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Simple banking: profitability and the yield curve

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Abstract

How does bank profitability vary with interest rates? We present a model of a monopolistically competitive bank subject to repricing frictions, and test the model's predictions using a unique panel data set on UK banks. We find evidence that large banks retain a residual exposure to interest rates, even after accounting for hedging activity operating through the trading book. In the long run, both level and slope of the yield curve contribute positively to profitability. In the short run, however, increases in market rates compress interest margins, consistent with the presence of non negligible loan pricing frictions.

JEL classification: E4, G21.

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Summary

This paper examines the relationship between bank profitability and interest rates. Understanding this link is important for policymakers. If interest rates have a systematic effect on bank profitability, and if in the short run profitability is a major determinant of bank capital, it follows that monetary policy may have implications for the resilience of the financial system. We investigate the effects of interest rates on profitability using a new, unique panel data set containing information on the UK activities of UK and foreign banking groups for 1992–2009. We find evidence of a systematic effect of market interest rates on bank profitability. In the long run, high yields and a steep yield curve boost banks' income margins. In the short run, though, an increase in short-term yields depresses income, which is consistent with the presence of frictions affecting the repricing of banks' assets and liabilities in an asymmetric way.

We begin with a simple theoretical model of a bank which is subject to credit and interest rate risk, which chooses its interest margin to maximise expected profits. The model provides us with a number of testable implications. First, in equilibrium the net interest margin (NIM) is likely to be positively related to short-term interest rates, as banks raise their loan rates and shrink their lending quantities in response to higher market rates. Second, the short-run and long-run effects of interest rates can differ. In particular, if banks borrow short and lend long, and if their interest rates are not fully flexible in the short run, banks will be exposed to 'repricing' risk. The combination of maturity mismatch and repricing frictions is indeed a popular explanation for why sharp changes in interest rates might compress bank profits.

We find that high interest rates are associated with large interest income margins, as predicted by the model. We also find that the slope of the yield curve matters positively for interest income: after all, banks indeed seem to borrow short and lend long. The short-run impact of an increase in short-term market rates, however, is negative. This is consistent with the existence of significant repricing frictions that prevent banks from implementing their pricing decisions instantaneously. We also find that level and slope of the yield curve affect the net interest margin and trading income in opposite directions, which suggests that banks hedge interest rate risk through derivatives. Even after accounting for hedging, however, large banks appear to retain a residual exposure to UK interest rates: the interest rate effects in the banking book 'pass through'

into operating profitability. Thus monetary policy – set for the economy as a whole – appears to have systematic effects on bank profitability, providing one potential motivation for the use of macroprudential policy tools.

We present two applications of our estimated model. First, we explore the interaction of level and slope effects and short and long-run multipliers by running a 'monetary policy shock' through the model. A typical policy tightening raises short-term rates and flattens the yield curve, thus depressing banks' income through two distinct channels. This effect is fairly short-lived, and somewhat attenuated by hedging. Higher rates have an unambiguously positive effect on bank profits in the long run. Second, we use our estimated NIM equation to decompose the sources of profitability since 1992, examining the model-implied contributions of the level and slope of the yield curve to the average net interest margin over the sample.

> ‘The business of banking ought to be simple; if it is hard it is wrong’ (Bagehot 1873, Ch. IX).

1 Introduction

What is the relationship between profitability and interest rates? This is an old question, but one on which the events of the last three years and the debate on macroprudential policy cast an entirely new light. If interest rates have a systematic effect on bank profitability, and if in the short run profitability is a major determinant of bank capital, it follows that monetary policy may have implications for financial system resilience. For central banks with dual objectives, this might reinforce the case for having two sets of instruments: one set to manage the balance between demand and supply, and another to enhance financial stability. This paper provides evidence on the first step in this chain of reasoning. We investigate the effects of interest rates on profitability using a new, unique panel data set containing information on the UK activities of UK and foreign banking groups for 1992–2009. We find evidence of a systematic effect of market interest rates on bank profitability. In the long run, high yields and a steep yield curve boost banks’ income margins. In the short run, though, an increase in short-term yields depresses income, which is consistent with the presence of frictions affecting the repricing of banks’ assets and liabilities in an asymmetric way.

Maturity and credit transformation lie at the core of banking: borrow short, lend long, and earn a spread on the difference. As in Bagehot’s times, net interest income derived from the banking book is crucial to overall profitability. But as the crisis of 2008 has shown, modern banking involves a lot more besides. It entails a number of complementary income-generating activities, most of which are likely to be affected by changes in interest rates. Trading income is an important case in point. It is not only quantitatively significant, but also affected by hedging activities intended to manage interest rate risk generated in the banking book, *inter alia*. Answering our question thus calls for an ‘holistic’ approach whereby the effects of trading activities are accounted for in drawing conclusions about the behaviour of headline net profitability.

We begin with a simple partial equilibrium theoretical model of a bank which chooses its interest margin to maximise expected profits, accounting for repricing frictions. The model follows the banking sector in Gerali *et al* (2010), and provides us with a number of testable implications. In equilibrium, the net interest margin (NIM) is likely to be positively related to short-term interest rates, as banks raise their loan rates and shrink their lending quantities in response to higher funding costs. But short-run and long-run effects can differ. In particular, if banks borrow short and lend long, and if their interest rates are not fully flexible in the short run, banks will be exposed to 'repricing' and 'yield curve' risk (BCBS (2006)). The combination of maturity mismatch and repricing frictions is indeed a popular explanation for why sharp changes in interest rates might be negatively affect bank profits, and a crucial ingredient in the 'bank capital view' of the transmission of monetary policy (eg Van den Heuvel (2007) and Gambacorta and Mistrulli (2004)). Taking the model to the data allows us to test the empirical relevance of this mechanism in a context where the long-run implications of a change in interest rates are linked to an explicit behavioural model, and hedging is fully taken into account. To our knowledge, such an analysis has not been attempted yet.

