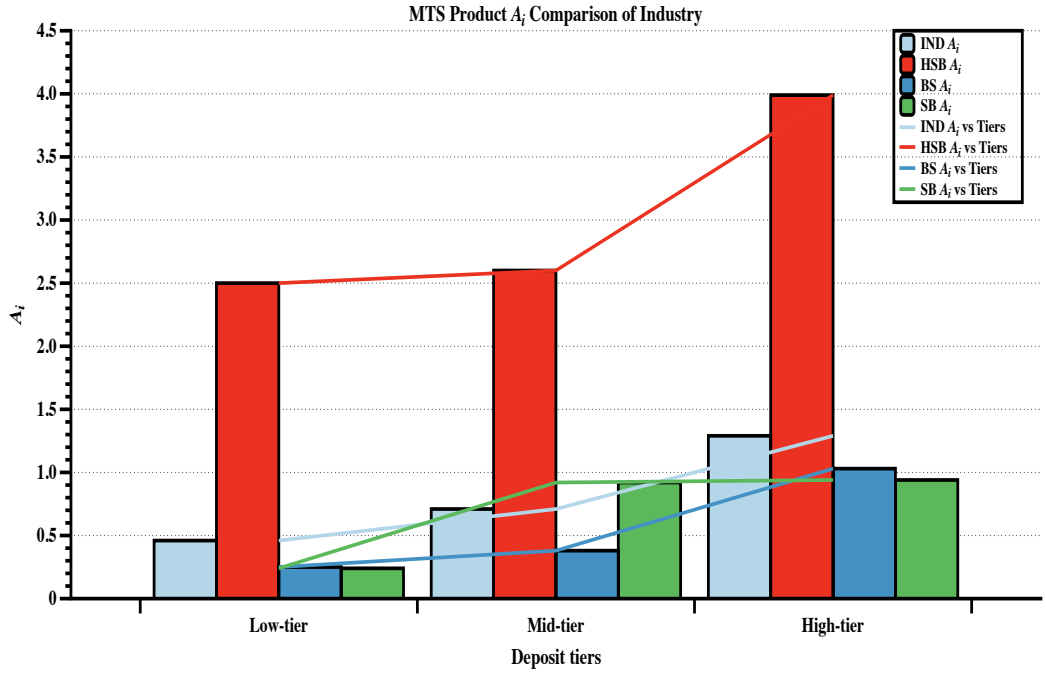

Figure 4-7 Comparison of A for industry for MTS

5 DETERMINANTS OF INTEREST MARGINS IN NINE EU COUNTIRES

5.1 Introduction

5.1.1 Motivation for the Study

Chapters 3 and 4 analyse the interest rate pass-through of monetary policy in the UK financial market. Chapter 3 shows that the adjustment speed of interest rates in response to base rate change is very sticky and pass-through is incomplete in the long-run for lending, deposit and mortgage products. Lending products are found to have the highest mark-ups, the stickiest adjustment speeds, and an overshooting of parameter C_i. In general, lending products are found to be the most expensive, with very high mark-ups above the cost of funds. The analysis also reveals a lack of competition in the market for mortgage and deposit products.

Chapter 4 presents a comparison of interest rate pass-through parameters for three types of firms (HSB, BS and SB). We find the *Law of One Price* does not apply in the savings account market in the UK. This is because High street banks enjoys the economies of scale and exercise market power and pay relatively higher prices to maintain and attract bigger deposit base. The highest interest rates on savings and current accounts are set the HSB, followed by BS and SB. Moreover, the adjustment speed is the fastest in HSB and slowest in SB. The level of competition is the lowest in HSB and highest in SB. This is due to the fact that smaller banks really have to fight hard to attract more customer deposits compared to high street banks which enjoy the economies of scale.

This study explores the determinants that affect the price setting behaviour of the financial market using aggregated country level monetary financial institutions (MFIs) data for nine EU countries. Literature on the determinants of interest rate pass-through is scarce. According to Bernanke and Gertler (1995), this area is still a black box, meaning the transmission process and determinants of pricing are still unknown. If the factors that determine interest rate setting are identified, it could help smoothen and

strengthen the monetary policy process. The dynamics of banks' interest margin setting behaviour to policy rate and its determinants is a key element of the monetary policy transmission mechanism.

In the aftermath of global financial crisis there has been structural, macroeconomic and monetary changes in the banking sector. For example; the banking competition has increase post-crisis for least affected, but decrease for most affected countries; economic growth has slowed down. ECB introduced unconventional monetary policy with the introduction of their asset purchase programme in 2009 to help growth and competition in economy and financial sector and to control inflation. So naturally the determinants of interest margins may have changed in some sort of way. Our paper contributes to the understanding of the way interest rate margins react to changes in structural, macroeconomic, country level factors. While several studies on this issue have already been carried out, we attempt to deepen the understanding of the interest margin determinants of households by using a larger harmonised data set available from the ECB website and especially understanding the differences in determinants in post crisis period for the least affected and most affected countries of EU.

5.1.2 Research Questions

This study uses a large sample of data for MFIs for the nine EU countries; five least affected and four most affected by the financial crisis to investigate the determinants of lending margins. The main research question is: *What are the determinants of bank lending margins?* Accordingly, the study explores the following questions:

- How do various market structure, macroeconomic, monetary and bank-specific variables at country level impact lending margins?
- Have the determinants changed post-crisis?
- Are the determinants of lending margins for the least stressed and most stressed countries different?

5.1.3 Structure of the Study

Section 5.1 is introduction to the study, which includes: motivation, research questions; and structure of the study; Section 5.2 describes data collection, and provides definitions and abbreviations of the independent and dependant variables. Section 5.3 comprises a brief literature review, focusing on those studies closest to the present investigation. Section 5.4 describes the methodology used in this paper; it explains the econometric model. Section 5.5 presents the results and discussion; it presents descriptive statistics and discusses the empirical results. Finally, Section 5.6 summarises the most important findings and provides concluding remarks.

5.2 Data Collection

Data is collected from the statistical data warehouse (SDW) of the ECB. Lending margins data is aggregated monthly data for MFIs for the period Jan 2003 to Oct 2017 for nine EU countries. The data comprise dependent variables; lending margins for households (*HHS*). In total, we collect data for 12 independent variables: *diversification, capitalization, liquidity risk, credit risk, interest-rate risk*, *market share, Herfisham Herfindahl Index (HHI), inflation, GDP, financial deepening, Euro Interbank Offered Rate (Euribor) and base money*.

Out of the nine EU countries, data has been divided into two sample; 1) for the five least affected countries during the financial crisis and 2) for four most affected countries during the financial crisis. These countries are chosen on the basis of composite index of system stress (CISS) data. Figure 5-1, panel A, shows CISS for Austria, Germany, France, Belgium and Finland; Panel B shows CISS for Ireland, Italy, Spain and Greece. Clearly, the five countries in Panel A experience much lower CISS and appear to be more stable during the period from 2008 to 2013 compared to Panel B countries.

5.2.1 Definitions and Abbreviation for Dependent and Independent Variables

The study employs four sets of independent variables to investigate the determinants of interest rate margins: first, bank industry characteristics at country level; second, market structure; third, macroeconomic variables and fourth, monetary policy factors. Analysis includes: *diversification*, *capitalization*, *liquidity risk*, *credit risk*, *interest-rate risk*, *market share as* bank specific characteristics*; competition* is used as the market structure variable; *inflation*, *GDP* and *financial deepening* are included as macroeconomic variables. *Euribor* and *ECB's monetary base* are used as monetary policy variables.

5.2.1.1 Dependent Variables

Lending Margins for Households (*HHS*)

The dependent variable is *lending margins on loans for households for household purchases (HHS)*. These lending margins are measured as the difference between monetary financial institutions' (MFIs') interest rates for new business loans and a weighted average rate of new deposits from households.

5.2.1.2 Bank Specific Independent Variables

5.2.1.2.1 Diversification into non-interest Income

Securities held by bank is used as a proxy for product *diversification*. This variable reveals the importance of non-interest income for banks in different countries. According to theory and empirical findings, as discussed in Section **2.5.4.2.4**, a negative sign is expected for the relationship between non-interest income and margins.

5.2.1.2.2 Capitalisation

Capital & reserves is used as a measure of bank soundness. Higher *capitalization* provides banks with a higher cushion against *credit risk*. Therefore, according to theory, banks with higher *capital* can take advantage of higher risk returns and may set higher lending margins (see Section **2.5.4.2.2**).

5.2.1.2.3 Liquidity Risk

Liquidity risk relates to not having sufficient cash or borrowing capacity to meet deposit withdrawals or new loan demand. We use the loan to deposit ratio as a proxy for *liquidity risk*. According to theory, lower liquidity should result in a reduction in lending margins (see Section **2.5.4.2.3**).

5.2.1.2.4 Credit risk

Measurement of *credit risk* is not straightforward and is limited by data availability. It is measured here as the difference in 10-year government bond yield and monthly EURIBOR rate. According to theory, an increase in *credit risk* is expected to increase interest rate margins (see Section 2.5.4.2.5).

5.2.1.2.5 Interest Rate Risk

To capture *interest rate risk*, we include a measure of the monthly standard deviation of the daily 10-year government bond yields for loans. According to theory, an increase in *interest rate risk* should increase interest margins.

5.2.1.2.6 Market Share

To capture the effects of bank *market share* on margins, a *market share* variable is included in the model. This is estimated as Total bank assets divided by total commercial bank assets for each year in the country under study. According to theory, greater *market share* can lead to higher market power, resulting in banks setting higher lending margins (see Section **2.5.4.2.8**).

5.2.1.3 Market Structure Variables

5.2.1.3.1 Competition

To measure competition in the market, the Herfindahl Index *(HHI)* is used. *HHI* is a measure of concentration in the market; higher concentration is associated with lower competition, while lower concentration is associated with higher competition. According to theory, a positive relationship between concentration and interest margins is expected.

5.2.1.4 Macroeconomic Variables

5.2.1.4.1 Inflation

To measure *inflation* in the economy, we sue harmonized index of consumer prices (HICP) obtained from the ECB's data warehouse. The Harmonized Index of Consumer Prices (HICP) is an indicator of inflation and price stability for the European Central Bank (ECB). It is a consumer price index which is compiled according to a methodology that has been harmonized across EU countries.

5.2.1.4.2 Economic Growth

Economic growth is measured by real *GDP*.

5.2.1.4.3 Financial Deepening (Loans to GDP)

Too measure *financial deepening* in the economy we use Loans to GDP ratio as a proxy.

5.2.1.5 Monetary Policy Variables

5.2.1.5.1 Policy Rate

To represent the monetary policy stance of the ECB, the Euro interbank offer rate (*EURIBOR*) is used.

5.2.1.5.2 ECB Monetary Base

To measure the effects of ECB non-standard monetary policy on lending margins, the ECB monetary base is used as a proxy for ECB non-standard policy. Liquidity conditions are captured by the *ECB monetary base*, which in the aftermath of the global financial crisis (GFC) reflects the provision of ample liquidity through the ECB's non- standard monetary policy operations. As a result, including this measure may shed light on the significance of non-standard monetary policies for one of their main targets; that is, reducing the fragmentation of lending conditions in the Euro-area economy. In the aftermath of the GFC, the ECB expanded its balance sheet several

times; this expansion was mainly accomplished by providing ample liquidity to eligible monetary operations counterparties. As a result, the ECB formally argues (see ECB, 2012) that non-standard monetary policy measures are better reflected in the development of the monetary base of the Eurosystem (*base money*). In this regard, Giannone et al. (2012) argue that this development adequately reflects the effects of non-standard monetary policy measures. The *base money* coefficient is added in the model as a control variable to add the effects of unconventional monetary policy.

5.3 Review of Literature on Independent Variables

Section **Error! Reference source not found.** presents the literature on the determinants of interest rate. Broadly speaking, these can be grouped into four main categories: bank specific factors; market structure; macroeconomic factors; and monetary policy factors. In the following sections, the literature and findings relating to these categories are discussed in detail.

