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Abstract

A key feature of the financial crisis was that the cost to banks of unsecured term funding rose sharply relative to expected policy rates and did so heterogeneously across banks. This paper examines the pass-through of bank funding costs to retail loan and deposit rates in the United Kingdom, and how this changed during and after the financial crisis. We estimate separate equations for individual banks and find that the common component of funding costs passes through quickly and completely. But cost changes that are not homogeneous across banks generally exhibit slower pass-through, and are affected by the state of market competition.

Key words: Transmission mechanism, interest rate pass through.

JEL classification: C23, E43, E51, E52.

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1 Introduction

Prior to the global financial crisis that began in mid-2007, banks in the United Kingdom were able to finance new lending by issuing term funding at only a small premium to expected policy rates, despite high levels of leverage. And intense competition meant that they were willing to lend to good quality customers at only a small premium to those rates. In these circumstances, a change in Bank Rate was transmitted fully to the interest rates affecting households and businesses.

But the financial crisis had profound effects on the provision of credit to households and businesses in the United Kingdom. The cost to banks of raising unsecured funding rose sharply relative to expected policy rates and became very heterogeneous over a prolonged period (Beau *et al*, 2014). This marked a significant break from the earlier 'age of innocence'.[1] At the same time the financial crisis resulted in a significant increase in the concentration of the UK banking sector as a number of banks either went out of business (e.g. Northern Rock) or were absorbed into larger groups (e.g. HBOS was taken over by Lloyds TSB). Following the crisis, around 75% of the stock of UK mortgage lending was accounted for by 6 major banks, namely Banco Santander, Barclays, HSBC, Lloyds Banking Group, Nationwide and Royal Bank of Scotland.

The shock to bank funding costs and the reduction in banking sector competition had a range of consequences. In particular, the rates at which banks were willing to lend on new business to good quality customers rose sharply relative to expected policy rates. And banks were unwilling to lend at all to some borrowers with high risk characteristics. In addition, banks were prepared to pay more to attract retail deposits such that spreads over expected policy rates became positive. As such the transmission mechanism of monetary policy appeared to become impaired as the rates affecting households and businesses no longer tracked changes in policy rates.

In order to mitigate the effects of the financial crisis, Bank Rate was reduced in March 2009 to 0.5%, its effective lower bound at the time. The spread that had opened up between retail rates and policy rates remained evident, however. Two related facts suggested that the health of the banking sector itself was the source of this impairment of the transmission mechanism, rather than any change in consumer behaviour associated with the effective lower bound. First, was that even though Bank Rate was cut to 0.5%, fixed-rate mortgage rates and deposit rates remained firmly in positive territory, well above the lower bound. And second, this change in

[1] 'The age of innocence – when banks lent to each other unsecured for three months or longer at only a small premium to expected policy rates – will not quickly, if ever, return.' King (2008)

pricing behaviour occurred in advance of the first cut in Bank Rate. Partly to address these developments, the Bank of England operated a number of schemes at different times to ensure that solvent banks could continue to obtain funding under difficult market conditions. These included the Special Liquidity Scheme (SLS), the Credit Guarantee Scheme (CGS) and the Funding for Lending Scheme (FLS).

The primary purpose of this paper is to examine the determinants of interest rates on new loans and deposits in the United Kingdom over a period that includes the financial crisis and its aftermath. In a highly concentrated banking sector the aggregate impact of such a credit supply shock can be affected by how individual banks respond to the circumstances they face. In this paper, we investigate the pricing of loans and deposits by each of the largest six major banks and examine how their pricing was affected by the behaviour of their rivals.[2]

Much of the academic literature on how banks set interest rates was developed before the financial crisis and based on variations of the Monti-Klein framework (Monti, 1971, Klein, 1971). One strand of the literature was concerned with the monetary transmission mechanism and focused on the speed and extent of pass-through from policy rates to loan and deposit rates,[3] while another strand took an industrial organisation (IO) perspective and examined the determinants of mark ups over costs.[4]

Given the close relationship between bank funding costs and official interest rates that prevailed before the financial crisis the literature was able to ignore the impact of funding spreads on loan and deposit rates faced by households. More recently, a number of empirical papers have used the Monti-Klein framework to investigate how loan and deposit rates in a range of countries have been set since the financial crisis.[5] While all take account of shifts in the interbank cost of funding common to all banks, few of these papers make allowance for the bank-specific cost of obtaining term funding. And we are not aware of any papers that estimate the loan and deposit pricing among individual lenders over this period.

This paper therefore contributes to this literature by examining the determination of the pricing of new loans and deposits in the United Kingdom on a bank-by-bank basis using a sample period covering the financial crisis. A key contribution of the paper is to distinguish between

[2] Darracq Paries *et al* (2014) investigate a similar question for individual countries in the euro area.
[3] See Hoffman & Mizen (2004), De Graeve *et al* (2007), Fuertes & Heffernan (2009)
[4] See Gambacorta (2008)
[5] See Raknerud & Vatne (2012), Rogers (2013)

the common and idiosyncratic costs of funding for individual banks. As in the earlier literature we find evidence of full and rapid pass-through from expected policy rate changes to loan and deposit rates. But there is also evidence of substantial differences in pass-through of other components of bank funding costs that appear to reflect different behaviour across banks during the financial crisis. The evidence of heterogeneity in bank behaviour suggests that purely aggregate analysis of this issue that does not take account of the different circumstances of individual banks could be misleading.

This paper is organised as follows. Section 2 motivates the empirical strategy by setting out a simple partial equilibrium example of how banks set loan and deposit rates in a concentrated banking system. It also outlines the costs that banks face in raising term funding and describes how this changed for different banks over the financial crisis. Section 3 describes the evolution of the data we use in estimation. Section 4 sets out our empirical methodology. Section 5 presents our findings on pass-through of wholesale costs to loan and deposit rates. Section 6 uses the estimated relationships to assess the effect of the Funding for Lending Scheme on loan and deposit rates over and above its effect on bank wholesale funding costs. Section 7 concludes.

2 Optimal price setting in theory and in practice

This section motivates the empirical part of the paper by examining loan price setting in the context of an individual bank in a highly stylised market. It builds on a standard implication of the Monti-Klein model that, under certain conditions, a bank's decisions about the optimal pricing of its loans is separable from the optimal pricing of its deposits. When, for example, a bank can borrow as much as it likes at an exogenously given rate of interest in the interbank market, then its optimal lending rate is determined by this rate, provided it is not too high, and not by the interest rate it pays on retail deposits. If it could attract retail deposits at a marginal cost far lower than the interbank rate, perhaps because it has an extensive branch network, then optimally it would take up those funds and place them on deposit in the inter-bank market, and decide separately on the rate at which it wishes to lend.

We first show how in theory, in the simplest possible partial equilibrium example, a bank sets its loan rates as a mark-up over its exogenously given marginal costs – the rate available in the interbank market. But, in a relatively concentrated banking system such as the one that prevails in the United Kingdom, banks' demand conditions are likely to depend on the rates set by their competitors. Once we allow banks to respond to their competitors' rates, we show that the optimal size of their mark-up depends on those competitor rates. Since competitors' loan rates are themselves driven by competitors' funding costs, this implies that pass-through of changes in costs depend on how correlated they are between competitive banks. We go on to describe how banks' operational set-up allows them to determine marginal costs in practice, and also separately to decide on their optimal mark-up.

2.1 Competition between banks – linear two bank example

We sketch a two bank, static example, based on a simple Monti-Klein framework.[6] Assuming two banks, with linear loan demand functions given by:

$$L_1 = a - \beta r_1 + \gamma r_2 \tag{1}$$
$$L_2 = a - \beta r_2 + \gamma r_1 \tag{2}$$

where a, β and γ are positive constants and r is the interest rate charged on new loans by each bank. Bank 1 makes profits on its new loans of

$$\Pi_1 = L_1 r_1 - L_1 MC_1 - FC_1, \tag{3}$$

where MC and FC refer to marginal and fixed costs. The bank's optimal funding mix and its associated costs are assumed to be determined independently of its loan pricing decision, so these are treated as exogenous. This assumption is discussed in more detail below. Substituting (1) into (3) gives:

$$\Pi_1 = (a - \beta r_1 + \gamma r_2)(r_1 - MC_1) - FC_1. \tag{4}$$

The bank maximises (4) with respect to its own rate, giving the equilibrium equation (5), conditional on its competitor's rate, and assuming the mark-up is high enough to cover fixed costs:

$$r_1 = \frac{1}{2\beta}(a + \beta MC_1 + \gamma r_2). \tag{5}$$

[6] See Freixas and Rochet (1997) for a full discussion of the standard Monti-Klein type model.

The first two terms of the equation represent the pricing decision of a monopolist bank ($\gamma = 0$) – it sets its loan rate as a mark-up over its marginal cost. But the final term represents the 'competition effect' as the bank responds to its rivals. If marginal costs are positively correlated across banks, and the data strongly suggest they are, excluding this competition effect from our empirical specification would result in it being captured in a higher β coefficient. In other words, banks' responses to changes in their costs are partly reflective of a competitive response to changes in their rivals' prices. Price-setting behaviour by banks also implies that the interest rates they charge should be positively correlated, which is indeed what we observe in the UK data.

The banks' fixed costs do not affect their profit maximising interest rates, since these are independent of the quantity of loans made. This suggests that a bank's 'back book' of loans and deposits made in earlier periods would only optimally affect offered interest rates if they affect the marginal cost of new lending. The back book may affect the cost of new lending either because some assets and liabilities are due to mature, and therefore to re-price, in the current period; or alternatively because realised profits or losses from the bank's existing stock of assets may affect its cost of funding today. Fixed costs may also affect a bank's current decisions if they are large enough that new lending becomes loss making at any interest rate. But in that case the bank would optimally choose to stop all new lending, and in the long-run, to shut-down.

If bank 1 were too small to impact its rivals' demand, (5) would be the behavioural equation it would use to set its interest rate optimally. If it is large, however, it cannot take r_2 as given since its competitor would be expected to react to any changes in bank 1's loan rate.

Solving a symmetric equation (5) for bank 2 would give

$$r_2 = \frac{1}{2\beta}\left(a + \beta MC_2 + \gamma r_1\right). \qquad (6)$$

which endogenously depends on r_1 as long as γ is non-zero. In this simple case, solving the simultaneous equations (5) and (6) to give the Nash equilibrium interest rate for bank 1 purely in terms of the marginal costs of bank 1 and bank 2:

$$r_1 = \frac{1}{2\beta - \gamma}\left(a \; + \; \beta\,\frac{2\beta MC_1 + \gamma MC_2}{2\beta + \gamma}\right). \qquad (7)$$

Competition has two effects on cost pass-through in equation (7) if γ is strictly positive. First, there is a larger multiplier effect from changes in costs when banks react to changes in others' loan rates. A fall in bank 1's costs leading it to cut its interest rate will result in bank 2 also cutting its rate at the expense of a lower mark-up, in order to preserve some of its market share. The larger multiplier effect comes about because bank 1 will also consider that response in its own decision, cutting rates by more than it would with no competitor.

Second, and most relevant for our empirical strategy, the marginal costs relevant to an individual bank are not only its own: in this simple example its rate instead depends on a weighted average of its own and other banks' marginal costs. When costs are similar across banks, as they were prior to the crisis, the distinction between different banks' costs is of less interest. But in the post-crisis period, when costs became more heterogeneous, the model implies that low cost banks would be expected to price up closer to the rates charged by their competitors. Symmetrically, we would expect high cost banks to be forced to reduce their mark-ups in order to retain their optimal market share.

As well as being important for the level of loan rates, competitors' costs also matter for pass-through of changes in a bank's own cost. This pass-through may vary, depending on whether the change is correlated with changes in other banks' costs. The change in the lending rate from a ***common*** change in marginal costs is given by:

$$\frac{dr_1}{dMC_1{,}MC_2} = \frac{\beta}{2\beta - \gamma}; \qquad (8)$$

and the change in the rate from an ***idiosyncratic*** change in 1's marginal costs given by

$$\frac{dr_1}{dMC_1} = \frac{\beta}{2\beta - \gamma}\,\frac{2\beta}{2\beta + \gamma}, \qquad (9)$$

which is smaller than that from the common change.

Another key implication of this simple stylised example is therefore that pass-through is greater for correlated changes in marginal costs than idiosyncratic changes.

Which funding source determines the marginal cost?