We find that high interest rates are associated with large interest income margins, as predicted by the model. We also find that the slope of the yield curve matters positively for interest income: after all, banks indeed seem to borrow short and lend long. The short-run impact of an increase in short-term market rates, however, is negative. This is consistent with the existence of significant repricing frictions that prevent banks from implementing their optimal pricing decisions instantaneously. Thanks to the coexistence of (a) level and slope effects and (b) distinct long and short-run multipliers, our model provides a rich picture of the implications of a change in the yield curve on banks' net interest margins. We also find that level and slope of the yield curve affect the net interest margin and trading income in opposite directions, which suggests that banks hedge interest rate risk through derivatives. Even after accounting for hedging, however, large banks appear to retain a residual exposure to UK interest rates: the interest rate effects in the banking book 'pass through' into operating profits. Thus monetary policy – set for the economy as a whole – has systematic effects on bank profitability, providing one motivation for macroprudential instruments.

We present two applications of our estimated model. First, we explore the interaction of level and slope effects and short and long-run multipliers by running a 'monetary policy shock' through the model. We use a medium-size Bayesian Vector Autoregression (BVAR) to identify structural monetary policy shocks, and use the impulse responses to trace the path for bank profitability implied by our microeconometric estimates. A typical policy tightening raises short-term rates and flattens the yield curve, thus depressing banks' income through two distinct channels. This effect is fairly short-lived, and somewhat attenuated by hedging. Higher rates have an unambiguously positive effect on bank profits in the long run.

Second, we use our estimated NIM equation to decompose the sources of profitability since 1992. Our results suggest that the decline in interest rates over the period contributed strongly to a compression in bank margins. Within the period, we find evidence that banks found alternative ways of maintaining return on equity, providing a link between our paper and the growing literature on the 'risk-taking channel' of monetary policy (eg Borio and Zhu (2008)), and pointing to the potential use of macroprudential policy to address banks' responses.

The remainder of this paper proceeds as follows. In the next section we relate our work to the literature. Section 3 presents a simple theoretical model of banks' NIMs. Sections 4 and 5 discuss our unique data set and our empirical approach. Section 6 presents our key findings which relate nominal rates to NIMs. Section 7 explores the effects of different components of nominal rates on NIMs. The final impact of interest rates on profitability is assessed in Section 8, we present two applications of our model in Section 9, and conclude in Section 10.

2 Related literature

A number of papers study the impact of macroeconomic dynamics and changes in the structure of the banking sector on bank profitability. As Albertazzi and Gambacorta (2009) note, the co-evolution of these variables is of renewed interest given a new focus on macroprudential policy among central banks and academics interested in systemic stability (Borio and Shim (2007), Bank of England (2009) and Hanson *et al* (2010)). Much of the literature pre-dates the recent financial turmoil. Examples include Flannery (1981), Hancock (1985), Bourke (1989), Demirguc-Kunt and Huizinga (1999), Saunders and Schumacher (2000), Corvoisier and Gropp (2002), Lehmann and Manz (2006) and Beckmann (2007). Not surprisingly, the role of interest rates has received significant attention. Most papers document the existence of a positive correlation between long rates, or long to short-rate spreads, and banks' profits or interest income margins, which is typically interpreted as a consequence of their maturity transformation function.

For short-term interest rates (typically taken to be three-month Treasury bill yields) the conclusions are more ambiguous. Demirguc-Kunt and Huizinga (1999) find for instance that high rates boost profits, particularly in emerging market economies; Hancock (1985) finds that the correlation is negative in the United States; and Albertazzi and Gambacorta (2009) examine a group of OECD countries concluding that short-term interest rates have no significant impact on income margins.[1] Gambacorta (2008) studies the price-setting behaviour of a group of large Italian banks looking directly at the average interest rates on loans and deposits. The two rates are found to respond in a similar fashion to a short-term market rate in the short run, but the long-run pass-through is approximately unity for the loan rate and 0.7 for the deposit rate, which implies a positive effect of market rates on the spread earned by banks in equilibrium. As we will see, this result also emerges from our study, and we provide a theoretical explanation for it. Consistent with Hancock (1985), we find that income is affected by relative movements of interest rates at different maturities. Furthermore, we find that changes in rates of any given maturity can have radically different short and long-run implications for banks' interest margins. The short-run dynamics provide evidence of a 'bank capital channel' for monetary policy (eg Van den Heuvel (2007) and Gambacorta and Mistrulli (2004)). Taken together, our results confirm that taking into account the maturity profile and the dynamics of the adjustment is necessary in order to describe accurately the transmission mechanism, and suggest that some of the discrepancies documented in the literature could be explained by differences in the treatment of these two phenomena.