5.3.1 Theoretical and Empirical Literature

Ho and Saunders (1981) develop a dealership model in which banks are assumed to be risk-averse utility maximizing intermediaries for collecting deposits and granting loans over a single period. Transaction uncertainty arising due to the asymmetry between the supply of deposits and the demand for loans and market power are considered two significant factors driving interest margins. Ho and Saunders (1981) also empirically estimate the model for U.S. banks, using a two-step approach. In the first step, a regression model explains the bank interest margin in terms of bank-specific factors, such as implicit interest rate, opportunity cost of reserves, default premium, operating costs, and capital-asset ratio. The constant term of this regression represents an estimate of the *pure spread* component for the banks; that is, the portion of the margin that cannot be explained by bank-specific characteristics. In the second stage, the authors estimate a regression of pure spread against variables reflecting macroeconomic factors. The inclusion of a constant term in the second step aims at capturing factors that are neither bank-specific nor macroeconomic in nature but attributable to market structure and risk aversion.

McShane and Sharpe (1985), Allen (1988) and Angbazo (1997) extend and modify the dealership model. McShane and Sharpe (1985) considers interest uncertainty from loan and deposit returns to money market rates. Allen (1988) extends the model for various types of loans with interdependent demands. Angbazo (1997) introduces credit and interest rate risk, and the interaction between the two, into the theoretical model. The dealership model has been criticised on the grounds that it fails to recognize the bank as a firm having a certain production function associated with the provision of

intermediation services (Lerner, 1981). Cost inefficiencies in the production process across banks can have a distortionary effect on margins. Thus, Maudos and Fernández de Guevara (2004) make an interesting contribution, expanding the theoretical model by considering the importance of operating costs and market power (Lerner index), and providing a detailed description of the link between riskiness and margins. Their model specifically differentiates between market risk and credit risk, viewing these as separate factors, in addition to their interaction, which affect margins. The model is estimated empirically for the main European banking sectors for the period 1992 to 2000. The opportunity cost variable (OC) is approximated, by the yield on government securities investment. This variable is included in the profitability equation to reflect the substitution effect among different bank assets, and, more specifically, to capture the changing remuneration conditions of substitutes for the traditional loans granted by banks (the assets for which banks are price-takers). The effect of this variable on bank net margin is unknown (Wong, 1997), and depends on the bank's position (as net lender or borrower) in the money market (Angbazo, 1997).

5.3.2 Review of Literature on determinants of interest margins between bank retail rate and cost of funds rate

Taking inspiration from the theoretical literature, empirical studies apply a variety of econometric models, including OLS, pooled least square (Angbazo 1997; Demirguc-Kunt and Huizinga, 1999), fixed effect and random effect panel regression (Maudos and Guevara, 2003; Naceur and Goaied, 2004; Maudos and Solisc, 2009; Hamadi and Awdeh, 2012; Afanasieff et al., 2002) and dynamic panel data technique (Liebeg and Schwaiger, 2007; Hossain, 2010). Broadly, the factors concerning loan pricing can be summarized under four broad categories: bank specific factors; institutional, policy and regulatory factors; market structure; and macroeconomic factors. Bank specific factors such as bank size, capitalization, liquidity, managerial efficiency, non-interest operating expenses, loan quality, deposit growth, interest rate risk, credit risk, ownership, non-interest incomes, and risk aversion are identified by multiple studies as important determinants of interest margins. Regulatory and institutional factors include determinants such as implicit and explicit taxation (reserve requirements),

central bank discount rate, and inter-bank rate. Market structure focuses on the competition (market power) in the banking sector, bank concentration, and financial sector liberalization. Finally, the macroeconomic view focuses on the inflation rate, *GDP* growth, exchange rate, interest rate policies, gross national savings, and investment and *capital* formation as factors driving interest spreads and margins in the banking system.

Leibeg and Schwaiger (2007) in a study on Austria and Hossain (2010) in a study on Bangladesh find a negative impact of bank size on interest rate margins. On the contrary, Demirguc-Kunt et al. (2004) in a cross-country study show high net interest margins tend to be positively associated with the market share of banks. Similarly, Berger and Humphrey (1997) and Altunbas et al. (2001) find economies of scale for larger banks, whereas Pallage (1991) and Vennet (1998) find economies of scale for small banks or diseconomies for larger banks.

Estrada et al. (2006) argue that interest margins are positively affected by inefficiency. Similar studies by Maudos and Guevara (2003), Hamadi and Awdeh (2012), and Maudos and Solisc (2009) find that efficiency/quality of management is negatively correlated with net interest margins. Studies on credit risk show both negative and positive impacts. Liebeg and Schwaiger (2007), Williams (2007), and Hamadi and Awdeh (2012) provide evidence of a negative impact of credit risk on the interest margin. In contrast, Maudos and Guevara (2003) and Maudos and Solisc (2009) show a positive sign for both credit risk and interest rate risk. Hamadi and Awedh (2012) find liquidity negatively correlated with net interest margins for domestic banks. However, Doliente (2003) in his study of Southeast Asia takes a different view, showing margins to be partially explained by liquid assets.

As regards operating costs, risk aversion and loan quality, Doliente (2003), Maudos and Guevara (2003), Liebeg and Schwaiger (2007), Maudos and Solisc (2009), Mannasoo (2012), and Hossain (2010) in their respective studies show the positive impact of one or all of these variables on interest margins. Implicit taxes include reserve and liquidity requirements, whose opportunity costs tend to be higher as they are remunerated at less than market rates. In contrast, explicit taxes translate into

higher interest margins. Studies suggest that corporate tax is fully passed on to customers in poor as well as rich countries.

Most studies on banking structure generally produce ambiguous results regarding the impact of competition. Studies like those of Maudos and Guevara (2003), Maudosa and Solisc (2006), and Liebeg and Schwaiger (2007) demonstrate that competition in the banking sector positively affects interest margins. Chirwa and Mlachila (2004) find that interest rate spreads in Malawi increase significantly after the implementation of financial liberalization reforms, partially due to high monopoly power within the industry, which stifles competition. They conclude that high interest rate spreads in developing countries will persist if financial sector reforms do not alter the structure of the banking system. Estrada et al. (2006) and Männasoo (2012) provide evidence in support of this argument and conclude that market power is a key determinant of interest margins.

Goyal (2014) provides evidence in support of monetary transmission through the banks in the Indian context. Investigating the pass-through of money rates to bank lending rates, for different sectors and by type of bank ownership, he finds pass-through is affected by bank size and the degree of competitiveness. Since pass-through falls with competitiveness, it is higher to the extent the Indian banking sector is less competitive (Ansari and Goyal, 2011).

Mendoza (1997) identifies the low level of competition in the Belizean banking system as a primary reason for higher interest spreads than in Barbados, a country with a similar exchange rate regime and high reserve requirement. The price cost margin (PCM) is widely used as a measure of competition. However, the theoretical foundations for this measure are not robust. Theoretical papers, like those of Rosentahl (1980), Stiglitz (1989), Bulow and Klemperer (1999), and Amir (2003), present models where more intense competition leads to higher PCM instead of lower margins. Boone (2008) assumes that more efficient firms (that is, those with lower marginal costs) will gain higher market shares or profits, and that this effect will be stronger the heavier competition is in that market. In order to support this intuitive

market characteristic, Boone develops a theoretical measure, found to be more robust than other methods.

A number of studies support the view that macroeconomic factors are important determinants in explaining variations in interest margins. Afanasieff et al. (2002) identify the main determinants of bank interest spreads in Brazil and suggest that macroeconomic variables are the most relevant elements. Other studies find inflation to be associated with higher interest margins as it entails higher transaction costs (Demirguc-Kunt and Huizingia, 1999). Birchwood (2004) explicitly examines the impact of macroeconomic influences on nominal and real interest spreads in the Caribbean region and concludes that inter-regional differences may be due to economic cycles and inflation. As far as the impact of *GDP* growth on interest margins is concerned, Liebeg and Schwaiger (2006) and Hamadi and Awdeh (2012) have contrasting views. While the former argue that the *GDP* growth rate has a positive impact, the latter conclude that economic growth is negatively correlated with net interest margins.

To summarize, the above discussion suggests that determinants of bank interest margins vary considerably. Multiple factors contribute to high spreads and margins. Therefore, country, time and context specific studies are required.

5.4 Methodology

5.4.1 Empirical Model

There are two empirical approaches to estimate the theoretical model of Ho and Saunders (1981) (see Section 2.2.2 for details). One approach follows a two-stage process for the estimation of interest rate determinants, for example Ho and Saunders (1981) and Schumacher (2000). The other approach is the one-stage approach, where net interest margins are nested within an empirical specification that also includes their determinants (for example: McShane and Sharpe, 1985; Angbazo, 1997; and Guevara, 2005).

In this paper, we use difference in difference (DiD) single equation regression model for testing. DiD regression econometric models have become widely used an popular in studies recently. The simple setup is where outcome differences of two different time periods or two data samples are observed. In the case where the same variables are observed in each time period, the average gain in the second (post-crisis) group is subtracted from the average gain in the first (pre-crisis) group.

We can write out DiD regression model as follows:

Equation 5-1

$$\mathrm{y_{i,t}} = \alpha + \theta PR_{i,t} + \beta x_{i,t} + \lambda z_{i,t} + \eta m_{i,t} + \alpha' \mathrm{d2} + \theta' PR_{i,t} + \beta' \mathrm{d2} * x_{i,t} + \lambda' \mathrm{d2} * z_{i,t} + \eta' \mathrm{d2} * m_{i,t} + \varepsilon_{i,t},, i = 1, \dots, N, t = 1, \dots, T$$

where $\mathrm{y_{i,t}}$ is lending margin, $PR_{i,t}$ represents policy rate (PR), $x_{i,t}$ is $k \times 1$ vector for k market structure variable (*competition*), $z_{i,t}$ is z$\times$ 1 vector for the z bank industry variables (*bank size*, *equity*, *loans/deposits*), $m_{i,t}$ is $m \times 1$ vector for m macroeconomic variables (*GDP*, *inflation*, *financial deepening*). $d2$ is the dummy variable which is 0 for the pre-crisis period and 1 for post-crisis, $d2 * PR_{i,t} is$ represents policy rate (PR) interaction term for the post-crisis, $x_{i,t}$ is interaction term for $k \times 1$ vector for k market structure variable (*competition*) , $z_{i,t}$ is the interaction term for the z$\times$ 1 vector for the z bank industry variables (*bank size*, *equity*,

loans/deposits), $m_{i,t}$ is the interaction term for the post-crisis for $m \times 1$ vector for m macroeconomic variables (*GDP*, *inflation*, *financial deepening*), and $\varepsilon_{i,t}$ is the error term. Interaction terms are created by multiplying them by the dummy variable which is equal to 1 for the post-crisis and 0 for the pre-crisis. The subscript i represents the cross-sectional dimension (banks), t represents the time dimension, and k represents the different independent variables in each group. α, the constant for the precisis period and $\theta, \beta, \lambda,$ and η are the coefficients for the pre-crisis for variable $PR_{i,t}$, $x_{i,t}$, $z_{i,t}$ and $m_{i,t}$ respectively. The coefficients $\alpha', \theta', \beta', \lambda',$ and η' are the differences between the coefficients for the post-crisis and pre-crisis.

5.5 Results and Discussion

5.5.1 Introduction

This section reports descriptive and empirical results for the independent and dependent variables. Descriptive analysis covers the trends in dependent and independent variables for the period Jan 2003 to Sept 2008 and Oct 2008 to Oct 2017 for five EU MFIs. The empirical section reports and discusses the results of DiD regression model results for the determinants of lending margins for *HHs*.

5.5.2 Descriptive Statistics

This section reports the trends comparison of trend analysis of lending margins, structural, macroeconomic and monetary variables, for the five least affected and 4 most affected EU countries.