The above discussion assumes that marginal costs are exogenously given. That assumption follows from the implications of a standard Monti-Klein model, where the bank is a price taker in one of its available funding markets. Given that assumption, deposit pricing is completely symmetric to the results described for a model of loan pricing: deposits are priced as a mark-down on the exogenous marginal cost of the funding source where the bank acts as a price-taker. Pass-through of changes in that marginal cost is again greater if those changes are correlated across banks.

The assumption of separability between loan and deposit markets is valid as long as the bank is a price-taker in wholesale funding markets, and as long as the cost of funding in those markets is not too high. To illustrate (assuming for simplicity no competition), assume a bank faces the deposit supply curve:

$$D = d + er_d \tag{10}$$

But can alternatively fund itself in wholesale markets at a constant marginal cost *MC*. Given the supply curve (10), it then chooses D to minimise total cost:

$$C = D\left(\frac{D-d}{e}\right) + (L-D)MC + FC \tag{11}$$

It does so by equating the marginal cost of deposit funding ($\frac{2D-d}{e} = \frac{d}{e} + 2r_d$), to the marginal cost of wholesale funding. This gives an optimal deposit rate that is a mark-down on the wholesale marginal cost.

$$r_d = \frac{1}{2e}(eMC - d), \tag{12}$$

To the extent that banks have pricing power in deposit markets, we might expect their equilibrium deposit rates to be lower than the cost of market-based funding sources. This is because obtaining an extra unit of deposit funding incurs both the cost of paying r_d on the extra deposits, as well as the increased cost on infra-marginal deposits, $(\frac{d}{e} + r_d)$. The marginal cost of deposits is therefore likely to be higher than the rate observed on the stock. One implication of this simple analysis is that the observation that a bank's retail deposit rates are lower than its wholesale funding costs does not necessarily mean that it can fund itself more cheaply by increasing the share of its funding that comes from retail sources.

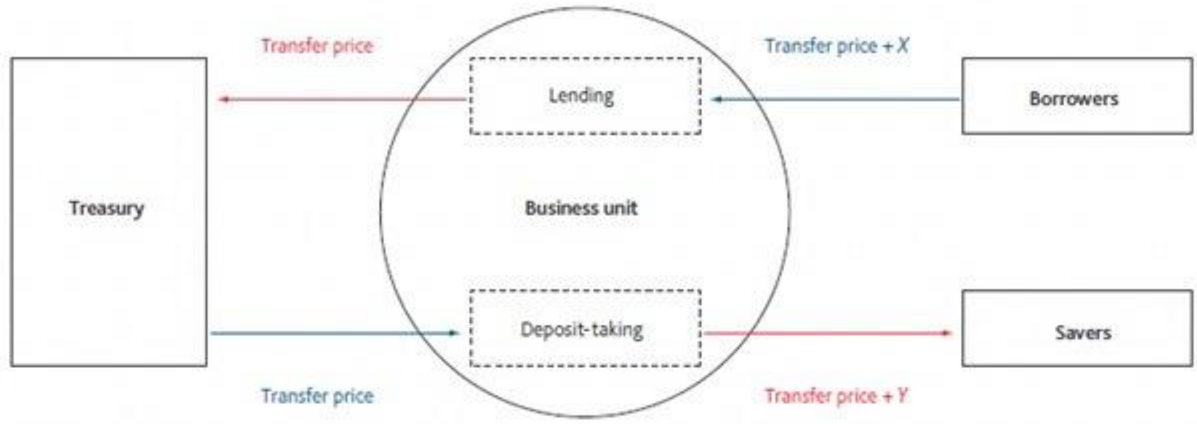
2.2 Price setting and marginal costs in practice

Although it is highly stylised, the simple description in the previous section closely resembles how banks price loans (and deposits) in practice where banks use a 'transfer pricing framework'. This is illustrated for an individual bank in Figure 1, from Button *et al* (2010), which describes transfer pricing in more detail. There are three key players in this framework: the bank's treasury, the bank's business unit and its customers. The decision by a bank to extend loans or raise retail deposits is made by its retail business unit. In principle, the business unit could use its own deposits to fund its loans – this may be the business model for a small independent bank, for example. However the larger banks which dominate the UK banking sector prefer to centralise their funding needs over their entire balance sheet in a treasury unit.

Funding via a treasury allows the individual business units to pool resources and insulate themselves against local shocks to funding or lending demand. The treasury can also make use of market funding to optimise across funding sources, by issuing debt and equity instruments to investors in wholesale funding markets. Given its cost of raising funding, the treasury sets a 'transfer price', at which the business unit can obtain funds from the treasury and at which it is remunerated on its own deposits supplied to the treasury. In steady state, this transfer price would be expected to equal to the marginal cost of raising funds. Banks are close to price takers in wholesale funding markets, so as long as it is not prohibitively high, the cost of wholesale funding should tie down the transfer price they pass on to the business unit for both loans and deposits in accordance with the Monti-Klein approach. This is indeed what we often observe in practice: many banks use the prevailing market price of their long-term wholesale debt as a proxy for their current cost of issuing new debt. In turn they use this cost as the basis for their transfer price.

As Figure 1 shows, the rate a bank actually charges on its new loans will be above the transfer price, or marginal cost of debt funding. For new deposit rates the rate offered will usually be lower. This reflects two factors: first, that there are other components of marginal costs faced by business units; and second, the optimal mark-ups banks choose.

Figure 1: Transfer pricing framework (from Button *et al* (2010))[(a)]



(a) A blue arrow indicates the rate at which the business unit is remunerated for lending funds to the treasury and to borrowers. A red arrow indicates the rate at which the business unit pays to borrow funds from the treasury or savers.

Other components of marginal costs

In addition to debt and deposit funding, banks fund themselves partly with equity, even though it is typically perceived to be more costly than debt funding.[7] They do so, either through choice or due to regulatory requirements, to cushion themselves against the risk of becoming insolvent if they suffer unexpected losses greater than the mean expectation of losses that would be priced into a loan. As a result, banks tend to factor in this cost of raising equity (also known as the ‘capital charge’) when setting the price for new lending. This cost tends to be higher for loans associated with greater risk or loans that are assigned higher risk weights. For instance, unsecured loans have higher risk-weights than mortgages as they are associated with higher unexpected credit losses.

For new lending rates, the business unit’s marginal costs on a new loan would also include any expected losses from the possibility of that loan defaulting. The business unit also takes account of the marginal operating cost of making a new loan, including factors like advertising and any marginal costs arising from its branch network.

[7] Equity investors typically demand a higher return than debt investors or depositors due to the presence of various financial frictions such as deposit guarantees or the preferential treatment of debt in the tax system. For more on these frictions, see Harimohan and Nelson (2014).

On the deposit side, the marginal cost of retail deposits will also include any marginal operating costs. In addition, banks choose to make some of their profits by running a maturity mismatch – lending long and borrowing short – so there will be an additional marginal cost to the bank of mitigating the associated liquidity risks. This could be thought of either of the opportunity cost of holding low-yielding liquid assets like government bonds or central bank reserves, or alternatively as the extra cost of paying higher rates on maturity-matched liabilities, such as term deposits.

Mark-ups

As well as other components of marginal cost, the rate on loans and deposits will also differ from the cost of debt funding as banks will not necessarily price at marginal cost. As equation (6) shows, banks will optimally set loan rates with a mark-up. Correspondingly, as shown by equation (12), deposit rates will be set with a mark-down over their marginal cost. But given competition, they will also take into account the rates charged by their competitor banks (equation (6)), or in equilibrium the marginal cost of their competitors (equation (7)). This type of retail-rate pricing behaviour is discussed in more detail in Cadamagnani *et al* (2015).

3 Data description

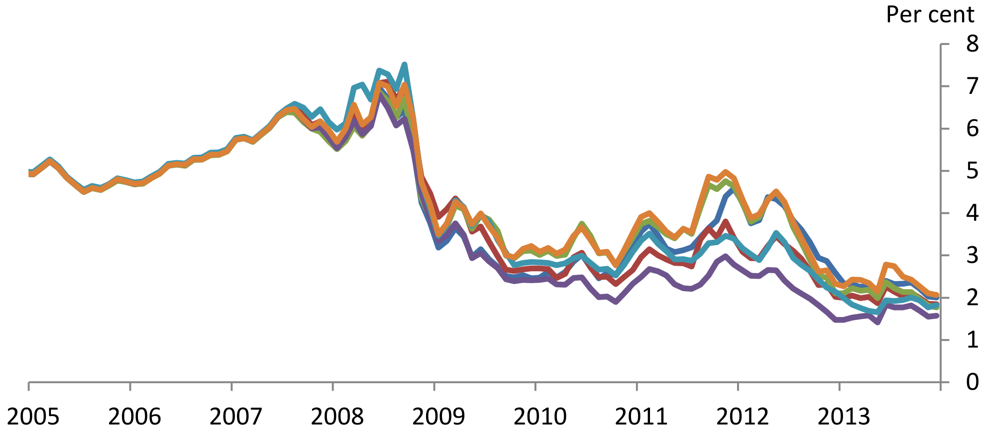
In this section we describe the key data series we use and how these evolved over the financial crisis.

Bank funding costs

The global financial crisis was triggered by emerging losses in the US sub-prime mortgage market. This intensified on 9th August 2007 when BNP Paribas suspended calculation of asset values of three money market funds exposed to sub-prime loans and halted redemptions. The immediate effect of this was that many banks could not securitise assets or roll over borrowing in wholesale markets. This affected some banks more than others and contributed to the high profile run on Northern Rock by retail depositors. Widespread nervousness about the true liquidity and capital positions of banks in general meant that the funding costs of lenders in the United Kingdom rose markedly relative to Bank Rate. That made it more expensive for them to fund the loans and facilities to which they were already committed and made it more expensive for them to fund new loans.

Chart 1 shows one of the measures of bank term funding costs we use in this paper: the two-year cost of wholesale bank funding, proxied by the LIBOR swap rate, plus the credit default swap (CDS) premium, the cost of insuring against a bank defaulting on its senior unsecured debt. This is plotted for each of the main banking groups. Prior to the financial crisis, the cost of term funding was almost identical for all of the major lenders (as Chart 1 shows) and only a little higher than Bank Rate. After the crisis, bank funding costs were often significantly higher than Bank Rate, and very heterogeneous reflecting investors' perceptions of the relative riskiness of these banks' assets. By late 2013, bank funding costs had again largely converged across banks on this measure, reflecting investors' perception that banks' senior unsecured debt securities had again become relatively safe assets.

Chart 1: Evolution of bank funding costs*



* 2yr swap rate + CDS premiums

A key contribution of our paper to the literature is to distinguish between the common and idiosyncratic components of our measure of banks' marginal funding costs. We capture the common component of banks' marginal funding costs partly using LIBOR swap rates, which are benchmark rates used in a wide range of market prices. They represent the cost an average bank has to pay to borrow unsecured and make its floating-rate repayments using its fixed rate income, swapped into floating rates. Swap rates largely consist of the maturity-matched risk-free rate, so depend mostly on the expected path of Bank Rate. The remainder of the funding cost is driven by investors' perceptions of bank-specific credit risk over the term of the loan for which the bank requires funding, for which we use CDS premiums as our proxy for wholesale funding spreads. Any changes in the idiosyncratic component of funding costs will be captured by changes in banks' relative credit risk, and thus their CDS premiums. Although our measure is correlated across banks, so that there will also be a common component of CDS premiums, there has been significant heterogeneity in funding costs in the post-crisis period, reflecting market perceptions of banks' relative riskiness.

An alternative measure of wholesale funding spreads is the secondary market unsecured bond spread. Any differences between these spreads and CDS premiums should create an arbitrage opportunity for investors, given the price of both measures is closely related to the default risk of the bank. So while in principle both measures should be very similar, in practice there have been periods where such arbitrage has been limited, in which case we would typically prefer to use banks' actual funding spreads, which more closely represent the actual cost that banks face when they raise wholesale funding. But these data are not available on a consistent, constant-maturity basis and are only available to us from the start of 2009. In contrast, consistent time-series data for CDS premiums are readily available from 2005 onwards. In our baseline specification in the next section, we therefore use CDS premiums as our primary proxy of banks' marginal funding costs. But to make sure our estimation is robust to this choice, we have also constructed an indicative measure of unsecured bond spreads using secondary market spreads for five-year euro senior unsecured bonds, where available.[8] To construct a longer time series we have spliced CDS data to the unsecured bond series prior to 2009. With the exception of the 2011-13 period, the two series have tracked each other closely, so unsurprisingly, the regression results look similar.