Maturity transformation exposes banks to interest rate risk which can be mitigated in various ways. First, banks can hedge interest rate risk by holding interest rate derivatives in the trading book. Flannery (1981) finds that large banks effectively hedge market rate risk by assembling asset and liability portfolios with similar average maturities. Gorton and Rosen (1995) find a similar offsetting movement between the value of interest rate derivatives and banking book income flows, noting that commercial banks as a whole appear to take the same side in derivatives contracts. More recently, Purnanandam (2007) finds the tendency to hedge risk to be stronger for banks more exposed to financial distress. The use of derivatives is also found to

[1] A further complication is that it is not possible to focus on 'first moments' only: volatility matters as well. Saunders and Schumacher (2000) argue that risk aversion and uncertainty on transaction volumes generate a positive relationhip between banks' margins and interest rate volatility, and document that this was indeed the case for EU and US banks in the early 1990s. This channel is not the focus of this paper, but we control for it in our empirical analysis.

confer immunity to monetary policy shocks. A second way in which banks can eliminate overall income risk is by diversifying their income structures. For some time there was a view that sources of non-interest income may provide a diversification benefit to banks (eg through fees and commissions on banking or trading activities). Evidence in Smith *et al* (2003), Stiroh (2004), Stiroh and Rumble (2006), and Lepetit *et al* (2008) casts doubt on this view: non-interest income may not reduce overall income risk if it is associated with inherently risky trading activities. Consistent with these studies, we take an holistic view of UK banks' income-generating activities and assess the extent to which non banking book income flows help to reduce the cyclicality of bank income, and particularly its sensitivity to interest rates. Our data suggests that these mitigating factors played a role in the United Kingdom, but did not completely compensate the traditional interest income channel: interest rates matter for the profitability of modern, sophisticated banks as well as for traditional banks.

Our work, and the key question that motivates it, is relevant to a wider research agenda on banks and the macroeconomy. Banks' pricing behaviour is central to the way they interact with the rest of the economy. Gerali *et al* (2010) develop and estimate a DSGE model with an imperfectly competitive banking sector, a key feature of which is an imperfect pass-through from policy rates to loan rates due to pricing frictions. They find that banks attenuate the impact of monetary policy shocks, mostly because of stickiness in interest rates. We study their framework in partial equilibrium below. A similar conclusion is reached by Andreasen *et al* (2012), who extend the Gertler-Karadi (2011) model to include maturity transformation, and find that this feature significantly reduces the response of the economy to both productivity and monetary policy shocks.[2] Maturity transformation and pricing frictions are also important ingredients in the literature on interest rate risk. Drehmann *et al* (2010) and Alessandri and Drehmann (2010) develop a model where risk-neutral banks price loans subject to a known repricing schedule and stochastic fluctuations in interest rates and default frequencies, examining the interaction between credit and interest rate risk and its implications for the capital buffer of a representative bank. A similar model is embedded in RAMSI, a systemic risk model currently used at the Bank of England (Alessandri *et al* (2009), Aikman *et al* (2009)); the channel is of obvious relevance from a systemic perspective given that interest rate risk is not fully diversifiable in the aggregate. The microeconometric evidence discussed in this paper provides support for some of the assumptions

[2]Interestingly, the findings of both Gerali *et al* (2010) and Andreasen *et al* (2012) are at odds with Van den Heuvel's (2007) 'bank capital view': in Van den Heuvel's partial equilibrium model, maturity transformation amplifies monetary policy shocks. Andreasen *et al* (2012) discuss the reasons behind this difference.

that underpin these models, and can in principle be used to calibrate some of their parameters.

A related, important mechanism through which interest rates can affect bank behaviour is highlighted by the 'risk-taking channel' literature. Loose monetary policy can stimulate risk-taking through a 'search for yield' effect, possibly reinforced by explicit nominal return targets, or through its effects on asset prices and leverage (Borio and Zhu (2008), and Adrian and Shin (2009)). Using a range of asset price based measures of bank risk, Gambacorta (2008) and Altunbas *et al* (2010) find significant evidence of a risk-taking channel operating in the United States and in the euro area in the 1999-2009 period, with low interest rates being associated to higher expected default frequencies. The increase in risk was more pronounced for banks that actively engaged in securitisation (Altunbas *et al* (2010) and Delis and Kouretas (2011)). De Nicolo *et al* (2010) discuss an additional, countervailing mechanism linked to risk-shifting. If low market rates translate one to one into lower deposit rates but are not entirely passed through to loan rates, they will boost a bank's profits and increase its franchise value, weakening the risk-shifting motive (a more profitable bank has more to lose from a default, and will *ceteris paribus* adopt a more prudent behaviour). We share with this strand of work the conclusion that nominal interest rates matter for banks. Our results, like those in Gambacorta (2008), are consistent with an asymmetric pass-through to deposit and loan rates. Furthermore, we find that this asymmetry in the response of banks' interest income margins is not removed or compensated by either hedging or income diversification.

3 Theory

3.1 Model set-up

In Gerali *et al* (2010), the economy is populated by monopolistically competitive banks that supply differentiated loans to final borrowers and issue differentiated deposits to households. Consider a simple version of this model in partial equilibrium.[3] For expositional purposes, it is useful to divide a given bank j's operations into three branches: a loan branch, deposit branch, and a management branch. The bank is subject to an exogenous capital ratio target υ, deviations from which incur a quadratic cost. It is the management branch's job to moderate the scale of the bank's operations in order to comply with its capital target.

[3] Gerali *et al* allow final borrowers to be either households or firms. To simplify matters, we consider one type of final borrower here.