5.5.2.1 Trend Analysis for Lending Margins for *HHs* for Less-Stressed and More-Stressed EU Countries Pre- and Post-Crisis

Figure 5-2 shows the trend analysis of lending margins of five least and most four affected EU countries over the period Jan 2003 to Oct 2017. There is no single trend for any of the five EU least affected countries' lending margins. There is a decreasing trend from the end of 2003 to 2007. From the end of 2008 to end of 2009, there is a sharp increase; from the end of 2009 to end of 2012, rates increase slowly, with small

fluctuations. From the end of 2012, a declining trend is seen until 2017. There is a decreasing trend from the end of 2003 to 2005. After a slight increase in lending margins from 2005 to 2006 lending rates decline till the end of 2008. From the end of 2008 to end of 2009, there is a sharp increase; from the end of 2009 to end of 2012, rates increase slowly, with small fluctuations. From the end of 2014, an increasing trend is seen. From 2014 to till 2017 rates stay more or less the same.

Figure 5-3shows the comparison of trend for Structural variable *HHI*. It represents concentration in banking industry for the country. Higher concentration means lower competition. The *HHI* ratio for least stressed countries stays very smooth until the end of 2012. However, after 2012 we see a sharp declining trend in *HHI* till the end of 2017. This shows post-crisis there has been a huge decline in concentration ratio and increase in competition for least affected countries. However, for most affected countries we see a steady increasing trend in concentration ratio from the beginning of 2007 till the end of 2013. From 2013 to 2014 a huge increase in concentration is observed and 2014 onwards we see a steady increase till the end of 2017. Over all we notice a big increase in concentration ratio for most affected countries and huge decline for least affected countries for the whole period.

Figure 5-4shows represents the trend analysis of monetary policy variables *Euribor* and *base money*. **Figure 5-4**Panel A represents trend analysis of *Euribor*. *Euribor* rates increase from 2005 to the end of 2008. From 2008 to the end of 2010 there is sharp decline in *Euribor* rates because of financial crisis. From 2010 to 2011 rates increase slightly but then we see a slow declining trend till the end of 2017. **Figure 5-4**Panel b represents trend analysis of ECB *base money*. In line with the responses of all major central banks to the financial crisis, the volume of monetary policy operations undertaken by the Eurosystem increased substantially from 2007 onwards and in particular after September 2008. In a situation of malfunctioning money markets and liquidity stress on banks' balance sheets, the Eurosystem supplied central bank reserves to each counterparty elastically at a level well above the banking system aggregate demand, through fixed rate tenders with full allotment. Moreover, in 2009 the first programme of outright purchases of covered bonds (CBPP1) was launched. The resulting increase in excess central bank liquidity was mirrored by a significant

expansion of *base money*. The volume of monetary policy operations increased again sharply in the second half of 2011, mainly as a consequence of the two longer-term refinancing operations (VLTROs) with a three-year maturity conducted in December 2011 and February 2012, and, to a lesser extent, outright purchases of securities under the CBPP2. As a result of these operations, excess reserves and, therefore, *base money* displayed a further sizeable increase. Receding financial fragmentation and improved funding conditions in euro area financial markets from mid-2012 reduced the incentive for banks to keep high levels of liquidity. Thus, banks in 2013 used the option offered by the ECB of a voluntary early repayment of the VLTROs, leading to a return of *base money* closer to the levels implied by the extrapolation of the pre-crisis trend. The asset purchase programme (APP) has been an important driving force behind the robust developments in broad money recorded since 2015, with indirect effects playing a major role. Indirect effects of the APP on broad money have materialised via a wide set of channels through which the APP has influenced financial markets and economic activity. The APP has indeed resulted in a broad easing of financing conditions and favourable wealth effects, crucially supporting the recovery in lending and economic growth.

Figure 5-5 shows a trend analysis comparison of macroeconomic variables for the least and most affected countries. Panel A shows a comparison of inflation growth HICP; we see inflation is rising steadily for both but there is a drop in inflation rate from 2008 to 2009. From 2009 to 2014 the rate to inflation is rising but on a very slow rate. From 20013 to 2014 inflation rate is higher in most stressed countries compared to least stressed countries. From 2014 onwards we see a slight decline and inflation rate is stabilised which is because of the APP of ECB. Inflation from 2014 to 2017 is lesser for the most affected countries compared to least affected countries. Panel B represents *GDP* trend analysis. We see a steady increase in *GDP* growth from 2003 to the end of 2007. From 2008 to 2009 *GDP* growth declines sharply for both data samples. For most affected countries economic growth almost stops from 2009 to 2011 and declines again from 2011 to 2013. From 2013 we see a slow increasing trend in *GDP* and economy for most affected countries starts to grow and recover on a slow but steady pace. However, for least affected countries we see that economic growth is

happening on slow but steady rate from 2009 till the end of 2017. Panel C represents trend analysis of *financial deepening* variable. The *financial deepening* trend for least affected countries shows a slow but increasing trend throughout the period of 2003 to 2017. However, for most affected countries a sharp increasing trend is found from 2003 to 2009, but from 2009 till 2017 we see a declining trend. This indicates that banking system of most affected countries took a big hit due to financial crisis compared to least affected countries.

5.5.3 Discussion of Results

This section presents and discusses the results of the study's empirical analysis. Section 5.5.3.1 presents the results of the pre- and post-crisis comparison of *HHs* lending margins. Section **Error! Reference source not found.** presents the results of the pre- and post-crisis comparison of *NFCs* lending margins.

5.5.3.1 Pre-Crisis and Post-Crisis Comparison of Lending Margins for *HHs* in Least Stressed EU Countries

Table 5-1 shows the pre- and post-crisis results Equation 5-1 for *HHs* lending margins. Pre-crisis results show 9 explanatory variables are significant pre-crisis and 11 post-crisis, at least at the 10% significance level.

Results for *Diversification* in to other income are statistically significant and positive pre- and post-crisis. We use other income as a proxy for *diversification*. Due to increase in d*iversification* by 100 basis points lending margins increase by 32.5 basis point. However, post-crisis coefficient is 71.4 basis points higher compared to pre-crisis. Generally, as the banks diversify they tend to reduce the interest margins but we see a positive relationship. This suggests that banks in countries which are least affected are offsetting the risks of higher risk investments from *diversification* other activities by increasing the interest margins. This positive relationship is contrary to findings reported in most of the existing literature. In contrast to our findings, DeYoung and Rice (2004) and Valverde and Fernánde (2007) suggest that an increase in non-interest income reduces lending margins.

The results for *capitalization* are significantly negative pre- and post-crisis, however the negative coefficient size is smaller post-crisis (-53.6) compared to pre-crisis (-24.1). An increase of 100 basis points results in a decrease in lending margins of 24.1 pre-crisis; post-crisis we see 29.5 basis point more decrease in net-margins. This can be because banks with higher *capital* have better credit worthiness which can enable them to have cost funds available at lower costs. So, banks with higher *capital* can

charge lower interest margins. This finding is in line with the findings of and Claeys and Vander Vennet (2004), Wong (1997), Afanasieff et al. (2002), and Brock and Franken (2002) . However, it is in contrast to to theoretical predictions and the findings , which argue that higher *capital* is associated with higher interest rates (McShane and Sharpe, 1985; Hellmann et al., 2000; Claeys and Vander Vennet, 2004). These authors suggest that holding higher *capital* is costly for banks; therefore, to compensate, interest spreads are increased.

The coefficient on *liquidity risk* is positive and significant pre- and post-crisis; however, there is a decrease in the size of coefficient in post-crisis by 6%. This positive relationship is in line with the findings of previous studies (Angbazo, 1997; Afanasieff et al., 2002; Levine, 2003; Drakos, 2003; Doliente, 2005). These authors argue that an decrease in *liquidity risk* will result in lower net margins, while increased *liquidity risk* will increase net margins. The results of the current study contradict the findings of Brock and Franken (2002).

The coefficient on *credit risk* pre- and post-crisis is statistically significant and positive; however, post-crisis it is lower by 2 basis points. An increase of 100 basis point in *credit risk* results in a 9.6 basis point increase in lending margins. This evidence suggests that as the *credit risk* increase banks increase lending margins to compensate for the risk of default; as higher *credit risk* is associated to higher risk of no-repayment. Pre-crisis and post- crisis results indicate a positive relationship, which is in line with the theoretical explanation. This result is in line with the previous findings of Angbazo (1997), Brock and Rojas-Suarez (2000), Drakos (2003), Abreu and Mendes (2003), Gropp (2007), and Valverde and Fernandez (2007).

The coefficient on *interest rate risk* is insignificant pre- and post-crisis. The *market share* coefficient is significantly negative pre-crisis and significantly positive post-crisis. Post-crisis (25.8) the coefficient is 49.7 basis points higher than the pre-crisis (-23.9) and sign is positive instead of negative. Pre-crisis negative relationship provide evidence that pre-crisis banks with large *market share* have economies of scale and they pass down these benefits to customers by reducing lending rates. Post-crisis results show a positive relationship with lending margins and coefficient is 49 basis

points higher, which is in line with the literature. Higher *market share* can be translated as higher market power. According to our results banks with higher market power charge higher lending margins to customers. .

The coefficient on *HHI* is significantly negative pre-crisis and significantly positive post-crisis. Post crisis (16.1) coefficient is positive and it is 31.0 basis point higher than pre-crisis (-14.8). An increase in concentration brings a reduction in lending margins of 14.8 basis points pre-crisis. Pre-crisis findings show a negative relations which suggests that banks are exercising market power to keep the lending margins lower. As Ruthenberg and Elias (1996) argue that in countries with a small number of powerful banks, the large banks could restrict competition by keeping spreads artificially low. Number of other commentators also find a negative relationship between concentration and *HHI* (Rhoades, 1995; Ruthenberg and Elias, 1996; Jackson, 1997; Hannan, 1997; Claeys and Vennet, 2004; Crowley, 2007). Ruthenberg and Elias (1996) argue, large banks in highly concentrated markets can keep the interest rates artificially lower to block entry of new banks into the market. Positive relationship post-crisis between concentration and lending margin is in line with the theory and previous literature. Higher concentration represents lower competition, due to which higher the concentration the higher the lending margins will be

The *inflation* coefficient is insignificant pre-crisis and significantly negative post-crisis. An increase in *inflation* by 100 basis *points* decrease lending margins by 4.5 basis points. Pre-crisis, the ECB uses the PR to target inflation in the economy, and banks follow the rate to set interest rates on lending products. Generally higher inflation is associated to higher interest margins due to the transactions costs. Margins are also raised. Also in times of high inflation and demand more risky borrowers to will enter the market and reduce to the risk of possible defaults bank increase lending margins. Our results are opposite to the theory and against most of the previous literature. The negative relationship between inflation and lending margins can simply be explained by the government intervention and due to unconventional monetary policy. Our results are in contrast to with those of Saunders and Schumacher (2000); Demirguc-Kunt and Huizinga (2000); Boyd et al. (2001); Mendes and Abreu (2003); Demirguc-Kunt and Levine (2005).

The coefficient on *GDP* is insignificant pre-crisis and significantly negative post-crisis. Post-crisis *GDP* is still negative but the coefficient is 87.8 basis points. This result suggests that a *GDP* increase post-crisis is associated with increased competition among banks and a reduction in concentration, resulting in lower lending margins. These results are contrary to the findings of Abreu and Mendes (2003) and Claeys and Vennet (2004), but in line with Levine (2003).

The coefficient on *financial deepening* (*loans-to-GDP ratio)* is significantly negative pre-crisis and post-crisis. An increase in the ratio by 100 basis point increase pre-crisis results in a decrease in lending margins of 27.4 basis points. However, post-crisis loans to *GDP* coefficient is still negative but 46.6 basis points greater than pre-crisis. The ratio indicates an increase in loans relative to economic growth and represents *financial deepening* in the economy. Our results are in line with the literature and theoretical prediction that as the *financial deepening* ratio increases, lending margins will decline. The results are, however, contrary to those of DemirgüÇ-Kunt and Huizinga (2000), Corvoisier and Gropp (2002), More and Nagy (2003).