We assume that a bank's marginal funding cost at any date is captured by our proxy for the cost of wholesale term funding. The model described in the previous section explains how exogenously given marginal funding costs, determined in the wholesale markets in which banks are price takers, should determine the cost they are willing to pay for alternative sources of funding, including retail deposits. There are challenges to this assumption in practice, however.

First, some banks may optimally choose to fund themselves entirely through retail funding, or face limits on the proportion of their liabilities accounted for by wholesale funding, perhaps limiting the importance of wholesale funding costs. But for much of our sample period, most of the major banks had large 'customer funding gaps', suggesting that they had chosen to access wholesale funding markets in order to finance their lending and had a continuing need for wholesale funding.

Second, some banks' business models may have been such that they faced tight limits on the amount of wholesale funding they would use, meaning that the separability assumption of the Monti-Klein model no longer holds and that deposit rates were important in determining lending rates. However even if this has been the case, banks' wholesale funding rates have broadly

[8] Where a five-year bond is unavailable, a proxy based on the nearest maturity of bond available is used.

tracked retail bond spreads over our sample period. Wholesale funding rates should still therefore provide a reasonable proxy for marginal funding costs even for those banks that would not increase their usage of wholesale funding at any cost.

Finally, even though the Monti-Klein model predicts that the marginal funding cost should be determined in the market where banks act as price takers; there are several different types of market funding for which this is the case. We opt to use senior unsecured debt partly as it has been a key source of term funding for many banks over our sample period.[9] As a result, banks have tended to use senior unsecured bond spreads as a starting point for calculating their transfer price. Alternative methods of funding, such as covered bonds, come with hidden extra opportunity costs of the assets used to back them, which would not be captured in their market prices. In practice, the 'all-in' cost of covered bonds, including the cost of encumbering assets to back them, is much higher than the simple yield.

Other components of bank funding costs

In this paper the only component of marginal costs we include explicitly in our estimation is a measure of the marginal debt funding cost. Implicitly, the additional cost of equity, the expected loss per loan from default and marginal operating costs are all included in the constant term in our estimated results. These omitted variables are unlikely to bias our results, however, because in our estimation we focus on low-risk, 75% loan-to-value (LTV) loans where the equity cost and expected loss components are quantitatively very small. Marginal operating costs are more difficult to quantify, but it seems unlikely that these have changed significantly over our sample period, so again their omission is unlikely to bias the results.

Bank loan and deposit rates

We use a disaggregated dataset, containing monthly data on household lending and deposit rates for 6 major UK banks.[10] The key advantage of using individual data for each of the six banks is that this allows us to examine the differences in pass-through behaviour across banks and the extent of strategic interaction. These banks represent a large proportion of the total UK banking system's total stock of mortgages and deposits over our sample period.

[9] This is true despite an increase in banks' reliance on other sources of funding such as covered bonds and secured funding in general.
[10] Where banks have undergone mergers during our sample period, we use data from one of the pre-merger banks for the earlier part of the sample.

In this paper we focus our analysis on one representative product each for mortgages and deposits: the 2 year 75% LTV fixed mortgage rate and the 1 year fixed retail bond rate – two of the most popular products in their respective market segments. From a data perspective, they have the advantage that consistent interest rate data is available for these products going back prior to the financial crisis.[11] These rates are selected from a sample of advertised rates on *Moneyfacts*, a financial publication that provides rate and product information for mortgages, unsecured loans and deposits.[12]

Chart 2: Swathe of 2yr 75% LTV fixed mortgage rates

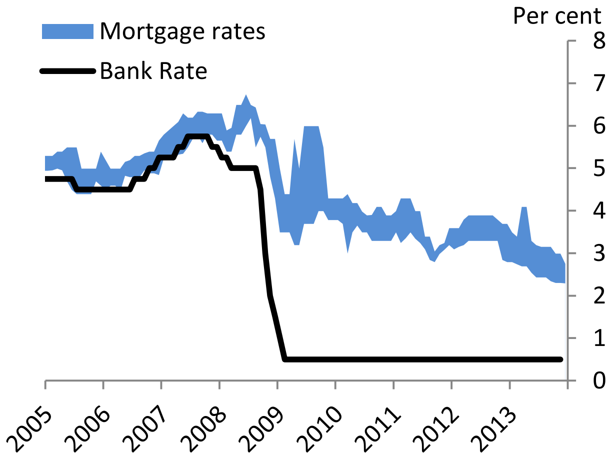
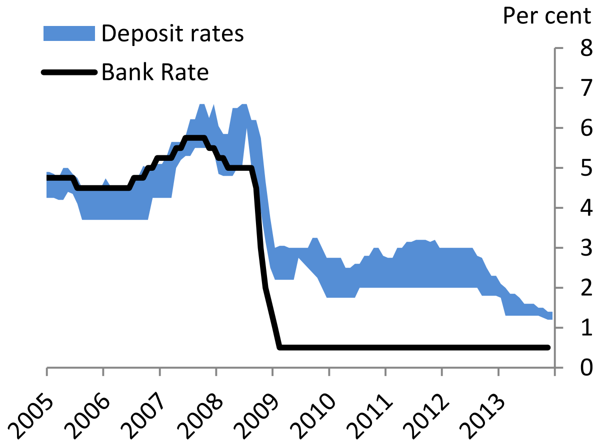


Chart 3: Swathe of 1yr fixed deposit rates



We use <u>quoted</u> lending/deposit rates (Charts 2 and 3) rather than the '<u>effective</u>' rates that record the average rates at which transactions take place (Charts 5 and 6 in Annex A). Using quoted rates allows us to control for unobservable changes in borrower credit quality over time, or across banks. If there is variation over time or across banks in borrower credit quality, this may lead to banks charging a different interest rate in order to maintain the same expected return on the loan. This leads to differences in the effective rates charged unrelated to exogenous changes in the bank's own costs or mark-ups, or those of its competitors. As quoted rates are offered before finding out detailed borrower characteristics, they control for such variables.

[11] Where a 2 year 75% LTV rate was unavailable for a given bank, either because that bank offered a slightly different product or where they temporarily discontinued a product, we use data on the most comparable mortgage rate – e.g. a 75% LTV rate with different terms, or if none were offered, a rate with a slightly different LTV. On the few occasions when no comparable mortgage/deposit product was offered and the product was then reintroduced at a worse rate, we linearly interpolated for the intervening months. On the few occasions no comparable mortgage product was offered and the product was then reintroduced at a better rate, we assume that the rate was unchanged in the intervening months. The different treatment is because we interpret the removal of a product as a restriction of credit supply, so would not expect a period where a bank stopped offering a wide set of mortgage products as being a period when the bank would otherwise have cut mortgage rates.

[12] For a detailed description of the Moneyfacts quoted rates data and how the Bank of England compile them for individual banks, see http://www.bankofengland.co.uk/statistics/Pages/iadb/notesiadb/household_int.aspx

Charts 2 and 3 highlight the impairment of the monetary transmission mechanism associated with the financial crisis. Prior to the crisis, quoted new mortgage rates were typically priced very close to Bank Rate. Since 2007, they have not fully tracked the falls in risk-free rates brought about by looser monetary policy, and their spreads relative to Bank Rate have increased. There has not been a significant change in the cross-sectional variation in the mortgage rates offered by different banks despite the sharp rise in heterogeneity in bank funding costs. According to the simple model in section 2, this is likely to reflect the effect of competition among lenders and the need to maintain fairly similar prices for similar products despite wide variation in marginal funding costs.

As far as retail deposit rates are concerned, prior to the crisis most banks bid for new deposits at rates close to or slightly below Bank Rate. But since the crisis banks have offered to pay significantly more than Bank Rate for retail deposits as the cost of wholesale funding also rose relative to Bank Rate.[13] For none of the banks have these particular deposit rates been themselves constrained by the zero lower bound, however.[14]

4 Baseline specification and methodology

We estimate loan and deposit pricing relationships at the individual bank level, rather than averaging variables and estimating on the aggregate time series. This has a number of advantages. First, the distribution of pass-through coefficients across banks is itself of interest – for example in analysing the effect of policy interventions, which may have only affected a subset of banks. Second, if heterogeneity is present, unlike the static case, dynamic regressions on the aggregate time series may produce biased estimates of the speed and extent of pass-through.[15] Third, if pass-through is incomplete or depends on different regressors for some banks but not others, this may only be visible at the individual bank level.

Baseline specification

The most general long run relationship between the loan (or deposit) rate set by a bank *i* and its determinants that we consider is a version of equation (5):

$$R^*_{it} = \mu_{i0} + \beta_i^S(R_t^S + \psi_i P_{it}) + \sum_{j\neq i}(\beta_{ij} R_{jt}) \qquad (13)$$

[13] Acharya and Mora (2012) found that banks in the US also actively sought deposits during the financial crisis.
[14] While this is true for the fixed rate bond series used in this paper, this is not true for interest rates paid on sight deposits where there has been a squeeze in the spread between sight deposit rates and Bank Rate following the reduction of Bank Rate to 0.5%.
[15] Pesaran and Smith (1995).

where $R^*{}_{it}$ is the long-run loan rate of bank i at date t, R_t^S is the maturity-matched swap rate, P_{it} is bank i's borrowing premium (CDS premium or asset swap spread) and μ_{i0} is the long-run mark up over funding costs.

In line with the model in Section 2, this equation allows for the loan rate of each bank to be influenced by the loan rates (and consequently the funding costs) of all other banks. This represents an extension to other models in the academic literature which allow each individual bank's loan rate to be influenced only by common market wide factors or specific characteristics relating to the bank (see Gambacorta, 2008, for example).

In the simple case, (β_{ij}=0) where bank *i* sets its loan rate independently of its competitors, β_i^S measures the extent of long-run swap rate pass-through and ψ_i the relative extent of bank borrowing risk pass-through. In more complex cases, β_{ij} measures the extent to which the loan rate of bank *i* is affected by the loan rate (and implicitly the funding cost) of bank *j*.

Our estimation strategy was to estimate an autoregressive distributed lag model in error correction form, embodying the general specification shown in equation (13) as a possible long run solution. We estimate the long-run parameters and short-run coefficients in a single step as in (14). Performing a first stage regression by OLS to estimate equation (13) would produce consistent coefficient estimates asymptotically, but is likely to be biased in small samples such as ours.

$$\Delta R_{it} = \phi_{ik} \sum_k \Delta R_{it-1-k} + \theta_{ik} \sum_k \Delta R^S_{t-k} + \varphi_{ik} \sum_k \Delta P_{it-k} + \alpha_i (R_{it-1} - R^*{}_{it-1}) + \varepsilon_{it} \qquad (14)$$

This set up allows for heterogeneous behaviour in the setting of loan pricing across banks. The dynamic equation is similar to others in the literature, although most impose homogeneous behaviour by restricting coefficients to be the same across banks (see Goggin *et al*, 2012, or Osborne *et al*, 2012, for example).[16]

Raknerud and Vatne (2012) do allow heterogenous adjustment across banking groups, but they restrict the long-run solution for loan rates (as in (13)) to depend only on the equivalent of swap rates and an indicative senior unsecured spread for the banking sector as a whole, rather than the rates applying to individual banks.

[16] We selected lag length using Schwartz Bayesian information criterion (SBIC). For most banks this suggested an optimal lag length is 2-3 months. We have used either 2 or 3 months in each set of results reported here, using the same lag length for each individual bank for consistency.

System estimation

In view of the potentially large number of parameters that could be estimated relative to the number of observations, it was necessary to restrict the number of parameters to be estimated. We did this in two alternative ways. In order to benchmark the results, we first estimated regressions imposing the condition (β_{ij}=0), which has the economic interpretation that banks set interest rates based only on their own costs. These single equation estimates were conducted by ordinary least squares (OLS). These estimates are clearly mis-specified when individual banks do take account of the loan rates of other banks in determining their own rates.

In our more general specification, we estimated versions of equation (14) for each bank as part of a system of simultaneous equations, using full information maximum likelihood (FIML). We began with the full range of possible long-run relationships between different banks' interest rates, and used a general to specific methodology to eliminate individually or collectively insignificant coefficients. The procedure we used was to keep a common dynamic structure across the equations for different banks and to drop terms in the interest rate spreads of rival banks depending on whether the t-statistic was significant at the 5% level. Estimating the equations together as a system allowed us to account for cross-correlation in the residual terms of each bank's equation – although the resulting coefficients were very similar to the equivalent estimates from individually estimating each bank's interest rate by OLS.

5 Results

This section sets out the results of our baseline specification for both lending and deposit rates. While all of the data used in this investigation is publicly available, we anonymise the identity of individual banks when discussing their behaviour.