Write the balance sheet of the management branch as

$$B_t(j) = D_t(j) + K_t(j), \quad \textbf{(1)}$$

where B denotes loans, D denotes deposits, and K denotes bank capital. The management branch makes loans of $B_t(j)$ to the loan branch at an 'internal' interest rate of R_t^b, which in turn makes loans of $b_t(j)$. Hence the loan branch's balance sheet reads simply:

$$B_t(j) = b_t(j).$$

The objective of the loan branch is to choose its loan rate $r_t^b(j)$ to maximise its expected discounted profits. It is subject to a standard 'differentiated products' loan demand curve:

$$b_t(j) = \left(\frac{r_t^b(j)}{r_t^b}\right)^{-\varepsilon_b} b_t,$$

where b_t is the aggregate quantity of loans, $r_t^b \equiv \left[\int_0^1 r_t^b(j)^{1-\varepsilon_b} dj\right]^{1/(1-\varepsilon_b)}$ is the CES aggregate of economy-wide loan rates, and $\varepsilon_b > 1$ is the elasticity of substitution. The bank is subject to quadratic loan price adjustment costs *à la* Rotemberg, parametrised by $\kappa_b > 0$, such that its objective is to solve:

$$\max_{\{r_t^b(j)\}} \mathbb{E}_0 \sum_{t=0}^{\infty} \beta^t \left[r_t^b(j) b_t(j) - R_t^b B_t(j) - \frac{\kappa_b}{2}\left(\frac{r_t^b(j)}{r_{t-1}^b(j)} - 1\right)^2 r_t^b b_t \right],$$

where β is the bank's rate of time preference. In a symmetric equilibrium (dropping the j index), the loan branch's first-order condition is:

$$1 - \varepsilon_b + \varepsilon_b \frac{R_t^b}{r_t^b} - \kappa_b \left(\frac{r_t^b}{r_{t-1}^b} - 1\right)\frac{r_t^b}{r_{t-1}^b} + \beta\kappa_b \mathbb{E}_t\left[\left(\frac{r_{t+1}^b}{r_t^b} - 1\right)\left(\frac{r_{t+1}^b}{r_t^b}\right)^2 \frac{b_{t+1}}{b_t}\right] = 0, \quad \textbf{(2)}$$

which governs the dynamics of the loan rate. In steady state, the first-order condition simply reduces to:

$$r^b = \frac{\varepsilon_b}{\varepsilon_b - 1} R^b,$$

such that the loan branch charges a markup over its internal cost of funds, R^b.

The deposit branch faces an analogous problem to the loan branch. It issues $d_t(j)$ differentiated deposits subject to elasticity of substitution $\varepsilon_d < -1$ and deposit rate adjustment costs parametrised by κ_d to maximise its expected discounted flow of profits. It then lends these deposits to the management branch at internal rate R_t^d, such that $D_t(j) = d_t(j)$. Assume the alternative for the deposit branch is to lend at the interbank rate set by the central bank r_t. Then by arbitrage $r_t = R_t^d$. Using this, the deposit rate first-order condition then takes an analogous form to equation **(2)**, such that in a symmetric equilibrium:

$$-1+\varepsilon_d-\varepsilon_d\frac{r_t}{r_t^d}-\kappa_d\left(\frac{r_t^d}{r_{t-1}^d}-1\right)\frac{r_t^d}{r_{t-1}^d}+\beta\kappa_d\mathbb{E}_t\left[\left(\frac{r_{t+1}^d}{r_t^d}-1\right)\left(\frac{r_{t+1}^d}{r_t^d}\right)^2\frac{d_{t+1}}{d_t}\right]=0.$$

Once more, in steady state,

$$r^d=\frac{\varepsilon_d}{\varepsilon_d-1}r,$$

such that the deposit rate is a mark down on the rate set by the central bank.

Finally, the management branch has to choose the scale of operations so as to satisfy the capital target υ. In particular, accounting for quadratic costs of deviating from its capital target, the management branch's problem is to solve:

$$\max_{B_t(j)} R_t^b B_t(j)-r_t\left[B_t(j)-K_t(j)\right]-\frac{\kappa}{2}\left(\frac{K_t(j)}{B_t(j)}-\upsilon\right)^2 K_t(j),$$

where we have used the balance sheet constraint to eliminate $D_t(j)$. The first-order condition is

$$R_t^b(j)=r_t-\kappa\left(\frac{K_t(j)}{B_t(j)}-\upsilon\right)\left(\frac{K_t(j)}{B_t(j)}\right)^2,$$

which defines the spread over the interbank rate that the management branch charges the loan branch to recoup the costs of deviating from the capital ratio target. Note that in steady state, when the bank attains its target capital ratio, $R^b(j)=r$.

The bank's capital evolves according to (omitting the j index):

$$K_t=(1-\delta)K_{t-1}+\Pi_t,$$

where δ is the return on equity, and where the consolidated bank's final profits are given by:

$$\Pi_t=r_t^b b_t-r^d d_t-\frac{\kappa}{2}\left(\frac{K_t}{b_t}-\upsilon\right)^2 K_t-\frac{\kappa_b}{2}\left(\frac{r_t^b}{r_{t-1}^b}-1\right)^2 r_t^b b_t-\frac{\kappa_d}{2}\left(\frac{r_t^d}{r_{t-1}^d}-1\right)^2 r_t^d d_t.$$

In this partial equilibrium version of the model, the bank attains its target capital ratio in steady state when the return on equity satisfies:

$$\delta^{-1}=\frac{\upsilon}{r^b-r+\upsilon r}.$$

The model is closed by positing an aggregate demand curve for loans, $b_t(r_t^b)$. In Gerali *et al*, this is given by a binding loan to value (LTV) ratio, which in partial equilibrium can be written:

$$b_t(1+r_t^b)=m_t,$$

where the right-hand side is the LTV ratio times the value of collateral that final borrowers are able to pledge.