Regarding the impact of policy rate on lending margins; the policy rates has statistically significant negative effect on lending margins pre-crisis and post-crisis. Lending spreads are estimated to decrease by 15.9 basis points following a 100 basis point increase in *Euribor*. This suggests that lending rates increase by 84.9 basis point, this suggests an almost complete pass-through pre-crisis. The magnitude of impact as measured by the size of the coefficient is higher by 1.3 basis in post-crisis (-14.6) compared to pre-crisis (15.9). Post-crisis the lending rate increases by 86.4 basis point following 100 basis increase in *Euribor*. This suggests that post-crisis pass-through has slightly improved in case of least stressed countries.

Base money coefficient is significantly negative pre-crisis and significantly positive post-crisis. An increase in *base money* pre-crisis results in 11.2 basis point decrease in lending margins. Post-crisis the coefficient on *base money* is positive (25.9) and 13.6 basis point larger than pre-crisis (-11.2). This shows evidence that unconventional monetary policy has been successful in raising and maintaining inflation which lead to demand and increased lending margins. We can see from figure – panel – and

increase in inflation from years 2014 onwards and increase in monetary base in figure—panel from 2014 onwards. We find, therefore, that post-crisis the ECBs non-conventional monetary policy does have a positive effect on lending margins for *HHs*.

5.5.3.2 Pre-Crisis and Post-Crisis Comparison of Lending Margins for *HHs* in Most Stressed EU Countries

Table 5-1: DiD Regression Results for the HH for Least Stressed Countries.

Variables	Coef.	Std. Err.	P-Value	Variables	DiD Coef.	Std. Err.	P-Value
Cons.	14.960***	2.443	0.000	Dummy2	-11.405***	2.682	0.000
Diversification	0.325***	0.069	0.000	PostDiversification	0.714***	0.078	0.000
Capitalization	-0.241**	0.096	0.012	PostCapitalization	-0.295***	0.108	0.007
LiquidityRisk	0.071***	0.013	0.000	PostLiquidityRisk	-0.060***	0.013	0.000
CreditRisk	0.096***	0.033	0.004	PostCreditRisk	-0.002***	0.034	0.004
InterestRateRisk	-0.182	0.603	0.763	PostInterestRateRisk	-0.508	0.791	0.521
MarketShare	-0.239***	0.073	0.001	PostMarketShare	0.497***	0.083	0.000
HHI	-0.148***	0.335	0.000	PostHHI	0.310***	0.437	0.000
Inflation	-0.001	0.011	0.957	PostInflation	-0.045***	0.013	0.000
GDP	-0.035	0.060	0.560	PostGDP	-0.842***	0.075	0.000
FinancialDeepening	-0.274***	0.045	0.000	PostFinancialDeepening	-0.466***	0.052	0.000
Euribor	-0.159***	0.049	0.001	PostEuribor	0.013**	0.064	0.083
BaseMoney	-.112***	0.217	0.000	PostBaseMoney	0.136***	0.229	0.000
Number of obs		1602.000		R-squared		0.705	
F(25, 1576)		150.870		Adj R-squared		0.701	
Prob > F		0.000		Root MSE		0.427	

The stars show the significance level of the coefficients. One * means results are significant at the 10% level; two mean results are significant at the 5% level; and three mean results are significant at the 1%. Did coeff. represents the difference between post crisis and pre-crisis variable.

Table 5-2 shows the pre- and post-crisis results from Equation 5-1 for *HHs* lending margins for most stressed countries. Pre-crisis results show 7 explanatory variables are significant pre-crisis and 10 post-crisis, at least at the 10% significance level.

Pre-crisis, the *diversification* coefficient is insignificantly negative for pre-crisis and its positively significant (44.4) post-crisis. Usually as the banks diversify and other income increases they tend to reduce the interest margins. Post-crisis we find a positive relationship between lending margins and *diversification*; 100 basis point increase in other income increases lending margins by 44.4 basis points. In post-crisis we notice that other income is reducing through-out post-crisis period and lending margins. Hence reduction in other income also leading to reduction in lending margins and vice versa. This suggests that banks in countries which are offsetting the risks of higher risk investments when they invest in nontraditional by increasing the interest margins. This positive relationship is contrary to findings reported in most of the existing literature. In contrast to our findings, DeYoung and Rice (2004) and Valverde and Fernánde (2007) suggest that an increase in non-interest income reduces lending margins.

We find that in the case of *capitalization* the results are significantly negative pre-crisis and significantly positive pre-crisis. An increase of 100 results in a decrease in lending margins of 82.4 pre-crisis; post-crisis we see 154.3 more increase in the coefficient. We can see from figure **Figure 5-6**, Panel B, there is an increasing trend in *capital* and reserves pre-crisis. This can be because banks with higher *capital* have better credit worthiness which can enable them to have cost funds available at lower costs. So, banks with higher *capital* can charge lower interest margins. This finding is in line with the findings of and Claeys and Vander Vennet (2004), Wong (1997), Afanasieff et al. (2002), and Brock and Franken (2002) . However, it is in contrast to to theoretical predictions and the findings , which argue that higher *capital* is associated with higher interest rates (McShane and Sharpe, 1985; Hellmann et al., 2000; Claeys and Vander Vennet, 2004). These authors suggest that holding higher *capital* is costly for banks; therefore, to compensate, interest spreads are increased.

The coefficient on *Liquidity risk* is significant and negative pre-crisis and positive and significant post-crisis. Pre-crisis increase in *liquidity risk* would result in a 25.9 basis point decrease in lending margins. This negative relationship pre-crisis contradicts most of the precious studies. Post-crisis coefficient (3.1) coefficient is positive and increase by 29 basis points compared to pre-crisis coefficient (25.9). This positive relationship is in line with the findings of previous studies (Angbazo, 1997; Afanasieff et al., 2002; Levine, 2003; Drakos, 2003; Doliente, 2005). These authors argue that a decrease in *liquidity risk* will result in lower net margins, while increased *liquidity risk* will increase net margins. The pre-crisis results of the current study contradict the findings of Brock and Franken (2002).

The coefficient on *credit risk* pre-crisis is insignificant; however, post-crisis it is significantly positive. This evidence suggests that post-crisis as the *credit risk* increase banks increase lending margins to compensate for the risk of default; as higher *credit risk* is associated to higher risk of no-repayment. Post-crisis results indicate a positive relationship, which is in line with the theoretical explanation. This result is in line with the previous findings of Angbazo (1997), Brock and Rojas-Suarez (2000), Drakos (2003), Abreu and Mendes (2003), Gropp (2007), and Valverde and Fernandez (2007).

The coefficient on *interest rate risk* is significantly negative pre- but insignificant post-crisis. According to theory higher *interest rate risk* is associated with higher lending margins. Our result is in contrast with theory and with the findings of Gropp et al. (2007).

The *market share* coefficient is significantly positive pre-crisis and significantly negative post-crisis. Post-crisis coefficient (-28.5) is -0.777 basis points lower than the pre-crisis (28.5) and sign is negative instead of positive. Pre-crisis results show a positive relationship with lending margins, which is in line with the literature. Higher *market share* can be translated as higher market power. According to our results banks with higher market power charge higher lending margins to customers. . Post-crisis negative relationship provide evidence that banks with large market shares have economies of scale and they pass down these benefits to customers by reducing

lending rates. This negative relation can also be due to the unconventional monetary policy.

The coefficient on *HHI* is significantly positive pre- and post-crisis. An increase in concentration by 100 basis points brings an increase in lending margins of 26.8 basis points pre-crisis. Post crisis coefficient (45.8) is positive and it is 19.0 higher compared to pre-crisis coefficient (26.8). Positive relationship post-crisis between concentration and lending margin is in line with the theory and previous literature. Which finds a positive relationship between concentration and lending margins. According to this theory markets with higher concentration of banks and lower competition enables them to charge higher prices of loans and increase lending margins.

The *inflation* coefficient is statistically significant and negative pre- and post-crisis. Post-crisis coefficient (-7.4) is 3.16 basis points higher than Pre-crisis (-10.24). Generally higher inflation is associated to higher interest margins due to the transactions costs. Margins are also raised in times of high inflation and demand; when more risky borrowers will enter the market. The risk of default will increase and to compensate for the higher probability of default, bank increase lending margins. Our results are opposite to the theory and against most of the previous literature. The negative relationship between inflation and lending margins can simply be explained by wither the irresponsible lending by the banks. Post crisis the negative sign can be due to unconventional monetary policy. Our results are in contrast to with those of Saunders and Schumacher (2000); Demirguc-Kunt and Huizinga (2000); Boyd et al. (2001); Mendes and Abreu (2003); Demirguc-Kunt and Levine (2005).

The coefficient on *GDP* is significant and negative pre- and post-crisis. Post-crisis coefficient (-33.1) is 88.9 basis higher compared to pre-crisis coefficient (-122). This result suggests that a *GDP* is associated with increased competition among banks and a reduction in concentration, resulting in lower lending margins. These results are contrary to the findings of Abreu and Mendes (2003) and Claeys and Vennet (2004), but in line with Levine (2003).

The coefficient on *loans-to-GDP ratio* is significantly negative pre-crisis and post-crisis. An increase in the ratio by 100 pre-crisis results in a decrease in lending margins of 56.5. However, post-crisis coefficient (-3.79) is 52.7 higher compared to pre-crisis coefficient (-56.5). The ratio indicates an increase in loans relative to economic growth and represents *financial deepening* in the economy. Our results are in line with the literature and theoretical prediction that as the *financial deepening* ratio increases, lending margins will decline. The results are, however, contrary to those of DemirgüÇ-Kunt and Huizinga (2000), Corvoisier and Gropp (2002), More and Nagy (2003).

Regarding the impact of policy rate on lending margins for most stressed countries ; the policy rates has statistically insignificant negative effect on lending margins pre-crisis and post-crisis. Hence we do not find any evidence of pass-through for mostt stressed countries.

The *base money* coefficient is insignificantly negative pre-crisis and significantly positive post-crisis. An increase in *base money* pre-crisis results in 71.7 basis point increase in lending margins. This shows evidence that unconventional monetary policy is successful in increasing the demands of lending activities and raising the lending margins as a result. Post-crisis the coefficient on *base money* is positive and much larger than pre-crisis coefficient. We find, therefore, that post-crisis the ECBs non-conventional monetary policy does have a positive effect on lending margins for *HHs*. We can see from figure – panel – and increase in inflation from years 2014 onwards and increase in monetary base in figure—panel from 2014 onwards. We find, therefore, that post-crisis the ECBs non-conventional monetary policy does have a positive effect on lending margins for *HHs*.

5.6 Conclusion

This paper investigates the determinants of lending margins for *HHs* products for the five least affected and four most affected EU countries by financial crisis. Focusing on bank structural factors, bank-specific characteristics, and macroeconomic factors at country level, the study considers whether there are differences in the determinants of lending margins before and after the crisis period.

Results conclude that post crisis determinants of lending margins have changed. For least stressed countries we find that the sign on coefficient has changed for *market share*, *HHI*, and *base money*. However, for most of the country level bank specific variables i.e., *other income, capitalization, liquidity, risk, credit risk* relationship and sign on coefficient has stayed the same. Also the loans to *GDP* and *Euribor* has stayed the same. On the other hand for most affected countries we find all bank specific determinants at country level all have opposite sign with the coefficient post-crisis. However, the coefficients have stayed the same for Structural (*HHI*) and macrocosmic variables (*Inflation, GDP and financial deepening*). Pre-crisis behavior of determinants between least and most affected is not homogeneous. Only two variables has same relationship with lending margins pre-crisis. However, post-crisis we find majority of the variables are homogeneous among least and most affected variables. We find out of twelve, eight variable show the same relationship. Only *capitalization*, and market share have opposite relationship post-crisis.

For least affected countries pre-crisis most important determinants associated to reduction in lending margins are *capitalization, interest rate risk, financial deepening* and *Euribor*; the ones associated to increase in lending margins is *diversification* into other income. However, post-crisis determinants that cause highest reduction in lending margins are *GDP*, *financial deepening* and *capitalization*. Determinants that are associated to highest increase in the lending margins are *diversification*, *HHI, market share* and *base money*. For most affected countries pre-crisis most important determinants associated to reduction in lending margins are *diversification*, *capitalization, interest rate risk* and *financial deepening*; the ones associated to increase in lending margins is *HHI*. However, post-crisis determinants that cause

highest reduction in lending margins are *GDP* and *market share*. Determinants that are associated to highest increase in the lending margins are *diversification*, *HHI*, *capitalization* and *base money*.