In order to assess our estimations and interpret our results correctly, we first test whether the interest rate variables used in our estimations are stationary or not. Theoretically they are stationary processes: nominal rates are bounded below (by the zero-lower bound) and do not go to infinity. But in finite samples they generally behave as unit roots, and Campbell & Perron (1991) argue that for near-integrated stationary models it may be better to use asymptotic theory for non-stationary processes. As Table A in Annex C shows, for each of the interest rate series used in this paper, we cannot reject the null hypothesis of non-stationarity using the Augmented Dickey Fuller test.

In addition to stationarity, we also test whether the regressors used in our estimations are weakly exogenous. We take as given that they are contemporaneously exogenous, as it seems unlikely that there is causality from individual banks' pricing decisions to immediate changes in market expectations of monetary policy, or to investors' perceptions of banks' credit risk, the main determinants of their market funding costs. But this may not necessarily be true in the longer-run as retail rates could potentially affect market funding costs via their impact on the macroeconomy. To test this, we estimated a VECM for each bank separately where that bank's own market funding costs are determined endogenously. As Table B in Annex C shows, the ECM coefficients are significant for the mortgage rate equations but generally insignificant for the swap rate and CDS equations, suggesting that changes in swap rates/CDS are not influenced by changes in mortgage rates. Empirically it is less clear that market funding costs are weakly exogenous with respect to deposit rates for all banks (Annex C, Table C). This may mean our single-equation results below are less reliable. But focusing on the deposit rate equation in isolation allows us to explore the influence of competition with a smaller increase in the number of parameters in our estimation.

5.1 Lending Rates

Estimation without competition effects (β_{ij}=0)

In order to benchmark our results, we first estimate lending rate relationships for the individual banks on the assumption that loan rates are not sensitive to what other banks charge. The estimation period runs from April 2005 to December 2013. The drivers of each bank's loan rate are then the two-year swap rate and that bank's own CDS premium. We also estimate equivalent relationship for the average of the 6 banks' mortgage rates. The detailed results are shown in Annex B, Table A and are summarised in Table 1.

Table 1 – Estimated long-run pass-through to mortgage rates of a 100bp change in swap rate and CDS premiums (bps)

Bank	swap rate	X^2 Test of 100% swap rate pass-through	Own CDS	X^2 Test of 100% own CDS pass-through
A	74	5.58 [0.018]*	68	1.05 [0.305]
B	81	2.11 [0.146]	110	0.19 [0.666]
C	118	0.96 [0.328]	182	3.14 [0.077]
D	86	0.18 [0.675]	69	0.21 [0.645]
E	128	0.78 [0.377]	131	0.24 [0.628]
F	64	2.28 [0.131]	30	2.26 [0.133]
Average	122	0.64 [0.423]	166	1.34 [0.247]

In the simple benchmark case, although the precise long-run coefficient estimates differ slightly across banks, most banks would appear to pass through close to 100% of any change in swap rates. Only bank A has a coefficient significantly different from 100%. In the period prior to 2008 when there was little variation in CDS premiums, this bank did not have a long-run coefficient on swap pass-through significantly different from 100%. Taking the estimates for other banks and the pre-crisis estimates together, we interpret the results as evidence that pass-through is close to complete for changes in swap costs. In the remainder of the results we therefore test for and impose a coefficient of 100% on long-run pass-through for all banks. This helps us to better control for long-run collinearity between swap costs and CDS premiums.

Swap rates and CDS premiums are negatively correlated over our sample, partly due to market expectations of an endogenous response of monetary policy to developments in the banking sector. Over the crisis, negative news about the health of the banking sector generally increased banks' CDS premiums, but may also have worsened market expectations of the economic outlook, and led participants to expect more stimulative monetary policy as a result. The expected path for policy rates is the main driver of swap rates over our sample, so swap rates are lower in the periods (largely the post-crisis period) in which CDS premiums are highest.

Estimating an aggregate relationship for all six banks together implies long-run pass-through that is not significantly different from 100% for either swap rates or CDS premiums, but the speed of adjustment in that case is estimated to be very slow and slower than estimated in any of the individual relationships, suggesting that a simple aggregate relationship does not adequately capture the richness of the response of loan rates to shocks in the banking sector as a whole.

Estimated system (taking account of competition effects ($\beta_{ij} \neq 0$))

Our more general estimation removes the restriction that the coefficients estimating a given bank's interest rate response to changes in its competitors' rate must be equal to zero. But given the discussion in the previous section, it imposes the additional restriction that long-run swap pass-through is equal to 100%.[17] We then performed model selection using a general-to-specific procedure where we kept a common dynamic structure across the equations for different banks and dropped terms in the interest rate spreads of rival banks depending on whether the t-statistic was significant at the 5% level. The initial unrestricted model contained 46 coefficients to be

[17] Although we impose this restriction, it is not rejected statistically in the case of five of the six banks in the system. When the lagged swap rate is added to all of the equations in the system, it is only significantly different from zero (by a t-test) in the bank A equation (t=3.38) where the point estimate of long-run swap pass through is 82%. For all of the other banks the point estimate is within 10 percentage points of 100% (and the highest value of the t-statistic on the swap coefficient, that would signify pass-through of other than 100%, is 1.02).

estimated using 105 monthly observations for each equation. The results (with standard errors in brackets) are shown in Table 2.

Table 2 – Estimated mortgage rate system results (FIML)

Dependent variable: Monthly Change in Mortgage Rate (Δ*Ri*)[18]

Estimation period: April 2005 – December 2013

	System Estimation 1 (using CDS premiums)						System Estimation 2 (using unsecured bond spreads)					
	Bank A	Bank B	Bank C	Bank D	Bank E	Bank F	Bank A	Bank B	Bank C	Bank D	Bank E	Bank F
RA(-1)-swap(-1)	-0.33						-0.21					
	(0.07)						(0.06)					
RB(-1)-swap(-1)		-0.38		0.25				-0.45		0.31		
		(0.07)		(0.08)				(0.07)		(0.08)		
RC(-1)-swap(-1)	0.17		-0.22		0.12		0.13		-0.19		0.08	
	(0.05)		(0.04)		(0.05)		(0.05)		(0.04)		(0.05)	
RD(-1)-swap(-1)				-0.56						-0.58		
				(0.09)						(0.09)		
RE(-1)-swap(-1)		0.28		0.23	-0.27	0.22		0.36		0.19	-0.18	0.22
		(0.07)		(0.07)	(0.07)	(0.06)		(0.07)		(0.07)	(0.06)	(0.06)
RF(-1)-swap(-1)						-0.24						-0.24
						(0.06)						(0.05)
fundingsp_1	0.22	0.21	0.30	0.07	0.12	0.03	0.07	0.21	0.31	0.05	0.07	0.02
	(0.08)	(0.05)	(0.06)	(0.03)	(0.04)	(0.04)	(0.09)	(0.04)	(0.07)	(0.03)	(0.03)	(0.03)
Δswap	0.11	0.51	0.38	0.36	0.45	0.30	0.08	0.47	0.42	0.38	0.45	0.31
	(0.11)	(0.10)	(0.16)	(0.09)	(0.11)	(0.12)	(0.11)	(0.1)	(0.16)	(0.09)	(0.12)	(0.12)
Δswap(-1)	0.19	0.01	0.19	0.23	0.34	0.29	0.24	0.07	0.23	0.28	0.38	0.27
	(0.14)	(0.14)	(0.19)	(0.12)	(0.14)	(0.15)	(0.14)	(0.13)	(0.19)	(0.12)	(0.14)	(0.15)
Δswap(-2)	0.21	-0.05	-0.03	0.14	-0.02	0.40	0.23	0.00	0.04	0.13	0.02	0.42
	(0.13)	(0.12)	(0.16)	(0.12)	(0.12)	(0.14)	(0.13)	(0.12)	(0.17)	(0.11)	(0.13)	(0.14)
Δfundingsp	0.03	0.03	-0.31	-0.10	0.07	0.09	-0.09	0.01	-0.11	-0.16	0.08	0.03
	(0.17)	(0.09)	(0.14)	(0.09)	(0.10)	(0.09)	(0.19)	(0.08)	(0.15)	(0.08)	(0.07)	(0.09)
Δfundingsp(-1)	-0.24	-0.20	-0.24	-0.14	-0.15	-0.22	0.01	-0.30	-0.29	-0.04	-0.16	-0.23
	(0.18)	(0.10)	(0.16)	(0.09)	(0.11)	(0.10)	(0.2)	(0.08)	(0.16)	(0.09)	(0.08)	(0.09)
Δfundingsp(-2)	0.07	-0.08	-0.32	-0.04	-0.01	0.01	0.11	-0.03	-0.23	0.04	-0.03	0.05
	(0.18)	(0.09)	(0.15)	(0.09)	(0.10)	(0.09)	(0.2)	(0.08)	(0.16)	(0.08)	(0.07)	(0.09)
CONSTANT	0.02	-0.10	0.02	-0.02	0.02	0.01	0.03	-0.11	0.02	-0.01	0.02	0.02
	(0.04)	(0.04)	(0.05)	(0.03)	(0.03)	(0.03)	(0.03)	(0.03)	(0.05)	(0.03)	(0.03)	(0.03)
DIAGNOSTICS												
NORM (χ^2)	χ2 (12)=138.14[0.00]**						χ2 (12)= 142.82[0.00]**					
AR 1-2 (F)	F(72,408)=1.19[0.16]						F(72,408)=1.24[0.11]					
Hetero (F)	F(540,63)=1.35[0.07]						F (540, 63)= 2.02[0.00]**					
OID Test	χ2 (192)=354.25[0.00]**						χ2 (192)= 467.09[0.00]**					

The top section of the table shows the estimated level coefficients, where the negative coefficient (on the diagonal) represents the short-run speed of adjustment. So the coefficient on RA(-1)-swap(-1), for example, implies that each month there is 33% error-correction of bank

[18] Regression also contained additional mortgage rate dynamic terms as explanatory variables, which for conciseness we do not report.

A’s interest spread towards its estimated long-run level, conditional on the other variables. These ECM terms are all highly significant. The other estimated level coefficients represent the long-run cointegrating relationships, which are discussed in more detail in the next subsection. The negative and significant coefficients on the ECM terms are consistent with the interpretation that the variables are cointegrated.

The bottom half of the table shows some of the estimated short-run dynamics for each bank’s interest rate. In general there are positive, significant coefficients on changes in swap rates, suggesting these are passed-through quickly. There are negative and/or insignificant short-run coefficients on CDS premiums, suggesting that these are passed through only at the speed of ECM adjustment, if not more slowly.

The system diagnostics do not suggest autocorrelation in the equation residuals. The assumption of normality in the errors is rejected, although such a result is not uncommon when estimating using monthly interest rate data, which tends not to exhibit smooth adjustment. It is possible that we could avoid this by using quarterly averages, but at the expense of losing some of the interesting monthly information in our data. This version of the system also fails the test of over identifying restrictions, but this is largely as a result of the high number of variables in our unreduced system. Using a smaller starting point, with only one ‘average’ measure of funding spreads gives a very similar result, but does not fail this test. This suggests the failure is largely as a result of the high number of collinear funding spread variables in our initial system.

Discussion

While complete long-run pass-through of changes in swap costs is in line with the theoretical example presented earlier, it is less clear from theory how quickly we might expect banks to respond. That may depend on whether delayed pass-through is as a result of pricing frictions, as in standard macro models, or due to a desire to maintain market share in the face of temporary shocks. In the short-run, the majority of the pass-through of changes in swap costs appears to occur within one quarter, with most banks passing through around one-third to one-half of shocks contemporaneously (within one month). That there is relatively fast pass-through for common shocks to marginal costs lends support to arguments that competitive pressures are a more important driver. Banks may be more able to pass through changes in marginal costs immediately when those shocks are faced by all banks, without any corresponding effect on market share.

The long-run cointegrating relationships implicit in Table 2 are summarised in Table 3. We would caution against reading too much into the exact relationships the data suggest, given that many of our series are highly correlated, so there may also be other equally valid relationships which our general-to-specific model selection procedure failed to identify. There are, however, some interesting features of these estimated relationships, which do seem to be robust to the exact model specification.