3.2 Maturity mismatch and dynamics of the net interest margin

The loan and deposit rate adjustment cost parameters κ_i, $i = b, d$, in Gerali *et al*'s model can be thought of a reduced-form way of capturing *maturity mismatch*. To see this, consider a bank that can reprice some fraction $1 - \eta_b$ $(1 - \eta_d)$ of its loans (debt) each quarter, by analogy with Calvo sticky price adjustment. Then it is well known that the Rotemberg parameter κ_i, $i = b, d$ is related to this repricing frequency according to:

$$\kappa_i = \frac{(\varepsilon_i - 1)\,\eta_i}{(1 - \eta_i)(1 - \beta\eta_i)},$$

(see eg Keen and Wang (2007)), where β and ε_i are the discount rate and price elasticity as defined above. In this way we may interpret the κ_i parameters, and in particular $\kappa_b - \kappa_d$ as capturing maturity mismatch, since κ_i is monotonically increasing in the fraction of loans (deposits) that can not be repriced, η_i. For example, when the fraction of loans that cannot be repriced goes to unity, κ_b would tend to infinity.

Maturity mismatch will then have implications for the dynamics of the net interest margin (NIM), which in steady state is given by:[4]

$$NIM \equiv r^b - (1 - \upsilon)\, r^d. \qquad \textbf{(3)}$$

Using the steady state expressions for loan and deposit rates, it is clear from equation **(3)** that the steady state NIM is increasing in funding costs, r. As the bank's funding costs rise, it passes these on to final borrowers in the form of higher lending rates. Since this increase in funding costs is scaled by a positive mark-up, the bank's net interest margin must rise as a result. That is, the bank passes on its higher funding costs to final borrowers by more than one-for-one, and it does this owing to its market power:

$$\frac{\partial NIM}{\partial r} = \left(\frac{\varepsilon_b}{\varepsilon_b - 1} - \frac{\varepsilon_d}{\varepsilon_d - 1}\right) + \upsilon\frac{\varepsilon_d}{\varepsilon_d - 1} > 0.$$

In a separate appendix, we show that this prediction naturally arises in a richer, but static, model in which risk-averse banks price loans subject to credit and interest rate risk.[5]

Short-run dynamics will differ, however. If loans are able to be repriced more slowly than deposits, as is the case for a bank performing maturity transformation, then the short-run effect of

[4] Since in steady state we have that $b = d + K$, so $d/b = 1 - \upsilon$.

[5] The model is a modified version of Wong (1997). In this case the credit spread arises because of the bank's risk-taking behaviour, and can be shown to depend positively on banks' expected funding costs.

a rise in funding costs will be to compress the bank's net interest margin. In the most extreme case, no loan contracts can be repriced, whereas all deposit contracts can be.

In general, there will exist a critical level of maturity mismatch μ^*, such that for $\kappa_b - \kappa_d > \mu^*$, the short-run effect of a rise in funding costs will be to *compress* the NIM. Thus in general, the short-run and the long-run impact of a rise in the short rate in the economy will differ in their impacts on the bank's net interest margin. Chart 1 provides a simple simulation of the impulse response of the NIM to a temporary shock to funding costs and provides a simple benchmark against which to judge our empirical results.[6] In this example, a positive, temporary but persistent funding cost shock is experienced by the bank. Its funding costs initially rise by more than its loan rate due to the repricing frictions associated with making long-term loans, compressing the NIM below its steady-state level. This friction is gradually alleviated, the bank raises its loan rate and compresses its loan quantity, boosting the NIM. As the funding cost shock passes, loan and deposit rates return to their steady-state levels.

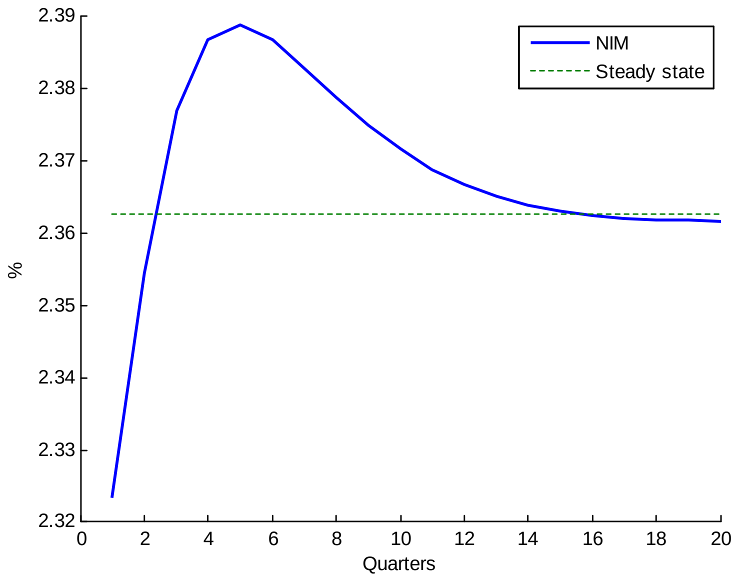
These considerations suggest we should expect the presence of somewhat nuanced dynamics of the NIM in the data if the model captures some of the key aspects of reality. Moreover, the model presents us with some testable implications. First, the *level* of short-term interest rates should matter positively for the steady-state 'long-run' net interest margin. Second, *changes* in short-term interest rates should be negatively related to the net interest margin, which is consistent with banks running maturity mismatched banking books. We turn next to an examination of these dynamics empirically.