The study finds that least affected countries follow *Euribor* more closely and we find that the pass-through is almost complete and evidence of improved pass-though is found for lending margins during 2008-2017. However, results indicate that the most affected countries don't really follow *Euribor* rate strictly and we found pass-through coefficients insignificant. Evidence is found for both least and most affected countries that unconventional monetary policy is successful in increasing the demands of lending activities; as a result raising the lending margins. Post-crisis the coefficient on *base money* is positive for both least and most affected countries. We find, therefore, that post-crisis the ECBs non-conventional monetary policy does have a positive effect on lending margins for *HHs*. Study also finds that in the case of least affected countries macroeconomic variables are (*inflation*, *GDP*) are insignificant but highly significant post-crisis. Increase in the effectiveness of structural, macroeconomic and monetary policy variable is noted. Similar results are found for most affected countries that the effect size of coefficients for macroeconomic and structural variables have increased post-crisis.

APPENDIX OF FIGURES AND TABLES

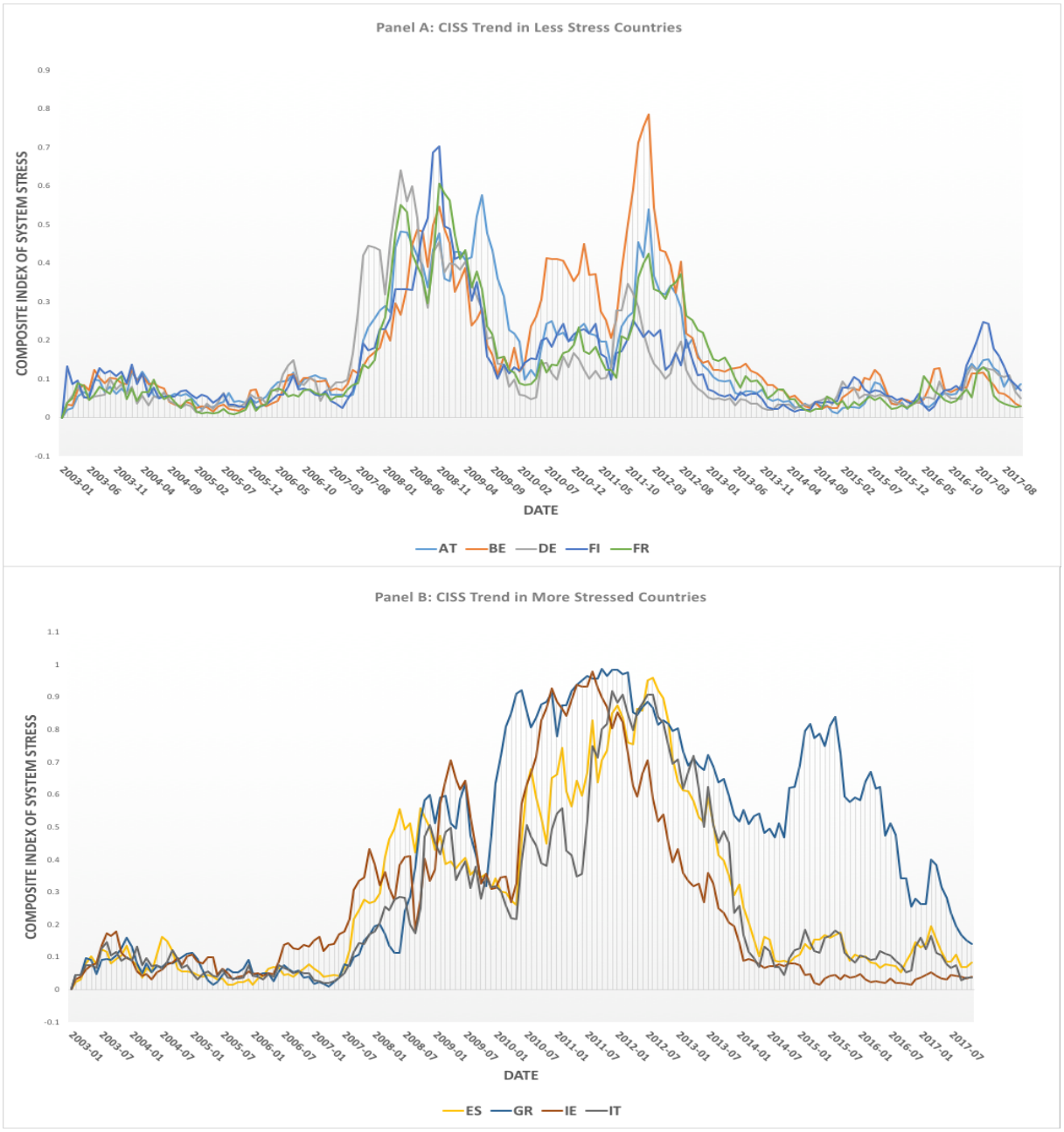

Figure 5-1 Comparison of average lending margins for HHs and NFCs

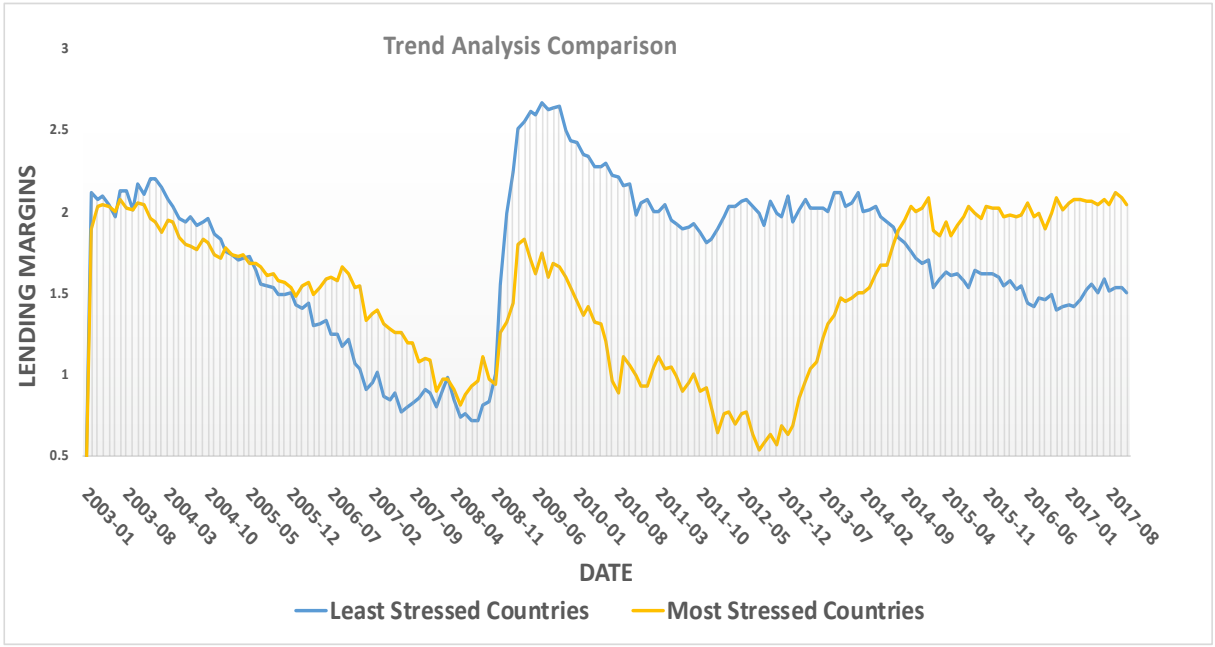

Figure 5-2: Trend analysis of lending margins for least and most affected countries.

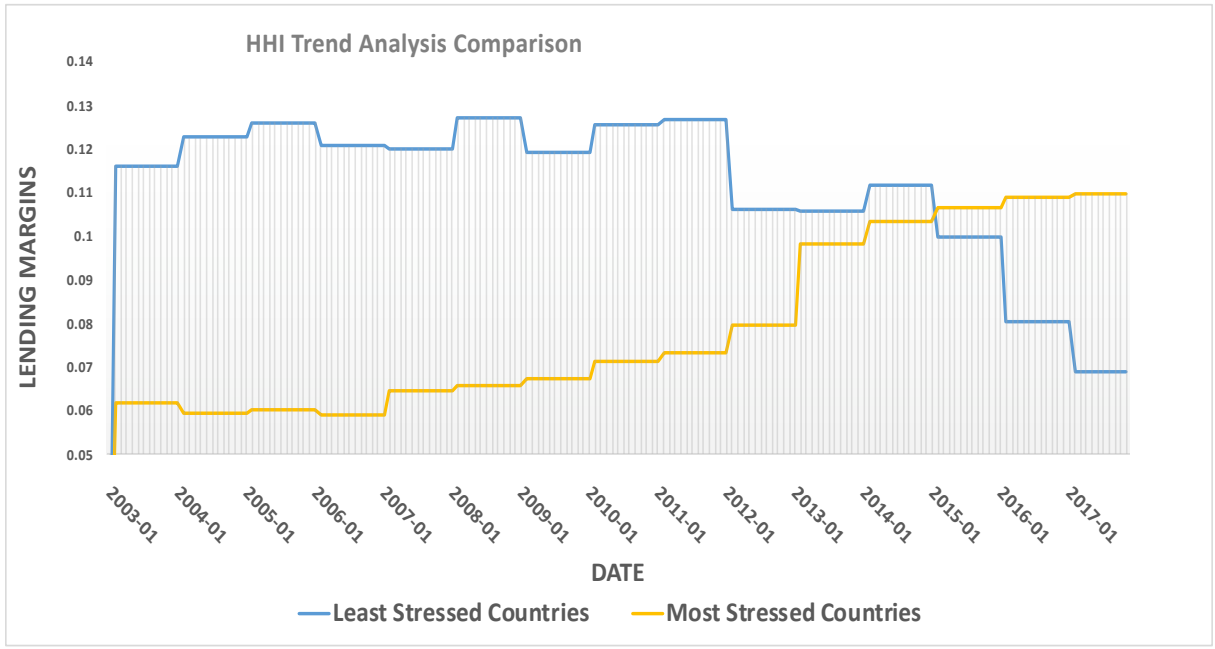

Figure 5-3: Trend analysis of structural variable (competition) for least and most affected countries.