Table 3: Estimated long-run cointegrating relationships (mortgage spreads over swaps)
Bank A mortgage spread = 0.50*Bank C mortgage spread + 0.66*Bank A CDS
Bank B mortgage spread = 0.74*Bank E mortgage spread + 0.57*Bank B CDS
Bank C mortgage spread = 1.38*Bank C CDS
Bank D mortgage spread = 0.40*Bank E mortgage spread + 0.45*Bank B mortgage spread + 0.12*Bank D CDS
Bank E mortgage spread = 0.46*Bank C mortgage spread + 0.45*Bank E CDS
Bank F mortgage spread = 0.89*Bank E mortgage spread + 0.12*Bank F CDS

First, of the six banks, only Bank C's mortgage spread appears not to depend on the mortgage spreads charged by its competitor banks. This could be interpreted as suggesting that this bank is the market leader for this product, with other banks' responding partly to changes in competitors' rates rather than their own costs. As a cross-check of this result, we estimated our simple specification in which ($\beta_{ij}=0$), with each variable adjusted so that it was measured in terms of differences from the market average. The results (Table C in annex B) show that only this bank is estimated to change its mortgage rate relative to the market average when faced with a change in its relative marginal costs. This is consistent with market leader type behaviour. An alternative interpretation is that the results do not reflect any special significance of this bank *per se*, only that this bank's funding costs and interest rates happened to be around the market average for most of our sample period, and all banks coalesced around the market average.

A second interesting feature of the results is that competitive pressures look to have remained an important factor even in the post-crisis period. As Chart 1 illustrates, some banks have typically had much higher marginal funding costs than others since 2008. But the relationships in Table 3 suggest that the banks with the highest funding costs have been unable to pass through much of those increases, instead having to price down based on their competitors' rates. These relationships help to explain those estimated in our simple specification, shown in Table 2. The heterogeneity in long-run pass-through suggested in Table 2 could be a reflection of the fact that there was heterogeneity in funding costs. Two of the banks with larger increases were unable to pass through much of those increases, resulting in lower coefficient estimates.

For the banks with lower funding costs, however, the results suggest they have been able to increase their rates by more than their own marginal funding costs increased. One interpretation for this is that those banks with lower funding costs in the post crisis period were able to optimally increase their mark-ups on new lending in response to lower competition from their high-cost rivals. An alternative interpretation is that there were other increases in marginal costs for all banks in the post-crisis period that were correlated with the increases in our measure of marginal funding costs. If so, these omitted variables may be upwardly biasing our estimates.

A final point, is that taken together, the results are in line with the predictions of the simple example shown earlier – common changes, either to swaps or CDS, are typically passed through more completely than idiosyncratic ones.

Charts 4 - 6 show the conditional responses of different banks' estimated responses to different shocks to their costs.

Chart 4: Response of individual banks' mortgage rates to a 1pp increase in swap costs (constrained to equal 1pp in the long-run)

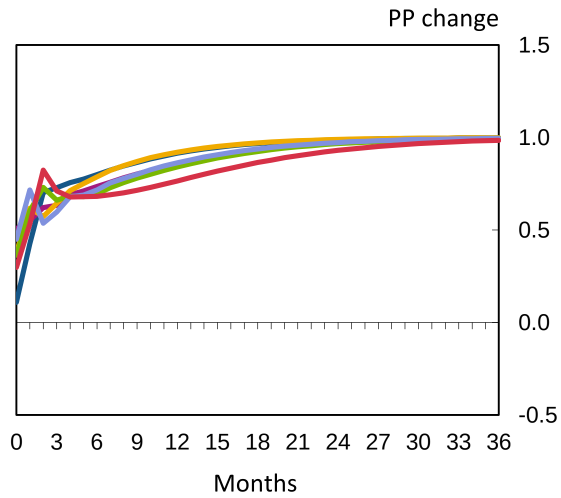


Chart 5: Response of individual banks' mortgage rates to a 1pp homogeneous increase in CDS

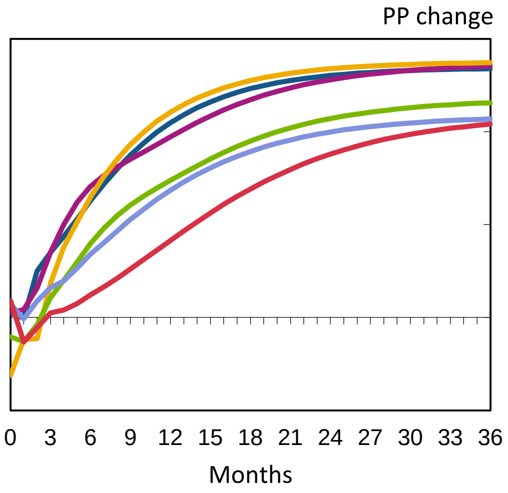


Chart 6: Response of individual banks' mortgage rates to an average increase in CDS of 1pp, heterogeneously distributed[19]

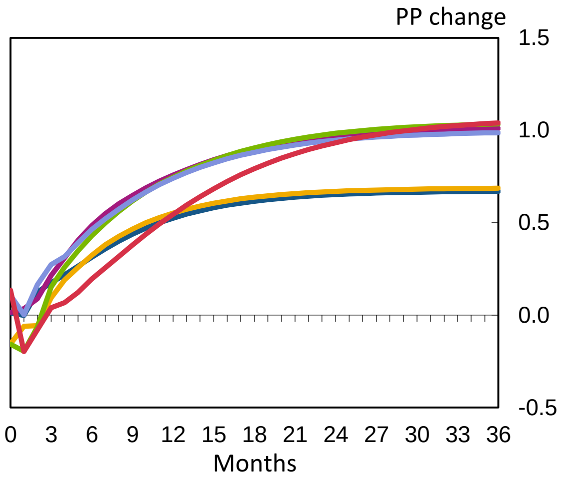


Chart 4 shows that the response of mortgage rates to a 1pp increase in swap rates (common for all banks) is quick and fairly homogenous across banks. Pass through is complete in the long-run (as discussed earlier, after testing, we impose 100% pass-through in the long-run) with around 70-100% being passed through in the first two months. Pass-through to mortgage rates of a common shock to other funding spreads (using both CDS premiums and unsecured bond spreads as proxies) is freely estimated to be over 100% in the long run, but to occur more slowly than a shock to swap rates (see Chart 5 vs. Chart 4). In practice shocks to funding spreads have been heterogeneous and the average response to a heterogeneous shock to CDS premiums is smaller than the response to a homogenous shock across banks (Chart 6 vs. Chart 5).

5.2 Deposit Rates

Estimation without competition effects (β_{ij}=0)

As with our discussion of loan rates, we first estimate deposit rate relationships for individual banks on the benchmark assumption that each bank sets its rate independently of its competitors (β_{ij}=0). Table B in Annex C sets out the results of this estimation for each of the banks in our sample. The long run results are summarised in Table 4.

[19] We simulate a permanent shock to CDS premiums that is heterogeneously distributed across banks similar to that observed by banks during the crisis. Specifically, the scenario is one where the average CDS increases by 100 bps but the CDS premiums for three banks increase by 50 bps and the CDS for the other three banks increase by 150 bps.

Table 4 – Estimated long-run pass-through to deposit rates of a 100bp change in swap rate and CDS premiums (bps)

Bank	swap rate	X^2 Test of 100% swap rate pass-through	Own CDS	X^2 Test of 100% CDS pass-through
A	95	0.02 [0.893]	78	0.02 [0.878]
B	95	0.12 [0.730]	78	0.38 [0.537]
C	93	0.25 [0.615]	97	0.01 [0.929]
D	77	0.75 [0.385]	27	1.35 [0.245]
E	79	1.07 [0.301]	26	2.11 [0.146]
F	70	5.39 [0.020]*	34	6.18 [0.013]*
Average	94	0.05 [0.819]	77	0.15 [0.702]

We find that the pass-through of swap rates to deposit rates by individual banks is close to complete in the long-run with around 70-100% of changes in swap rates being passed through after two months. But as discussed in the previous section, some of these coefficients might be biased downwards due to the post-crisis relationship between swap rates and CDS premiums. To eliminate this bias we impose a coefficient of 100% on long-run swap rate pass-through for all banks in our more general specification below.[20] As with the lending rate results, only one bank (F) has a long-run pass-through estimate significantly different from 100%, but this is not the case if we test using only the pre-crisis data when CDS premiums were more muted. For CDS premiums, the long-run pass-through estimates are generally smaller and more heterogeneous than those for swap rates. Moreover, for four out of six banks these coefficients are not statistically significant from zero, though in only one case is CDS pass-through significantly different than 100%. Taking these point results at face value would suggest that, for some banks, the pass-through of banks' funding spreads to their own deposit rates is small. But as discussed in the model outlined in Section 2, a bank's deposit rate is likely to depend on its competitors' rates as well as its own funding costs. So the small pass-through coefficient on own funding costs for some of the banks might simply reflect the fact that their competitors' rates are playing a more important role in their own deposit pricing. Our more general specification discussed below takes account of this strategic interaction.

Estimating an aggregate relationship for all six banks together implies 100% long-run pass-through for both swap rates and CDS premiums, but again the speed of adjustment is estimated to be slow, relative to most of the individual bank specifications, suggesting that a simple aggregate relationship does not adequately capture the richness of the response of deposit rates to shocks in the banking sector as a whole.

[20] Although we impose this restriction, it is not rejected statistically for any of the six banks in the system. When the lagged swap rate is added to each equation in the system, it is not significantly different from zero (by a t-test) in any individual bank equation. A test of whether 100% pass-through can be imposed on the system is not rejected at the 5% level ($\chi^2(6) = 9.0843$ [0.1689]).

Estimated system (taking account of competition effects ($\beta_{ij}\neq 0$))

As discussed in the section on lending rates, we estimate a system of simultaneous equations for each bank using full information maximum likelihood (FIML). Table 5 sets out the key results of this baseline specification.

Table 5 – Estimated deposit rate system results (FIML)

Dependent variable: Monthly Change in Deposit Rate (Δ*Ri*)

Estimation period: April 2005 – December 2013

	System Estimation 1 (using CDS premiums)						**System Estimation 2 (using unsecured bond spreads)**					
	Bank A	Bank B	Bank C	Bank D	Bank E	Bank F	Bank A	Bank B	Bank C	Bank D	Bank E	Bank F
RA(-1)-swap(-1)	-0.13			0.13	0.27		-0.14			0.15	0.30	
	(0.05)			(0.04)	(0.06)		(0.05)			(0.03)	(0.06)	
RB(-1)-swap(-1)	0.13	-0.14					0.14	-0.13				
	(0.07)	(0.04)					(0.07)	(0.04)				
RC(-1)-swap(-1)			-0.37						-0.21			
			(0.07)						(0.06)			
RD(-1)-swap(-1)				-0.24		0.31				-0.26		0.34
				(0.06)		(0.09)				(0.05)		(0.09)
RE(-1)-swap(-1)			0.18		-0.36				0.11		-0.39	
			(0.06)		(0.07)				(0.06)		(0.07)	
RF(-1)-swap(-1)						-0.30						-0.32
						(0.08)						(0.08)
fundingsp_1		0.12	0.23	0.08				0.10	0.12	0.11		
		(0.05)	(0.05)	(0.03)				(0.04)	(0.05)	(0.03)		
Δswap	0.94	0.66	0.77	0.06	0.35	0.45	0.82	0.63	0.76	0.07	0.32	0.51
	(0.13)	(0.11)	(0.15)	(0.09)	(0.14)	(0.13)	(0.10)	(0.10)	(0.14)	(0.08)	(0.14)	(0.13)
Δswap(-1)	-0.20	0.16	0.19	0.71	0.33	0.53		0.18	0.23	0.70	0.36	0.48
	(0.14)	(0.11)	(0.15)	(0.09)	(0.15)	(0.13)		(0.10)	(0.14)	(0.09)	(0.14)	(0.13)
Δfundingsp	-0.28	-0.02	0.09	0.12	0.08	0.03		-0.05	-0.05	0.10	0.05	0.06
	(0.17)	(0.09)	(0.13)	(0.09)	(0.11)	(0.09)		(0.08)	(0.12)	(0.07)	(0.08)	(0.09)
Δfundingsp(-1)	-0.03		-0.24	-0.14	-0.18	-0.33			0.07	-0.15	-0.09	-0.14
	(0.17)		(0.13)	(0.09)	(0.11)	(0.09)			(0.13)	(0.07)	(0.07)	(0.09)
CONSTANT	-0.04	-0.01	-0.22	0.04	0.04	-0.10	-0.05	0.01	-0.09	0.03	0.04	-0.11
	(0.04)	(0.03)	(0.06)	(0.02)	(0.03)	(0.04)	(0.04)	(0.03)	(0.05)	(0.02)	(0.03)	(0.04)
DIAGNOSTICS												
NORM (χ^2)	χ2 (12)= 93.31[0.00]**						χ2 (12)= 96.66[0.00]**					
AR 1-2 (F)	F(72,446)=1.72[0.00]**						F(72,451)=1.85[0.00]**					
Hetero (F)	F (312, 289)= 2.33[0.00]**						F (312, 289)= 2.28[0.00]**					
OID Test	χ2 (119)= 289.5[0.00]**						χ2 (122)= 240.54[0.00]**					

All long-run coefficients on swap rates, funding spreads and relevant competitors' rates are statistically significant. A coefficient of 100% long-run swap rate pass-through is imposed in accordance with the benchmark model results. For wholesale funding spreads (proxied by CDS premiums), pass-through for the average of the 6 banks in the long-run is less complete at around 80%. In addition, the size and significance of the long-run and short-run coefficients are robust to using unsecured bond spreads instead of CDS premiums.