4 Data

We use data collected by the Bank of England on a quarterly basis for the UK activities of all deposit-taking UK entities of UK and non-UK resident banks with assets over £5 billion. The data were 'quasi-consolidated' into groups, resulting in 44 active groups over the sample, which runs from 1992 Q1 to 2009 Q3. The proliferation of groups is the result of the convention adopted over the treatment of merger activity. When two banks merge an entirely new entity is

[6] The calibration of the model is as follows: $\beta = 0.99$, $\delta = 0.1049$, $\varepsilon_b = 3.12$, $\varepsilon_d = -1.5$, $\upsilon = 0.09$, $m = 1.0$, $\kappa_k = 11.49$, $r = 0.03$. These values are taken from Gerali *et al*'s estimated model, where applicable. We let the bank reprice 30% of its loans each quarter, and 60% of its debt, calibrating κ_b, κ_d according to the formula in the text. The positive shock to funding costs is temporary and characterised by a simple AR(1) process with an autoregressive parameter equal to 0.66.

Chart 1: Simulated theoretical impulse response of the net interest margin (NIM) to a temporary, persistent funding cost shock. See footnote 6 for a description of the calibration used.



created, while its constituent parts cease to operate separately. As discussed below, we implicitly assume this does not change the basic dynamics of profitability, but allow it to affect the level of the newly created entity's profitability through its individual effect. Note that quasi-consolidation is deliberately distinguished from 'full' consolidation – which properly strips out intra-group activity, and includes income and expenses from non-UK based activities. This has implications for the data we use. In particular, balance sheets will appear inflated to the extent that intra-UK group activity is large, but deflated to the extent that banks have large asset and liability stocks held overseas. Relatedly, profits will be higher (lower) to the extent that losses (gains) are made on overseas operations. We do not therefore expect to be able to match the data with the published accounts of the corresponding banking group. Nor do we expect to be able to capture the transmission channels through which international macroeconomic conditions affect UK-resident banking groups. Note that, in our data, derivatives are netted and recorded as an entry on the liability side of the balance sheet.

In the data reported by banks to the Bank of England, interest income (and interest expense) on loans to (and deposits from) customers is reported on a gross basis, without any income flows relating to the hedging of eg interest rate risk included. All income relating to this type of activity is reported in the trading income returns. We therefore think of the net interest income data as 'unhedged'. Trading income also includes revaluation profits or losses arising from holding trading instruments held on a mark-to-market basis. Such instruments include foreign exchange contracts, traded securities, and derivatives.

In our baseline regressions we present results for the full sample of banks, together with a focus on a subsample of the main UK commercial banks, which contains around 21 quasi-consolidated groups existing over the period 1992-2009 once mergers and acquisitions are accounted for. For net interest income, we also have data on UK building societies. We report results for both groups of institutions separately where appropriate, together with pooled results (which include small foreign-owned UK subsidiaries) for comparison. To the extent that we expect behaviour to differ across groups of institutions, this is interesting economically. For example, large UK banks may be able to cover the fixed costs of trading activities through which, for example, they attempt to hedge interest rate risk. They may therefore be able to take larger interest rate positions through their banking books than small UK building societies, for a given level of risk aversion.

Some simple descriptive statistics appear in Table A for the pooled sample. Net interest income is the largest source of income, around 2.3 times as large as fee income and around 13 times as large as trading income. By far the most volatile source of income is through trading activities: the coefficient of variation for trading income is around 7.3, or 6-7 times as large as that for net interest income and net fee income. Both mean and median operating profit have fallen relative to total assets over the sample period, from around 0.4% in 1992 to around 0.2% in 2008. This reflects declines in both NIM and fee income. Trading income, for which we have data from only 1997 Q1 onwards, was volatile throughout the sample period – the only obvious cyclical pattern being the large fall around the crisis period of 2008. We turn next to more formal econometric evidence.

5 Empirical approach

5.1 Econometric model and estimation strategy

The question of how to treat (a) heterogeneity and (b) dynamics is particularly delicate in our case. Both of these features are important *a priori*: bank characteristics can differ significantly along many dimensions, and banks obviously operate in a dynamic environment which can generate rich correlation structures in their cash flow and balance sheet indicators, especially at a quarterly frequency. Furthermore, our panel is unbalanced, is one in which both N and T are reasonably large, and has T larger than N. A number of different estimators with different bias and variance characteristics can be used in this context. Rather than relying exclusively on a single supposedly 'optimal' estimation strategy, we explore the data using a range of alternatives. To some extent these approaches are complementary.

Our empirical analysis is based on the following general specification:

$$y_{it} = \alpha y_{it-1} + \beta' X_{it} + \gamma' M_t + \varepsilon_{it}, \quad |\alpha| < 1, \tag{4}$$

$$\varepsilon_{it} = \eta_i + \upsilon_{it},$$

where, for every bank $i = 1, ..., N$ at time $t = 1, ...T$, $y_{it} \equiv Y_{it}/A_{it-1}$ represents income component Y_{it} normalised by (lagged) total assets, X_{it} is a vector of bank-specific controls, M_t is a vector of macroeconomic variables, η_i is a bank effect, and υ_{it} is an idiosyncratic disturbance. It is well known that the OLS estimate of α is inconsistent when T is not large – since y_{it-1} is correlated with the disturbance term $(\eta_i + \upsilon_{it})$. Standard results for omitted variable bias indicate that, even in large samples, the OLS estimate of α is biased upwards (see Bond (2002)). The within-groups estimator eliminates this inconsistency by transforming the equation to eliminate η_i, *viz.*, by taking differences relative to means. The within-groups estimator is biased downwards however – such that OLS estimator and the within-groups estimator are likely to be biased in opposite directions.