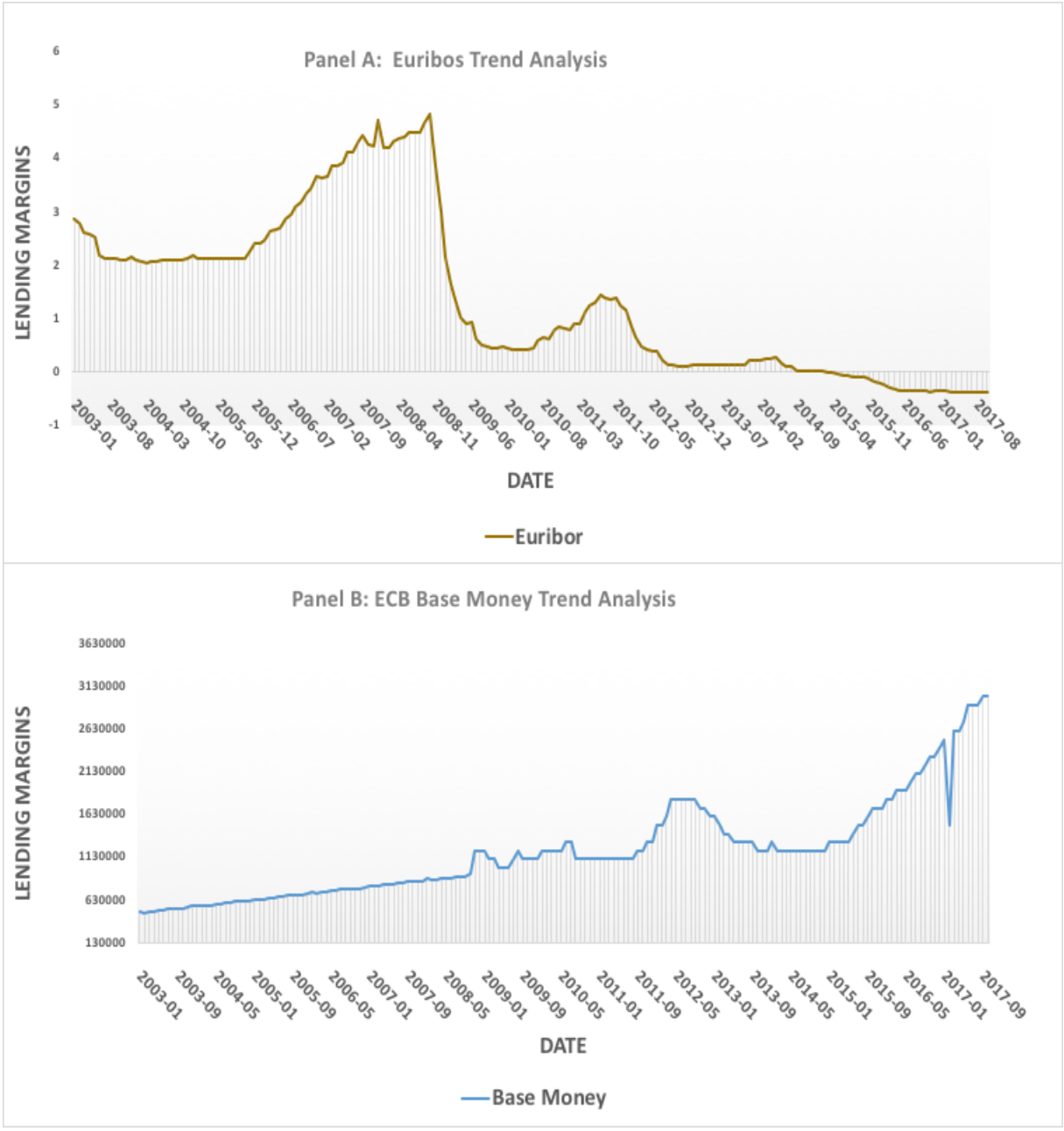

Figure 5-4: Trend analysis of monetary variables for least and most affected countries.

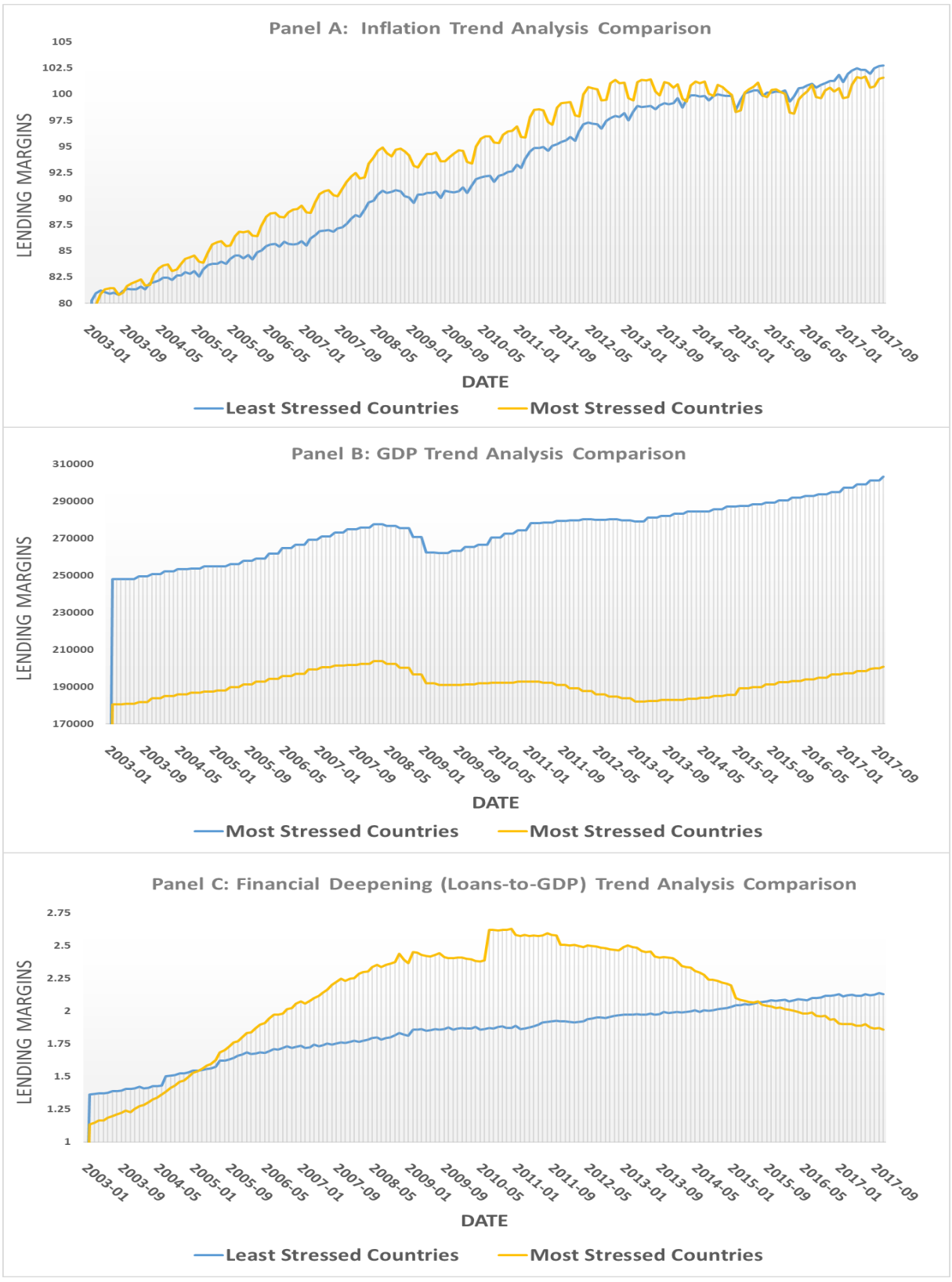

Figure 5-5: Trend analysis of macroeconomic variables for least and most affected countries.

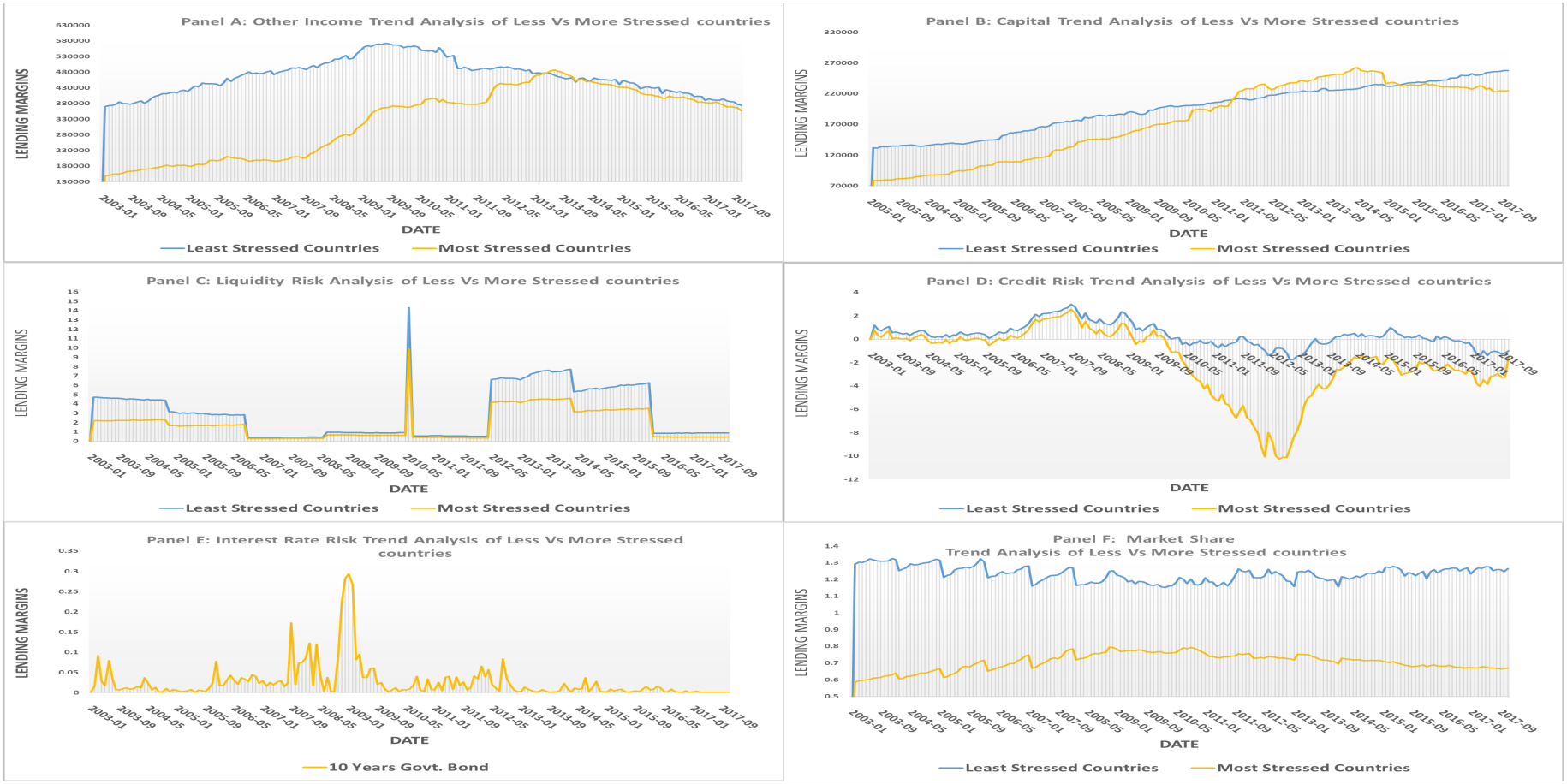

Figure 5-6: Trend analysis of country level bank specific variables for least and most affected countries.

Table 5-1: DiD Regression Results for the HH for Least Stressed Countries.

Variables	Coef.	Std. Err.	P-Value	Variables	DiD Coef.	Std. Err.	P-Value
Cons.	14.960***	2.443	0.000	Dummy2	-11.405***	2.682	0.000
Diversification	0.325***	0.069	0.000	PostDiversification	0.714***	0.078	0.000
Capitalization	-0.241**	0.096	0.012	PostCapitalization	-0.295***	0.108	0.007
LiquidityRisk	0.071***	0.013	0.000	PostLiquidityRisk	-0.060***	0.013	0.000
CreditRisk	0.096***	0.033	0.004	PostCreditRisk	-0.002***	0.034	0.004
InterestRateRisk	-0.182	0.603	0.763	PostInterestRateRisk	-0.508	0.791	0.521
MarketShare	-0.239***	0.073	0.001	PostMarketShare	0.497***	0.083	0.000
HHI	-0.148***	0.335	0.000	PostHHI	0.310***	0.437	0.000
Inflation	-0.001	0.011	0.957	PostInflation	-0.045***	0.013	0.000
GDP	-0.035	0.060	0.560	PostGDP	-0.842***	0.075	0.000
FinancialDeepening	-0.274***	0.045	0.000	PostFinancialDeepening	-0.466***	0.052	0.000
Euribor	-0.159***	0.049	0.001	PostEuribor	0.013**	0.064	0.083
BaseMoney	-.112***	0.217	0.000	PostBaseMoney	0.136***	0.229	0.000
Number of obs		1602.000		R-squared		0.705	
F(25, 1576)		150.870		Adj R-squared		0.701	
Prob > F		0.000		Root MSE		0.427	

The stars show the significance level of the coefficients. One * means results are significant at the 10% level; two mean results are significant at the 5% level; and three mean results are significant at the 1%. Did coeff. represents the difference between post crisis and pre-crisis variable.