Table 6: Estimated long-run cointegrating relationships (deposit spreads over swaps)
Bank A deposit spread = 0.95*Bank B deposit spread
Bank B deposit spread = 0.84*Bank B CDS
Bank C deposit spread = 0.49* Bank E deposit spread + 0.62*Bank C CDS
Bank D deposit spread = 0.57*Bank A deposit spread + 0.35* Bank D CDS
Bank E deposit spread = 0.75*Bank A deposit spread
Bank F deposit spread = 1.05*Bank D deposit spread

The long-run cointegrating relationships shown in Table 5 are summarised in Table 6 and suggest some interesting results about deposit pricing behaviour. First, these long-run relationships suggest that competitors' rates are an important influence on deposit pricing. Of the six banks in our sample, Bank B is the only bank whose deposit rates do not depend on the deposit rates charged by its competitors. This suggests that this bank could potentially be the market leader for this product, reacting only to changes in its own funding costs. The other five banks in our sample respond quite strongly to their competitors' rates and respond only partly to changes in their own funding costs.

For instance, over the estimation period, there is no long-run cointegrating relationship between Bank A's deposit spreads and its CDS premiums. In fact, even though this bank's funding costs were typically lower than all the other banks in the post-crisis period, its deposit rates were more in line with its competitors who had higher funding costs. Specifically, the cointegrating relationship in Table 5 suggests that Bank A deposit rates are not driven by its own funding spreads but are driven by what its competitors (Bank B in this case) is prepared to pay. This could be consistent with a desire to maintain market share of retail funding in the immediate aftermath of the financial crisis. The results for the other four banks suggest that they did not fully pass-through the big increases in their funding costs and were instead, pricing partly based on their competitors' rates.

A second interesting feature of these results is that common shocks to funding costs are passed through more quickly and completely to deposit rates than idiosyncratic shocks, in line with the predictions of the simple model presented in Section 2.

As Chart 7 shows, the response of deposit rates to a 1pp increase in swap rates (common for all banks) is quick and fairly homogenous across banks. Pass-through of swap rates to deposit rates is complete in the long-run (as discussed earlier, after testing, we impose 100% long-run pass-through) with around 70-100% being passed through in the first two months. Long-run pass-through of other funding spreads (using either the CDS premium or unsecured bond spread measures) is freely estimated to be in the range of 60%-90%. In addition, the pass-through of CDS premiums is a lot slower than the pass-through of swap rates (see Chart 8 vs. Chart 7). The results also suggest that the average response to a heterogeneous shock to CDS premiums is smaller than the response to a homogenous shock across banks (Chart 8 vs. Chart 9).

Chart 7: Response of individual banks' deposit rates to a 1pp increase in swap costs (constrained to equal 1pp in the long-run)

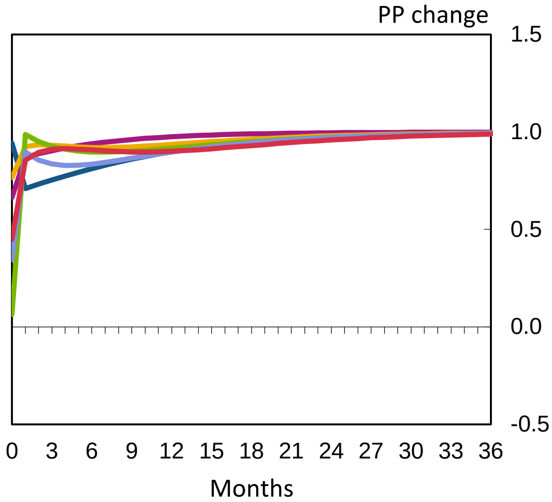


Chart 8: Response of individual banks' deposit rates to a 1pp homogenous increase in CDS

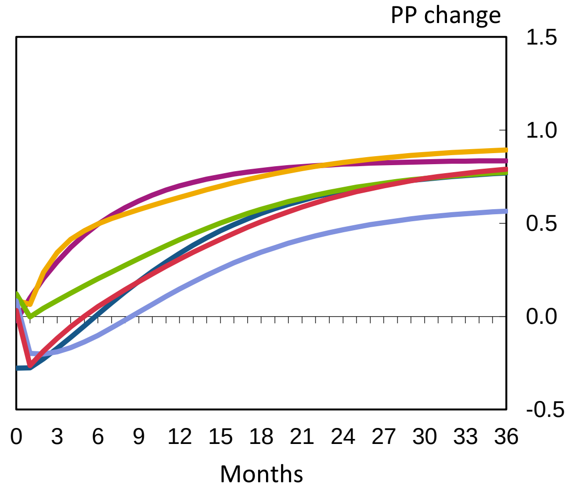
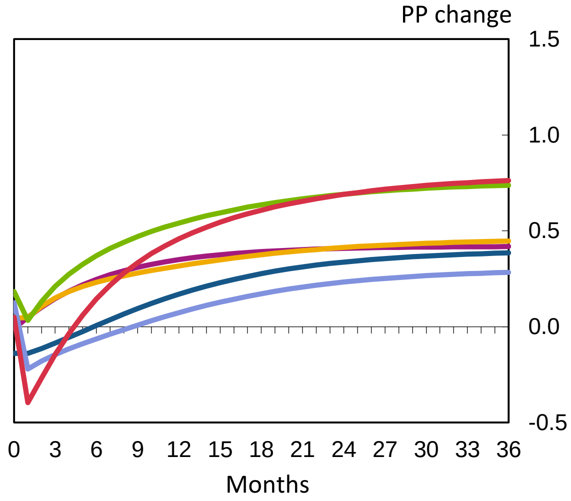


Chart 9: Response of individual banks' deposit rates to a 1pp increase in average CDS heterogenously distributed across the 6 banks[21]



[21] We simulate a permanent shock to CDS premiums that is heterogeneously distributed across banks similar to that observed by banks during the crisis. Specifically, the scenario is one where the average CDS increases by 100 bps but the CDS premium for three banks increases by 50 bps and the CDS for the other three banks increases by 150 bps.

6 The impact of the Funding for Lending Scheme on loan and deposit rates

The intensification of the crisis in the euro area during 2011 led to a marked rise in UK bank funding costs which caused interest rates on loans to rise and credit conditions to tighten in the twelve months to end May-2012. Given the heightened level of uncertainty and risk aversion associated with the euro area crisis, funding costs seemed likely to remain elevated for a considerable period of time. As changes in interest rates typically follow changes in funding costs with a lag, a further tightening in credit conditions was also in prospect. As a result, the Bank of England and HM Treasury launched the Funding for Lending Scheme (FLS) on 13 July 2012 to respond to the threat to the UK economy from elevated bank funding costs.

The FLS was designed to incentivise banks and building societies to boost their lending to UK households and private non-financial corporations (PNFCs) (Churm *et al*, 2012). It did so by providing funding to banks for an extended period at below market rates, with both the price and quantity of funding provided linked to participants' performance in lending to the UK real economy. Banks were offered an initial entitlement of discounted funding, (5% of their stock of outstanding loans to the real economy as of June 2012) as well as additional discounted funding the more they lent to households and businesses. As a result, participating banks were able to access funding at much lower prices than they were able to prior to the FLS. Participation in the first part of the scheme (July 2012 – Dec 2013) was widespread. There were 46 participants, covering over 80% of the stock of lending to households and PNFCs.

We test for evidence of two distinct channels through which the FLS may have affected bank lending rates. First, we test for <u>direct effects</u> of the additional quantity of FLS funding available at a lower price. We define these direct effects as any channels operating <u>in addition to the effect of the scheme on market funding costs.</u> For example, for banks that were unable or unwilling to obtain their desired quantity of funding at the market rate, the FLS could have increased the quantity they were able to lend at given market funding costs.

In addition to the direct effects of cheaper funding from the FLS, banks also observed a fall in costs in other sources of funding such as retail and wholesale funding. We therefore also test for <u>possible indirect effects</u> of the scheme operating via lower market funding costs. We can only examine 'possible' indirect effects because our results do not allow us to identify the drivers of the observed falls in market funding costs, which we treat as exogenous. Those falls may have reflected the fact that banks that had funding available to them through the FLS had a lower requirement for other sources of funding, leading market funding costs to fall as banks switched between FLS and market funding sources. But the falls could also have reflected the impact of other policy measures announced at the same time such as the ECB's announcement of its OMTs and LTROs. While it is hard to distinguish between the impacts of these different policies on funding costs, it is clear that banks' funding costs and retail rates fell from mid-2012. Given differences in balance sheet positions and the starting level of funding costs for different banks, the FLS and other policy measures influenced different banks' funding costs and therefore, their lending/deposit rates, in different ways.

Our methodology complements the understanding of FLS transmission from the estimates conducted by Churm *et al* (2015). In their study of the macroeconomic impacts of the UK's QE2 and FLS policies, the authors use a principal component regression to estimate the size of the indirect effect of the FLS on market funding costs. They then use those estimates to simulate the macroeconomic impact of the scheme on GDP and inflation. We add to their estimates by focusing on the intermediate stage in the transmission mechanism, from funding costs to retail rates. We also supplement them by testing for direct effects of the FLS over and above its impact on market funding costs. To our knowledge we are the first to try to quantify this mechanism.

In order to assess the extent to which pass-through behaviour of market funding costs changed, we use the specification (taking into account competition effects) described in the previous section. We re-estimate this up to June 2012, the month before the FLS was launched. We then construct an out-of-sample forecast for lending rates, and, as a comparison, for deposit rates. We use the system based on senior unsecured bond spreads (Tables 2 and 5, Estimation 2) to construct these out-of-sample forecasts. This is because while both unsecured bond spreads and CDS premiums implied a broadly similar level for wholesale funding costs for most our sample, there was a sharp reduction in bond spreads relative to CDS premiums in 2012. It is likely this reflected two factors: a reduction in the requirement for other sources of funding following the launch of the FLS and a reduction in the issuance of new bank bonds following the ECB's LTRO. Beau *et al* (2014) report that market contacts indicated that banks used secondary market spreads on existing bonds to calculate the marginal cost of wholesale funding. Therefore, on this basis, unsecured bond spreads and not CDS premiums are likely to be a better proxy for banks' alternative market source of funding over the post FLS period.[22]

[22] Moreover, in the BoE quarterly *Bank Liabilities Survey*, banks report that they use unsecured bond spreads as a starting point to calculate their transfer price.

Charts 10 and 11 compare the average outturns for mortgage and deposit rates with the corresponding out-of-sample forecasts over the same period. For both mortgage and deposit rates, we find that between June 2012 and December 2013 the actual outturns were slightly higher (by around 25bps) than the out-of-sample forecast. That suggests that, on average, banks were, if anything, pricing slightly above what they normally would have given observed movements in swap rates and unsecured bond spreads. This is true for both mortgage and deposit rates, which is suggestive that the error in the out of sample forecast was unrelated to any direct effect of the FLS on the pricing of mortgage rates.