The generalised method of moments (GMM) estimator proposed by Arellano-Bond (1991), and the 'system' GMM extension developed by Arellano-Bover-Blundell-Bond (1995, 1998), do not have these limitations. The latter has well-documented advantages when the data is highly persistent.[7,8] This is an extremely desirable feature in our context, because our data set includes various macroeconomic series of which some (including, crucially, interest rates) display strong autoregressive behaviour.

These estimators were developed for 'large N, small T' panels, however. Deviations from 'large N, small T' can result in small sample biases that make the asymptotic properties of the System GMM approach essentially irrelevant. The bias can affect the estimates of both coefficients and standard errors, but can also invalidate Hansen's specification test, which makes the problem extremely hard to detect (Roodman (2009)). It is difficult to establish in an abstract sense whether this is a serious limitation in our case. We prefer instead to report results using a range of estimation techniques which, together with knowledge of the asymptotic properties of the different estimators, can be used to draw conclusions that are robust across specifications.

In most cases our preferred set of estimates is based on a System GMM estimation where the instrument count is controlled by adopting an extremely parsimonious model specification and by collapsing the instrument set as advocated by Roodman (2009). Where appropriate, we report the instrument count and the 'average T' for each group in each model. But as a cross-check, we also present estimates based on a range of specifications and compare these to pooled OLS and within-group (fixed-effect) estimation results.

The discussion so far assumes that heterogeneity is limited to the fixed effect η_i. In Section 5.4 we exploit the moderately 'large T' nature of our panel to relax this assumption and explore more general specifications where other elements of the parameter vector $\left(\alpha, \beta', \gamma'\right)$ are allowed to vary across units.

[7]With persistent (near-random walk) series, lagged levels are poor instruments for differences. Instrumental variables estimators can be subject to serious finite sample bias when the instruments used are weak (Blundell and Bond (1998)). In this context, lagged differences may be better used as instruments for levels. This suggests the use of a 'System' GMM approach which estimates both differenced equations using lagged levels as instruments, together with levels equations using lagged differences as instruments. The levels equation provides an additional set of moment conditions which can also be tested using a Sargan test.

[8]Where the idiosyncratic errors display AR(1) dynamics, lagged levels dated $t-2$ may not be valid instruments. This can be accommodated by taking an extra lag of the instrument set used in both the 'difference' and the 'levels' equations, the validity of which can, of course, be tested.

5.2 Explanatory variables

Throughout, we use the following common set of explanatory variables. The bank-specific regressors we use are leverage (LEV, defined as the ratio of debt to total assets) and balance sheet growth (GTA defined as the growth rate of total assets). On the macro side, we use real quarterly UK GDP growth (GDP) to capture real activity. The interest rate measures we use are three-month government borrowing rates (R^{3m}), ten-year government rates (R^{10y}), which we use to construct a measure of the yield curve slope ($SLOPE = R^{10y} - R^{3m}$), and three-month Libor volatility (VOL^{libor}) (quarterly, annualised). We consider alternative measures of short rates and yield curve slope as robustness checks. First, we use the three-month interbank rate (R^{ib}) as an alternative measure of short rates, and we use the three-year government rate to construct an alternative measure of slope ($SLOPE^{3y}$). Second, we include measures of short rates and slope derived from a Nelson-Siegel yield curve model ($NSshort$ and $NSSlope$ respectively). In our trading income regressions, we also use the three-month interbank spread ($IBSpread$). Other macro regressors include FTSE volatility (VOL^{FTSE}) (quarterly, constructed from daily returns, then annualised), FTSE volume growth ($GFTSEvolume$), a sterling exchange rate index volatility measure (VOL^{ERI}) (constructed as the FTSE measure), and a Herfindahl index capturing sector concentration ($CONC$).[9]

Under System GMM, by default we treat bank-specific variables X_{it} (eg leverage, asset growth) as endogenous in choosing our instrument set,[10] but assume that the macroeconomic series M_t are exogenous to the models.[11] The validity of these assumptions can be formally tested as long as the models are overidentified.

We allow lags of both long and short interest rates to enter our estimating equations. We parametrise the interest rate terms to yield a particularly appealing form. In particular, our

[9]This is constructed as the sum of the squared shares of each bank in the total assets of all banks, such that $H_t = \sum_{i=1}^{N} \left(\frac{A_i}{\sum_j A_j} \right)^2$. We smooth the series over the previous four quarters to capture the idea that the effects of competition may be slow-moving.

[10]Hence the assumption is that the elements of X_{it} are correlated with v_{it} and earlier, but uncorrelated with v_{it+1} and subsequent shocks. Then treat X_{it} as y_{it-1}: difference and use lags X_{it-2}, X_{it-3}, ... (as in the case of y) in the difference equation, while using lagged differences as instruments in the levels equation.