Table 5-2: DiD Regression Results for the HH for Most Stressed Countries.

Variables	Coef.	Std. Err.	P-Value	Variables	DiD Coef.	Std. Err.	P-Value
_cons	21.833***	5.295	0.000	dummy2	-32.345***	5.751	0.000
Diversification	-0.629***	0.247	0.005	PostDiversification	1.073***	0.282	0.000
Capitalization	-0.824**	0.330	0.013	PostCapitalization	1.543***	0.360	0.000
LiquidityRisk	-0.259**	0.050	0.013	PostLiquidityRisk	0.290***	0.051	0.000
CreditRisk	-0.056	0.063	0.656	PostCreditRisk	0.162**	0.064	0.011
InterestRateRisk	-0.413***	0.928	0.000	PostInterestRateRisk	-0.329	1.235	0.790
MarketShare	0.491	0.634	0.617	PostMArketShare	-0.777***	0.715	0.000
HHI	0.268	6.827	0.380	PostHHI	0.190***	6.909	0.003
Inflation	-0.102***	0.036	0.000	PostInflation	0.032***	0.037	0.01
GDP	-0.122	0.275	0.694	PostGDP	0.889***	0.526	0.003
FinancialDeepening	-0.565***	0.095	0.000	PostFinancialDeepening	0.185*	0.106	0.081
Euribor	-0.055	0.106	0.799	PostEuribor	0.029	0.125	0.816
BaseMoney	0.370	0.738	0.617	PostBaseMoney	0.347***	0.747	0.001
Number of obs		712.000		R-squared		0.744	
F(25, 686)		79.580		Adj R-squared		0.734	
Prob > F		0.000		Root MSE		0.436	

The stars show the significance level of the coefficients. One * means results are significant at the 10% level; two mean results are significant at the 5% level; and three mean results are significant at the 1%. Did coeff. represents the difference between post crisis and pre-crisis variable.

6 CONCLUSION

6.1 Introduction

This chapter presents the study's key findings, contributions and implications, limitations, recommendations and future objectives. Section 6.2 reports the key findings; Section 0 discusses limitations and makes recommendations; Section 6.4 presents the contributions and implications.

6.2 Key Findings

For mortgage products in the pre-crisis period, the highest short-run adjustment speed per month is on products TR and 2Y-VR, and the lowest adjustment speed per month is on 5Y-FIX and ST-VR. The lowest long-run pass-through (LRPT) is on fixed rate mortgage products: 5Y-FIX, 3Y-FIX and 2Y-FIX. Competition on fixed rate mortgage products is relatively low compared to other mortgage products in the market. We find that the products with the slowest adjustment speed have the highest mark-ups; also, that the *LRPT* or competition among these products is the lowest. On the other hand, the products with the fastest adjustment speed, TR and 2Y-VR, have the lowest mark-ups and highest *LRPT*. The lowest *LRPT* is on fixed rate mortgage products: 5Y-FIX, 3Y-FIX and 2Y-FIX products.

The lending products are also found to have very sticky rates. The adjustment speed per month on CCL, 10K and OD is 5.2%, 3.1% and 8.1%, respectively. All three products have very slow adjustment speed. The time required to reach *LRER* for CCL, 10K and OD is 20, 32 and 12 months, respectively. The *LRPT* on these three credit products is much higher than unity, which signifies overshooting. This scenario can be explained by the asymmetric information costs hypothesis without rationing proposed by De Bondt (2005). CCL has the highest *mark-up* of all lending products, followed by OD.

For deposit products, the highest adjustment speed per month is on BOND, closely followed by INSTANT; the lowest adjustment speed is on ISA, followed by TIME.

The *LRPT* on TIME product is 1.154, which indicates complete pass-through and implies perfect competition in the UK financial market for these products. The *LRPT* for ISA is 1.525, which suggests a very high level of competition for this product in the market. Generally, for ISA and TIME accounts, depositors need to keep their money with the banks for longer periods. Since banks need a solid deposit base, they want to encourage this behaviour, so they all offer attractive deals to gain more customers. This, therefore, could be the reason for higher competition for these products. Pass-through for INSTANT and BOND is partial, which suggests a relatively lower level of competition. Three deposit products show a mark-down and one show a mark-up. The highest mark-down is on TIME, followed by ISA; the smallest mark-down is on INSTANT. These results are consistent with the theory that banks pay lower interest rates than LIBOR on deposits. The *mark-up* for BOND suggests that banks pay higher interest rates on this product in contrast to all other products. This may act as incentive for customers to leave money longer with the banks, as these are fixed rate long-term bonds. Mortgage products have the highest short-term adjustment speed. We also find that the adjustment speed for lending products is marginally slower compared to deposit products.

For mortgage products in the post-crisis period, we find the adjustment speed ranges from 3.7% to 23.6%. The highest speed per month is on products 5Y-FIX and TR, while the slowest speed per month is on 2Y-VR and ST-VR. An increase in adjustment speed is observed post-crisis for the 2Y-FIX, 3Y-FIX and 5Y-FIX products; however, the speed slows on 2Y-FIX and is unchanged for the TR and ST-VR products. The adjustment speed for mortgage products in the post crisis period is higher, at 14.8% per month, compared to 11.2% per month in the period 1999 to 2008. Post-crisis, the decline in LIBOR is substantial, while the subsequent increase is very small. The only two products that seem to follow the LIBOR rate are ST-VR and 2Y-VR, as these are the only two that show positive pass-through. For ST-VR, there is a partial or incomplete pass-through. The products which show negative pass-through their retail interest rates are declining instead of increasing against the direction of LIBOR, means they are moving in the opposite direction. This suggests that the direction of change in retail rates is opposite to the direction of change in LIBOR. The post-crisis changes

in LIBOR are very small, which may indicate that it is not dictating retail rates post-crisis.

In the post-crisis period, there is also a significant increase in the adjustment speed on lending products and retail rates are found to be less sticky. The adjustment speed per month on CCL, 10K and OD is 62.7%, 40.2% and 32.8%, respectively, compared to 5.2%, 3.1% and 8.1% pre-crisis. The average adjustment speed per month pre-crisis for these three products is only 5.5% compared to 45.3% after the crisis. All three lending products show long-run co-movements with LIBOR rates. The *LRPT* values for CCL and OD are much higher than one. Since banks are lending credit products to risky customers as well as low risk borrowers, high mark-ups on CCL and OD imply that banks earn higher revenues on these three products. We find that the *mark-up* has increased significantly on all three lending products. OD has highest *mark-up* of all lending products, followed by CCL and 10K. For deposit products, the highest adjustment speed per month is on ISA and TIME. The slowest speed per month is on INSTANT and BOND, respectively. Post-crisis, the average adjustment speed for all four deposit products is 28% compared to 7.16% pre-crisis. For deposit products, the Wald test finds no co-integration for ISA only. TIME deposits have *LRPT* for the highest of 0.659, which is less than one. For deposit products, the findings are in contrast to those found for the pre-crisis period, as all the products show mark-ups instead of mark-downs. This indicates that banks are paying higher interest rates than LIBOR. This may be because they fear losing their deposit base and are still willing to pay higher rates than LIBOR for their deposit products. In a perfectly competitive market, the marginal costs are equal to marginal rates. Banks seek to keep their depositors and also attract new customers in case of a shortage of liquidity due to the credit crunch. BOND has the highest *mark-up* followed by TIME deposits. Lowest *mark-up* is on INSTANT and ISA products.

In general, the study finds a very slow *SRAS* in UK banking industry pre-crisis for mortgage, lending and deposit products, and the speed is heterogeneous across products. *LRPT* is incomplete for most products. Partially higher pass-through is observed for TR, 2Y-VR and ST-VR products. *LRPT* is greater than one for CCL, 10K and OD, which could be explained by asymmetric information costs without rationing

(de Bondt, 2005). It is complete for TIME deposits, suggesting perfect competition, and pass-through is greater than one for ISA, suggesting availability of substitute products and high competition in the market. Post-crisis, the *SRAS* on all lending and deposit products increases significantly, and average speeds on deposit products are higher than lending products. In the post-crisis period, the *LRPT* for lending products decreases, but increases significantly for deposit products. It is also concluded that margins on lending products increase post-crisis. Traditionally, banks pay lower interest rates on deposit products but post-crisis they are seen to pay higher rates than LIBOR.

In the second paper, the stickiness of interest rate pass-through, competition and existence of the *Law of One Price* are investigated for three types of firm: HSB, BS and SB offering the same products (IAS and MTS accounts). The average *SRAS* for the industry for low, mid and high tier accounts is sluggish and sticky for both IAS and MTS accounts. The findings verify that that price setting behaviour in the UK banking industry is not only sticky but also that inter-bank and intra-bank heterogeneities exist in the short- as well as long-run variables. Results show that heterogeneities for *SRAS* not only exist within different types of firm offering the same products, but also within the same firm offering different products. Moreover, the results of t-tests for intra-bank heterogeneities find that *SRAS* is significantly lower for low tier IAS and MTS accounts than high tier products, confirming the existence of the *tier effect*. The results suggest that the *SRAS* for HSB is above the industry average for IAS and MTS on all deposit tiers. On the other hand, *SRAS* is lowest on SB for both types of product. The results for C_i in the industry as a whole for all IAS deposit tiers reveal that the accounts which have higher C_i also have higher *mark-up* and *SRAS*. For the industry, an increasing trend is found for C_i with an increase in tier size for both products. SB has the highest C_i for both products and HSB the lowest. Results indicate an increasing trend in A_i for all three types of FI and the industry with increases in tier size on both IAS and MTS products. The A_i also varies on all deposit tiers within the same type of firm. However, t-test results for intra-bank heterogeneity do not detect any significant differences among tiers within the same firm type. The

insignificance of t-test results implies that the *Law of One Price* does exist in the UK market for IAS and MTS products.

In the third paper finds that least affected countries follow *Euribor* more closely and we find that the pass-through is almost complete and evidence of improved pass-though is found for lending margins during 2008-2017. However, results indicate that the most affected countries don't really follow *Euribor* rate strictly and we found pass-through coefficients insignificant. Evidence is found for both least and most affected countries that unconventional monetary policy is successful in increasing the demands of lending activities; as a result raising the lending margins. Post-crisis the coefficient on *base money* is positive for both least and most affected countries. We find, therefore, that post-crisis the ECBs non-conventional monetary policy does have a positive effect on lending margins for *HHs*. Study also finds that in the case of least affected countries macroeconomic variables are (*inflation*, *GDP*) are insignificant but highly significant post-crisis. Increase in the effectiveness of structural, macroeconomic and monetary policy variable is noted. Similar results are found for most affected countries that the effect size of coefficients for macroeconomic and structural variables have increased post-crisis.

6.3 Limitation and recommendations

The study covers many financial products offered by the banking industry. However, the use of aggregated data means we fail to capture the whole picture for individual banks. With bank level data, it is possible to achieve a more detailed analysis and examine whether the banks that show co-integration also show higher pass-through, *SRAS*, or below average mark-up. We can find the range of adjustment speed, *mark-up* and *LRPT*. These findings are only possible with bank level data.

In the second paper, bank level data are used to investigate the dynamics of interest rate pass-through and the pricing of IAS and MTS products with low, mid and high tier deposits. Using bank level data, a comparison is made between HSB, BS and SB. However, the limitation of the study is the unavailability of bank level data for credit

products and bank balance sheet data, which did not allow further analysis of the determinants of interest rate pass-through for the UK banking industry.

Lastly, to identify the determinants of interest rate margins pre- and post-crisis, the study uses bank level aggregated harmonised data, available from the ECB SDW. However, availability of dis-aggregated bank level data would remove the aggregation bias.