Chart 10: Out of sample forecast v outturns for mortgage rates

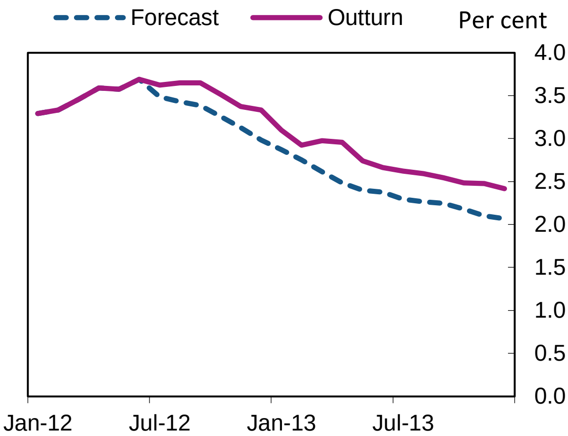
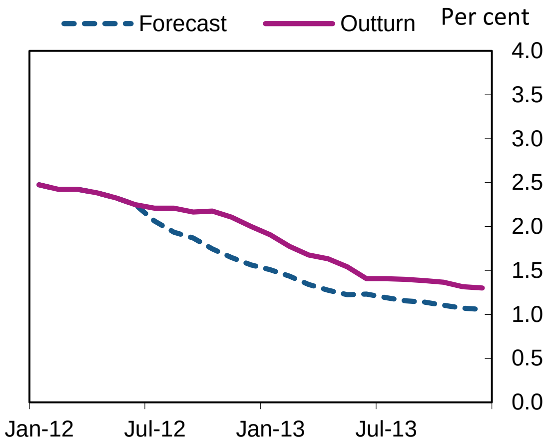


Chart 11: Out of sample forecast v outturns for deposit rates



Our estimates suggest that on average, the fall in both lending and deposit rates following the FLS can be more than explained solely by movements in swap rates and unsecured bond spreads. At first glance this might suggest that the incentives to lend built into the FLS had little additional impact. However, as explained above, market funding costs such as unsecured bond spreads fell sharply following the FLS. Churm *et al* (2015) find that the FLS contributed materially to the fall of over 100bps in unsecured funding spreads by the end of 2012.

Moreover, if market funding costs had not fallen and had remained at their June 2012 level, our model suggests that loan and deposit rates would not have fallen to the extent they actually did over 2012 and 2013 (Charts 12 and 13). Our results are therefore consistent with the main effect of the FLS coming via its indirect impact on market funding costs, and associated effects on retail deposit rates, rather than via the direct impact of the incentives to lend built into the scheme.

Chart 12: Out of sample forecast v outturns for mortgage rates (assuming senior unsecured bond spreads remained at their June 2012 level)

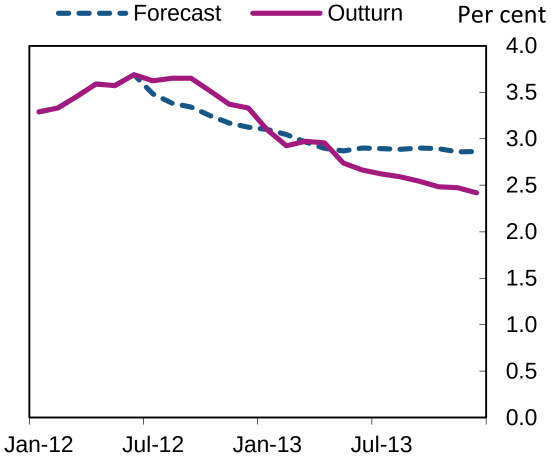
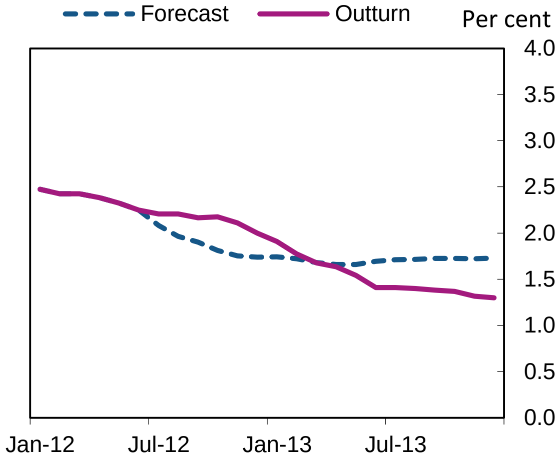


Chart 13: Out of sample forecast v outturns for deposit rates (assuming senior unsecured bond spreads remained at their June 2012 level)



Where our results are comparable, they are also consistent with the findings in Churm *et al* (2015), the key existing study of the impact of the FLS. That work finds that the indirect effect of the FLS reduced market funding costs and as a result, boosted GDP, with a peak effect of 0.8%. The results of our out-of-sample forecasts shown in Charts 12 and 13 illustrate the key channel through which the reduction in funding costs transmitted to the real economy, via lower lending and deposit rates facing households.

We also add to those estimates by examining whether the incentives built into the FLS had a direct effect in lowering mortgage rates, over and above their impact via market funding costs. We do not find evidence of any such effects, which could be for a variety of reasons. It may be that any direct effects of the scheme were small or negligible, relative to the large falls in market funding costs following its launch. Or it may be that any sizeable direct effects were concentrated in smaller banks and building societies outside our sample of the major UK banks. Even in the absence of such effects, our results highlight that the effect of schemes such as the FLS on market funding costs can have important effects when the monetary transmission mechanism is impaired.

7 Conclusion

This paper has examined the determinants of standard mortgage and deposit rates over a sample that includes the financial crisis and its aftermath. Over this period there was a sharp increase in these rates relative to Bank Rate that can be explained by the increase in funding costs experienced by the major lenders, reflecting their perceived increased riskiness. The paper makes a number of contributions.

First, this is the first paper to report estimates of loan and deposit pricing relationships for individual lenders that take account of the cost of unsecured wholesale funding and the rates set by their rivals. Our results suggest that estimates based on purely aggregate relationships are likely to be mis-specified and produce excessively slow estimates of the dynamic response of rates to their determinants.

Second, while the transmission mechanism of monetary policy in the United Kingdom was undoubtedly altered by the crisis, the evidence does not suggest that it was entirely ineffective in that shifts in swap rates, reflecting expectations of future policy rates, continued to be passed through quickly and completely to household rates.

Third, the estimation results have enhanced understanding of how heterogeneous shifts in the cost of wholesale funding are passed through to rates facing households. It appears that, over our sample period, the funding costs of the different banks do not matter equally (or according to their market shares). In particular the funding costs of the banks with the highest and lowest costs appear to have less influence on rates while those with medium costs have the most influence. This is likely to reflect the nature of strategic interaction in the industry with the least cost producer being able to price up to the costs of its rivals and the highest cost producer having to price down.

Fourth, as far as the Funding for Lending scheme is concerned, we find that its main effect came through its indirect impact on market funding costs rather than via the direct impact of the lower cost of scheme funding.

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Annex A: Data summary

Chart 1: Swathe of 2 year 75% LTV mortgage rates

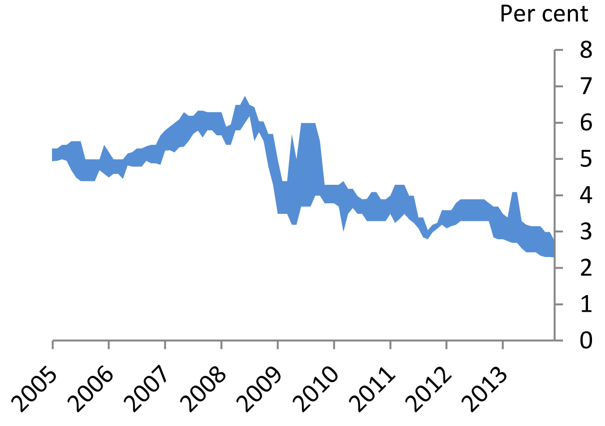


Chart 2: Swathe of 1 year fixed rate bond deposit rates

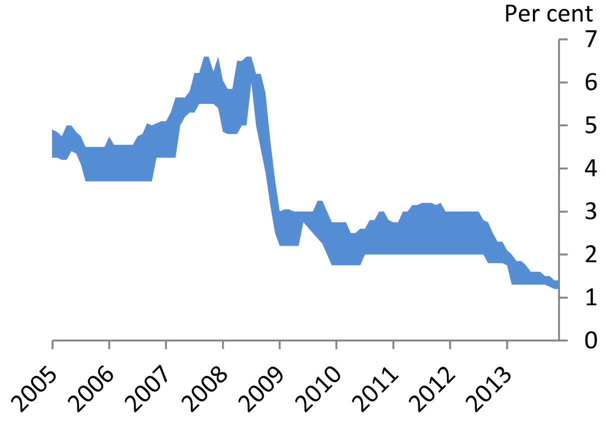


Chart 3: 5 year senior CDS premiums

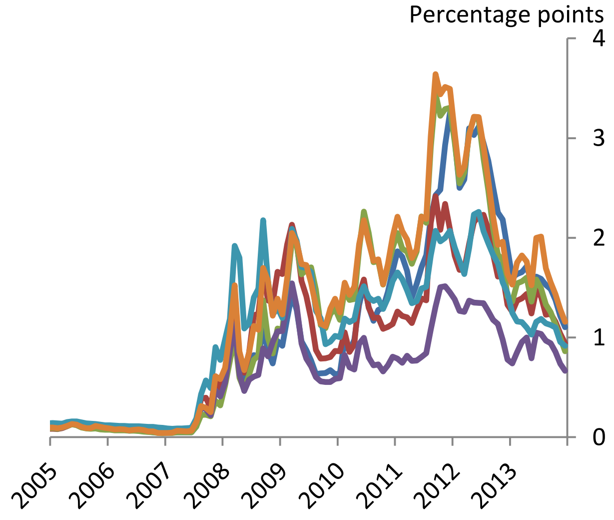


Chart 4: Bank rate and swap rates

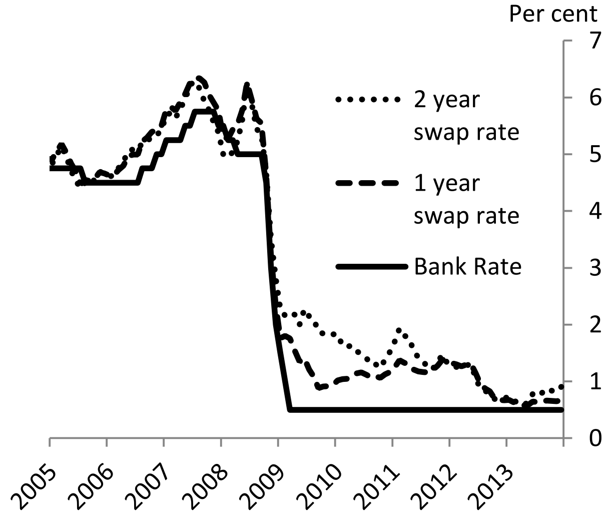


Chart 5: Aggregate fixed mortgage rates (effective vs. quoted rates)

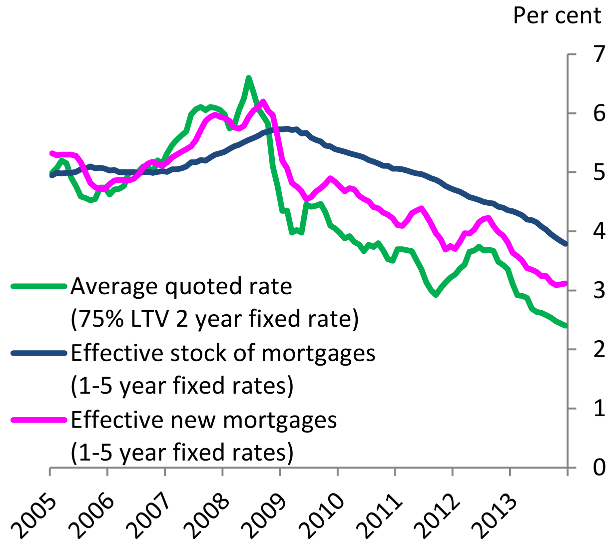
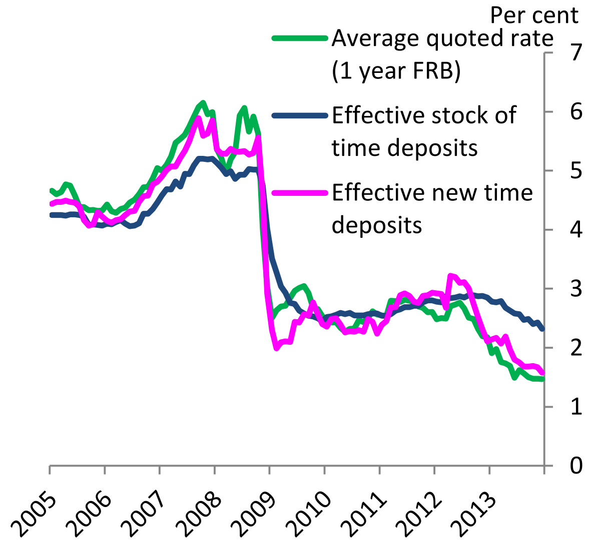


Chart 6: Aggregate deposit rates (effective vs. quoted rates)