6.4 Contributions and Implications

To the author's best knowledge, our first paper is the only study which investigates the interest rate pass-through and pricing behaviour of the UK industry for 13 deposit, lending and mortgage products for a longer period before and after the financial crisis. Hence, the study expands the current literature and understanding of pricing behaviour before and after the crisis in the UK banking industry. We find very slow *SRAS* for both deposit and lending products, and *SRAS* is heterogeneous across products. In pre-crisis, more complete pass-through for TR, 2Y-VR and ST-VR products. In addition, *LRPT* is greater than one for CCL, 10K and OD, which could be explained by asymmetric information costs without rationing (de Bondt, 2005). *LRPT* is complete for TIME, suggesting perfect competition, and pass-through is greater than one for ISA, suggesting the availability of substitute products and indicating high competition in the market.

To the author's best knowledge, the second paper is unique in examining bank level data for deposit savings products offered by three types of firms (HSB, BS, SB) over a longer period than previously studied. The analysis provides new insights into pass-through dynamics in the short and long run, identifies inter and intra bank heterogeneities, and tests for the existence of the *Law of One Price* in the UK banking industry. The results verify that that price setting behaviour in the UK banking industry is not only sticky but also that inter-bank and intra-bank heterogeneities exist in the short- and long-run variables. Results show that heterogeneities for *SRAS* not only exist within different types of firm offering the same products, but also within the same firm offering different products.

The third study adds to the literature in following ways: First, we use a large sample harmonised data set for the period of 2003 to 2017. Second, we deepen the understanding of the determinants by looking at the two groups of countries; least affected and most affected by crisis. Third, our study deepens our understanding the differences in determinants in post crisis period for the least affected and most affected countries of EU. If we know the factors that determine or influence the pricing of the interest rate price settings, it can help smoothen and strengthen the monetary policy process.

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APPENDIX :

Table 7-1: Chow test results to determination if the single equation model can be used.

D. TR	Coef.	Std. Err.	P>|t|	D.5Y-FIX	Coef.	Std. Err.	P>|t|	D. 2Y-FIX	Coef.	Std. Err.	P>|t|
TR L1.	-0.320	0.055	0.000	5Y-FIX L1.	-0.017	0.034	0.630	2Y-FIX L1.	-0.035	0.043	0.414
LIBOR L1.	0.255	0.049	0.000	Libor L1	-0.013	0.027	0.633	Libor L1	0.001	0.037	0.984
Dummy	0.026	0.368	0.944	Dummy = 0	0.094	0.288	0.744	Dummy	0.214	0.269	0.427
DL. TR	0.167	0.119	0.162	DL. 5Y-FIX	-0.025	0.059	0.677	DL. 2Y-FIX	-0.056	0.079	0.479
D. Libor	-0.351	0.113	0.002	D. Libor	-0.075	0.073	0.941	D. Libor	-0.103	0.088	0.243
_Cons	0.573	0.140	0.000	_Cons	0.153	0.134	0.258	_Cons	0.177	0.128	0.168
H_0 Hypothesis	H_1 Hypothesis	Chow-test results		H_0 Hypothesis	H_1 Hypothesis	Chow-test results		H_0 Hypothesis	H_1 Hypothesis	Chow-test results	
Dummy = 0	Dummy ≠ 0	F(3, 153)	5.630	Dummy = 0	Dummy ≠ 0	F(3, 153)	0.900	Dummy = 0	Dummy ≠ 0	F(3, 153)	4.630
DL. TR = 0	DL. TR ≠ 0	Chow F-value	0.001	DL. 5Y-FIX = 0	DL. 5Y-FIX ≠ 0	Chow F-value	0.092	DL. 2Y-FIX = 0	DL. 2Y-FIX ≠ 0	Chow F-value	0.234
D. Libor = 0	D. Libor ≠ 0	we reject H0		D. Libor = 0	D. Libor ≠ 0	we reject H0		D. Libor = 0 = 0	D. Libor ≠ 0	we cant reject H0	

The above results are for the following regression equation for the chow test. $\Delta x_t = \alpha_i + \gamma_1 x_{t-1} + \theta_1 y_{t-1} + \beta\ dummy + \gamma_2 Dummy\ x_{t-1} + \theta_2 Dummy\ y_{t-1}$. The chow test results shows if the coefficients in before and after crisis are significantly different or not. If the F value in our chow test is less than 10% tit means we reject null hypothesis it means that coefficients are pre-and post-crisis are significantly different and we cannot use single equation model for our testing.

Table 7-2: : Chow test results to determination if the single equation model can be used

D.2Y-VR-MOR	*Coef.*	*Std. Err.*	*P>|t|*	*D.3Y-FIX-MOR*	*Coef.*	*Std. Err.*	*P>|t|*	*D.ST-VR*	*Coef.*	*Std. Err.*	*P>|t|*
2Y-VR L1.	-0.270	0.053	0.000	3Y-FIX L1.	-0.048	0.042	0.261	ST-VR L1.	-0.453	0.075	0.000
Libor L1	0.228	0.049	0.000	Libor L1	0.000	0.033	0.993	libor L1.	0.401	0.068	0.000
Dummy	0.417	0.254	0.102	Dummy	0.215	0.344	0.533	Dummy	-0.022	0.742	0.977
DL. 2Y-VR	0.072	0.107	0.503	DL. 3Y-FIX	-0.045	0.083	0.593	DL. ST-VR	0.236	0.213	0.268
D. Libor	-0.274	0.113	0.017	D. Libor	-0.132	0.082	0.091	D. Libor	-0.595	0.154	0.000
_Cons	0.214	0.086	0.014	_Cons	0.259	0.149	0.085	_Cons	1.015	0.188	0.000
H_0 Hypothesis	H_1 Hypothesis	Chow-test results		H_0 Hypothesis	H_1 Hypothesis	Chow-test results		H_0 Hypothesis	H_1 Hypothesis	Chow-test results	
Dummy = 0	Dummy ≠ 0	F(3, 153)	7.710	Dummy = 0	Dummy ≠ 0	F(3, 153)	1.740	Dummy = 0	Dummy≠= 0	F(3, 153)	19.030
DL. 2Y-VR	DL. 2Y-VR ≠ 0	Chow F-value	0.000	DL. 3Y-FIX	DL. 3Y-FIX ≠ 0	Chow F-value	0.092	DL. ST-VR	DL. ST-VR ≠ 0	Chow F-value	0.000
D. Libor = 0	D. Libor ≠ 0	we reject H0		D. Libor = 0	D. Libor ≠ 0	we reject H0		D. Libor = 0	D. Libor ≠ 0	we reject H0	

The above results are for the following regression equation for the chow test. $\Delta x_t = \alpha_i + \gamma_1 x_{t-1} + \theta_1 y_{t-1} + \beta\ dummy + \gamma_2 Dummy\, x_{t-1} + \theta_2 Dummy\, y_{t-1}$. The chow test results shows if the coefficients in before and after crisis are significantly different or not. If the F value in our chow test is less than 10% tit means we reject null hypothesis it means that coefficients are pre-and post-crisis are significantly different and we cannot use single equation model for our testing.

Table 7-3: Chow test results to determination if the single equation model can be used

D.CCL	Coef.	Std. Err.	P>|t|	D.10K	Coef.	Std. Err.	P>|t|	D.OD	Coef.	Std. Err.	t	P>|t|
CCL L1.	-0.055	0.012	0.000	10K L1.	-0.027	0.013	0.034	OD L1.	-0.069	0.02338	-2.95	0.004
Libor L1	0.063	0.025	0.013	Libor L1	0.094	0.033	0.005	Libor L1	0.101	0.031129	3.26	0.001
Dummy	-0.024	1.156	0.983	Dummy	0.760	0.651	0.244	Dummy	2.238	2.059006	1.09	0.279
DL. CCL	0.028	0.069	0.691	DL. 10K	-0.033	0.065	0.612	DL. OD	-0.081	0.107262	-0.76	0.449
D. Libor	-0.149	0.088	0.094	D. Libor	-0.092	0.126	0.468	D. Libor	-0.099	0.101064	-0.97	0.331
_Cons	0.564	0.182	0.002	_Cons	-0.230	0.187	0.222	_Cons	0.659	0.293162	2.25	0.026
H_0 Hypothesis	H_1 Hypothesis	Chow-test results		H_0 Hypothesis	H_1 Hypothesis	Chow-test results		H_0 Hypothesis	H_1 Hypothesis	Chow-test results		
Dummy = 0	Dummy ≠ 0	F(3, 153)	3.290	Dummy = 0	Dummy ≠ 0	F(3, 153)	2.400	Dummy = 0	Dummy = 0	F(3, 153)	=	5.13
DL. CCL = 0	DL. CCL ≠ 0	Chow F-value	0.023	DL. 10K= 0	DL. 10K ≠ 0	Chow F-value	0.070	DL. OD = 0	DL. OD ≠ 0	Chow F-value	=	0.0021
D. Libor = 0	D. Libor ≠ 0	we reject H0		D. Libor = 0	D. Libor ≠ 0	D. Libor = 0		D. Libor = 0	D. Libor ≠ 0	we reject H0		

The above results are for the following regression equation for the chow test. $\Delta x_t = \alpha_i + \gamma_1 x_{t-1} + \theta_1 y_{t-1} + \beta\, dummy + \gamma_2 Dummy\, x_{t-1} + \theta_2 Dummy\, y_{t-1}$. The chow test results shows if the coefficients in before and after crisis are significantly different or not. If the F value in our chow test is less than 10% tit means we reject null hypothesis it means that coefficients are pre-and post-crisis are significantly different and we cannot use single equation model for our testing.

Table 7-4: Chow test results to determination if the single equation model can be used

D.INSTANT	Coef.	P>|t|	D.ISADEP	Coef.	P>|t|	D.FRBDEP	Coef.	P>|t|	D.TIME	Coef.	P>|t|
INSTANT L1.	-0.215	0.001	ISADEP L1.	-0.021	0.485	BOND L1.	0.023	0.725	TIME L1.	-0.070	0.220
Libor L1	0.144	0.002	Libor L1	0.036	0.320	Libor L1	-0.053	0.400	Libor L1	0.065	0.230
Dummy	0.438	0.003	Dummy	0.348	0.004	Dummy	0.488	0.317	Dummy	0.447	0.006
DL. INSTANT	-0.016	0.962	DL. ISADEP	-0.187	0.490	DL. BOND	-0.233	0.229	DL. TIME	-0.070	0.457
D. Libor	-0.226	0.005	D. Libor	-0.245	0.268	D. Libor	-0.042	0.094	D. Libor	-0.316	0.001
_Cons	-0.331	0.008	_Cons	-0.110	0.278	_Cons	0.127	0.345	_Cons	-0.125	0.310
H_0 Hypothesis	H_1 Hypothesis	Chow-test results	H_0 Hypothesis	H_1 Hypothesis	Chow-test results	H_0 Hypothesis	H_1 Hypothesis	Chow-test results	H_0 Hypothesis	H_1 Hypothesis	Chow-test results
Dummy = 0	Dummy ≠ 0	F(3,153)=3.770	Dummy = 0	Dummy ≠ 0	F(3,153)=8.550	Dummy = 0	Dummy ≠ 0	F(3,153)=1.330	Dummy = 0	Dummy ≠ 0	F(3,153)=4.140
DL. INSTANT = 0	DL. INSTANT ≠ 0	Chow F-value =0.012	DL. ISADEP = 0	DL. ISADEP ≠ 0	Chowtest F-value =0.000	DL. BOND = 0	DL. BOND ≠ 0	Chowtest F-value =0.087	DL. TIME = 0	DL. TIME ≠ 0	Chowtest F-value =0.007
D. Libor = 0	D. Libor ≠ 0	we reject H0	D. Libor = 0	D. Libor ≠ 0	we reject H0	D. Libor = 0	D. Libor ≠ 0	we reject H0	D. Libor = 0	D. Libor ≠ 0	we reject H0

The above results are for the following regression equation for the chow test. $\Delta x_t = \alpha_i + \gamma_1 x_{t-1} + \theta_1 y_{t-1} + \beta\ dummy + \gamma_2 Dummy\, x_{t-1} + \theta_2 Dummy\, y_{t-1}$. The chow test results shows if the coefficients in before and after crisis are significantly different or not. If the F value in our chow test is less than 10% tit means we reject null hypothesis it means that coefficients are pre-and post-crisis are significantly different and we cannot use single equation model for our testing.