Annex B: Estimation results for lending rates and deposit rates

Table A: Estimated pass-through of a change in funding costs to lending rates (without taking account of competitors' rates (β_{ij}=0))

Dependent variable is Δ*rate*[23] **Estimation Period: April 2005 – December 2013**

	using CDS premiums						
	Bank A	Bank B	Bank C	Bank D	Bank E	Bank F	Average
rate(-1)	-0.29	-0.19	-0.17	-0.09	-0.09	-0.18	-0.07
	(0.08)	(0.05)	(0.05)	(0.06)	(0.05)	(0.07)	(0.04)
swap(-1)	0.22	0.16	0.20	0.08	0.12	0.12	0.08
	(0.05)	(0.04)	(0.04)	(0.03)	(0.04)	(0.04)	(0.02)
fundingsp(-1)	0.20	0.21	0.31	0.07	0.12	0.06	0.11
	(0.08)	(0.05)	(0.08)	(0.04)	(0.04)	(0.04)	(0.03)
Δswap	0.03	0.56	0.40	0.37	0.48	0.28	0.37
	(0.11)	(0.11)	(0.16)	(0.11)	(0.11)	(0.12)	(0.06)
Δswap(-1)	0.11	-0.04	0.22	0.07	0.34	0.16	0.17
	(0.14)	(0.14)	(0.18)	(0.13)	(0.14)	(0.15)	(0.08)
Δswap(-2)	0.11	-0.07	-0.04	0.10	-0.05	0.25	0.02
	(0.14)	(0.13)	(0.16)	(0.12)	(0.12)	(0.14)	(0.08)
Δfundingsp	-0.02	-0.01	-0.45	-0.07	0.06	0.08	-0.10
	(0.17)	(0.10)	(0.15)	(0.11)	(0.10)	(0.1)	(0.07)
Δfundingsp(-1)	-0.33	-0.12	-0.19	-0.04	-0.14	-0.18	-0.06
	(0.17)	(0.10)	(0.17)	(0.12)	(0.10)	(0.1)	(0.07)
Δfundingsp(-2)	-0.18	-0.11	-0.26	-0.02	-0.01	-0.02	-0.05
	(0.18)	(0.10)	(0.16)	(0.11)	(0.10)	(0.10)	(0.07)
CONSTANT	0.46	0.14	-0.15	0.08	-0.11	0.39	-0.08
	(0.19)	(0.13)	(0.18)	(0.17)	(0.16)	(0.25)	(0.10)
DIAGNOSTICS							
Adj R^2	0.30	0.36	0.27	0.22	0.33	0.27	0.53
AR 1-2 (F)	1.75	3.19	1.36	0.84	0.18	0.9	1.00
	[0.18]	[0.05]*	[0.26]	[0.44]	[0.84]	[0.41]	[0.37]
NORM (χ^2)	4.4	11.21	89.49	18.69	8.25	32.55	9.00
	[0.11]	[0.00]**	[0.00]**	[0.00]**	[0.02]*	[0.00]**	[0.01]*
Hetero (F)	2.51	1.4	1.32	1.08	1.96	2.45	1.16
	[0.00]**	[0.14]	[0.19]	[0.39]	[0.02]*	[0.00]**	[0.31]

(standard errors of coefficients in parentheses)

[23] Regression also contained additional mortgage rate dynamic terms as explanatory variables, which for conciseness we do not report.

Table B – Estimated pass-through of a change in funding costs to deposit rates (without taking account of competitors' rates (β_{ij}=0))

Dependent variable is $\Delta rate$[24] **Estimation Period: April 2005 – December 2013**

	using CDS premiums						
	Bank A	Bank B	Bank C	Bank D	Bank E	Bank F	Average
rate(-1)	-0.07	-0.14	-0.23	-0.08	-0.17	-0.23	-0.08
	(0.05)	(0.07)	(0.07)	(0.06)	(0.07)	(0.08)	(0.05)
swap(-1)	0.07	0.13	0.21	0.06	0.13	0.16	0.07
	(0.03)	(0.05)	(0.05)	(0.04)	(0.05)	(0.06)	(0.03)
fundingsp(-1)	0.06	0.11	0.22	0.02	0.04	0.08	0.06
	(0.09)	(0.05)	(0.06)	(0.03)	(0.05)	(0.05)	(0.03)
Δswap	0.88	0.68	0.65	0.03	0.31	0.35	0.53
	(0.14)	(0.11)	(0.16)	(0.10)	(0.16)	(0.13)	(0.08)
Δswap(-1)	-0.25	0.14	0.40	0.78	0.68	0.32	0.27
	(0.19)	(0.15)	(0.22)	(0.13)	(0.2)	(0.16)	(0.12)
Δswap(-2)	-0.03	0.09	-0.26	0.09	-0.44	-0.10	-0.22
	(0.16)	(0.14)	(0.20)	(0.15)	(0.18)	(0.14)	(0.12)
Δfundingsp	-0.42	-0.08	-0.05	0.13	0.13	0.08	-0.02
	(0.2)	(0.1)	(0.13)	(0.1)	(0.13)	(0.10)	(0.08)
Δfundingsp(-1)	0.05	0.26	-0.02	-0.08	-0.06	-0.36	-0.01
	(0.2)	(0.1)	(0.14)	(0.10)	(0.14)	(0.10)	(0.08)
Δfundingsp(-2)	-0.48	-0.24	-0.43	0.03	-0.05	0.15	-0.13
	(0.2)	(0.10)	(0.14)	(0.10)	(0.13)	(0.1)	(0.08)
CONSTANT	0.01	0.02	-0.12	0.10	0.12	0.20	-0.01
	(0.13)	(0.09)	(0.13)	(0.10)	(0.16)	(0.11)	(0.08)
DIAGNOSTICS							
Adj R^2	0.42	0.56	0.49	0.61	0.38	0.38	0.66
AR 1-2 (F)	0.79	2.29	1.69	1.69	0.68	0.83	2.29
	[0.46]	[0.11]	[0.19]	[0.19]	[0.51]	[0.44]	[0.11]
NORM (χ^2)	21.3	10.23	68.71	5.45	16.02	7.11	7.68
	[0.00]**	[0.01]**	[0.00]**	[0.07]	[0.00]**	[0.03]*	[0.02]*
Hetero (F)	1.06	1.55	3.46	1.80	2.86	1.13	8.00
	[0.41]	[0.08]	[0.00]**	[0.03]*	[0.00]**	[0.33]	[0.00]**

(standard errors of coefficients in parentheses)

[24] Regression also contained additional mortgage rate dynamic terms as explanatory variables, which for conciseness we do not report.

Table C – Estimated pass-through of a change in <u>relative</u> funding costs to <u>relative</u> mortgage rates

Dependent variable is $\boldsymbol{\Delta \text{rate } i - 0.2 \sum_{j \neq i} \Delta \text{rate } j}$

Estimation Period: April 2005 – December 2013

	All variables represent deviations from average of other 5 banks					
	Bank A	**Bank B**	**Bank C**	**Bank D**	**Bank E**	**Bank F**
ECM						
$\text{rate } i(-1) - 0.2\sum_{j \neq i} \text{rate } j(-1)$	-0.25	-0.25	-0.20	-0.48	-0.14	-0.10
	(0.08)	(0.08)	(0.06)	(0.11)	(0.05)	(0.05)
$\text{fundingsp } i(-1) - 0.2\sum_{j \neq i} \text{fundingsp } j(-1)$	-0.01	0.00	***0.42***	0.06	-0.12	0.01
	(0.05)	(0.06)	***(0.16)***	(0.05)	(0.09)	(0.07)
$\Delta\text{rate } i(-1) - 0.2\sum_{j \neq i} \Delta\text{rate } j(-1)$	0.05	0.02	0.08	0.13	0.08	-0.02
	(0.11)	(0.11)	(0.1)	(0.11)	(0.1)	(0.1)
$\Delta\text{rate } i(-2) - 0.2\sum_{j \neq i} \Delta\text{rate } j(-2)$	-0.03	0.00	0.03	-0.01	0.01	-0.10
	(0.1)	(0.1)	(0.1)	(0.1)	(0.1)	(0.1)
$\Delta\text{fundingsp } i - 0.2\sum_{j \neq i} \Delta\text{fundingsp } j$	0.05	0.05	-0.33	0.25	0.02	0.32
	(0.2)	(0.14)	(0.31)	(0.17)	(0.32)	(0.23)
$\Delta\text{fundingsp } i(-1) - 0.2\sum_{j \neq i} \Delta\text{fundingsp } j(-1)$	0.11	-0.09	-0.13	-0.02	-0.03	-0.22
	(0.2)	(0.14)	(0.33)	(0.16)	(0.32)	(0.23)
$\Delta\text{fundingsp } i(-2) - 0.2\sum_{j \neq i} \Delta\text{fundingsp } j(-2)$	0.02	0.18	-0.14	0.00	0.38	0.43
	(0.2)	(0.14)	(0.33)	(0.17)	(0.32)	(0.23)
CONSTANT	0.03	-0.02	0.06	-0.08	0.04	0.00
	(0.03)	(0.02)	(0.03)	(0.02)	(0.03)	(0.03)
Adj R^2	0.06	0.08	0.09	0.19	0.02	0.04

(standard errors of coefficients in parentheses)

Annex C: Additional Tests

Table A: Unit root tests (Augmented Dickey Fuller Tests)

Series	t-Stat	P-value
1 year swap rate	-1.26	0.647
2 year swap rate	-1.13	0.700
Bank D 1 year fixed rate bond	-1.25	0.651
Bank A 2 year mortgage rate	-0.59	0.867
Bank A CDS	-2.04	0.270
Bank A senior unsecured	-2.36	0.154
Bank B 1 year fixed rate bond	-0.62	0.859
Bank B 2 year mortgage rate	-0.36	0.910
Bank B CDS	-1.77	0.393
Bank B senior unsecured	-1.69	0.433
Bank C 1 year fixed rate bond	-1.03	0.740
Bank C 2 year mortgage rate	-0.78	0.821
Bank C CDS	-1.69	0.433
Bank C senior unsecured	-1.64	0.458
Bank D 1 year fixed rate bond	-1.11	0.709
Bank D 2 year mortgage rate	-0.32	0.916
Bank D CDS	-1.30	0.626
Bank D senior unsecured	-2.17	0.219
Bank E 1 year fixed rate bond	-0.88	0.790
Bank E 2 year mortgage rate	-0.40	0.903
Bank E CDS	-1.62	0.469
Bank E senior unsecured	-1.60	0.479
Bank F 1 year fixed rate bond	-1.06	0.730
Bank F 2 year mortgage rate	-0.82	0.809
Bank F CDS	-1.49	0.536
Bank F senior unsecured	-1.94	0.314

Table B – Testing for weak exogeneity of market funding rates with respect to mortgage rates using a 3-variable VECM with 1 lag and 1 cointegrating equation

Bank	Dependent variable		
	d(rate)	**d(swap)**	**d(CDS)**
Bank A	-0.294 [-4.77]	-0.0149 [-0.26]	0.0510 [-1.28]
Bank B	-0.139 [-3.46]	0.0299 [0.89]	0.0698 [1.84]
Bank C	-0.110 [-3.89]	0.0295 [1.70]	-0.00129 [-0.07]
Bank D	-0.0770 [-2.49]	0.0250 [0.87]	0.0278 [1.02]
Bank E	-0.0352 [-2.05]	0.0290 [2.09]	0.0135 [0.83]
Bank F	-0.180 [-3.18]	0.0240 [0.52]	0.0727 [1.25]

For the VECM corresponding to each bank, the table shows coefficients on the estimated cointegrating equation [t-statistics in parenthesis]

Table C – Testing for weak exogeneity of market funding rates with respect to deposit rates using a 3-variable VECM with 1 lag and 1 cointegrating equation

Bank	Dependent variable		
	d(rate)	**d(swap)**	**d(CDS)**
Bank A	-0.162 [-2.98]	-0.0882 [-2.64]	0.0353 [1.44]
Bank B	-0.0261 [-0.45]	0.111 [2.31]	0.167 [3.15]
Bank C	-0.0273 [-1.59]	0.0201 [2.09]	0.0139 [1.25]
Bank D	-0.0563 [-1.21]	-0.0247 [-0.48]	0.140 [2.90]
Bank E	-0.125 [-2.03]	-0.0974 [-2.46]	0.0630 [1.31]
Bank F	-0.153 [-2.44]	0.134 [2.77]	0.280 [4.42]

For the VECM corresponding to each bank, the table shows coefficients on the estimated cointegrating equation [t-statistics in parenthesis]