[11] M_t is treated as strictly exogenous, ie is uncorrelated with all past, present and future values of v_{it}. Then all values of M_t are available as instruments.

explanatory variables include

$$\beta_0 R_t^{3m} + \sum_{j=0}^{k} \beta_j^{\Delta} DR_{t-j}^{3m} + \gamma_0 SLOPE_t + \sum_{j=0j}^{k} \gamma_j^{\Delta} DSLOPE_{t-j},$$

where $\left(\beta_0, \gamma_0, \beta_j^{\Delta}, \gamma_j^{\Delta}\right)$, $j = 0, ..., k$ are coefficients to be estimated and D is the difference operator. This permits a clear separation between short rate and yield curve slope effects (through R^{3m} and $SLOPE$ respectively), together with a separation of long-run and short-run effects through levels terms (R^{3m}, $SLOPE$) and changes terms (DR^{3m}, $DSLOPE$) respectively.

6 The impact of interest rates on net interest margins

6.1 Key results

Table B contains our key results. Models (1)–(3) report fixed-effects regressions with one lag of the dependent variable, together with bank-specific controls, macroeconomic controls and, crucially, interest rates. For each model, we report the 'average T' which is relevant for assessing the extent of the dynamic panel bias in these estimates. It is of the order of 40 quarters for most of our NIM regressions. Columns (1)–(3) differ by the sample of banks studied. Column (1) reports results for major UK banks (MUK), column (2) contains results for building societies (BSOCs), while column (3) reports the results using both sets of institutions.[12] Finally, column (4) reports a System GMM model, for comparison, which we discuss in further detail later. We place it in Table B for ease of subsequent comparison.

Table B suggests that the *levels* of both short rates (R^{3m}) and yield curve slope ($SLOPE$) contribute positively to banks' NIMs. This is consistent with our theoretical model. In particular, the model suggests that as short rates fall, banks reduce their loan rates and expand credit provision, putting downward pressure on the NIM as their balance sheets expand. It is interesting to note that different types of institution exhibit different sensitivities to both short rates and slope. In particular, the major UK banks group displays around twice the sensitivity to interest rates as the building societies. This greater interest rate exposure may be possible for larger commercial banks as they are able to undertake hedging activity through their trading books,

[12] Two of the building societies are also treated as major UK banks owing to their size in the UK mortgage market, so the sets are not entirely independent. The results are not sensitive to this classification.

allowing them to offset some of their exposures to rates. We return to both hedging and heterogeneity later.

The effect of rates is both statistically and economically significant. For example, all else equal, for major banks (column (1)), a 100 basis points rise in short rates is associated with a rise in the NIM of around 0.035 percentage points per quarter, or 9.2% more income relative to the sample mean. Similarly, a 100 basis points rise in the yield curve slope would raise income by around 8% per quarter relative to the mean flow. Hence over interest rate cycles with variation in rates of this order of magnitude, the effects on income are economically significant.[13]

Our results also highlight the dynamic implications of interest rate *changes*. Parametrising the model with lagged levels converted into differences results in the appealing formulation we adopt. We interpret the coefficients on the $\{DR^{3m}, DR^{3m}_{t-1}\}$ and $\{DSLOPE, DSLOPE_{t-1}\}$ terms as short-run effects. Table B clearly shows that these interest rate change terms typically enter negatively and significantly. They are of a similar order of magnitude as the coefficients on the interest rate levels terms, and so are economically significant too. The negative short-run impact of interest rate changes suggests the presence of non-trivial short-run repricing frictions. So the implications of the theoretical model do not hold in the short run: rather, unexpected increases in rates initially compress banks' margins. Only in the long term once re-pricing becomes possible do higher interest rates contribute to higher NIMs. An implication of this finding is that the question of what 'the' impact of a change in rates is in practice cannot be answered without taking a stance on (a) how yields of different maturities move relative to one another, and (b) how persistent their fluctuations are. In other words, one needs a macro model that tracks these factors jointly. We examine this issue in more detail in Section 9.1 by looking at economically plausible yield curve dynamics extracted from a simple VAR.

One could consider a number of alternative strategies to isolate the correlation between yields and income margins. The results discussed above reflect a number of modelling choices, some of which could have a material impact on the estimates. Our analysis is also subject to potential measurement issues: summarising the key features of the yield curve is not a trivial task. In the

[13] The magnitudes for building societies are smaller. For these institutions, the effect of a change in short rates is roughly half that of major banks, while the effect of a change in the yield curve slope is roughly two thirds that of major banks. Compare columns (3) and (4) in Table D.

remainder of this section we explore the robustness of our results along both dimensions. Our key conclusions prove to be valid under a broad range of specifications.

6.2 Alternative estimation techniques

In assessing the robustness of our key results, we begin with a discussion of alternative estimation techniques. Table C reports the results of some simple static specifications, beginning with a pooled OLS estimate in column (1). Robust standard errors clustered by bank are used throughout. Though both short rates and slope show up significantly here, the specification neglects two key features of the data, *viz*. heterogeneity and dynamics. The OLS specification suffers from autocorrelated residuals (the Arellano-Bond test for AR1 residuals is rejected at the 5% level) and abstracts from unobserved individual effects (α is assumed to be zero and $\eta_i = \eta$ for all i in equation **(4)**). Columns (2)–(5) report fixed-effects results to address this issue for different subsets of institutions. While continuing to neglect dynamics, these specifications hint at the heterogeneity between types of institution we highlighted above, namely, the greater sensitivity of major UK banks relative to building societies to interest rates. As with the simple OLS regression, short rates and slope enter strongly significantly.

Table D adds dynamics to the model in the form of leaving the autoregressive coefficient α unrestricted. The OLS static benchmark equation is repeated in column (1) for comparison. Column (2) allows α to be unrestricted relative to the OLS static model of column (1), and it turns out to be highly significant. We know however that the estimate of α is likely to be biased upwards in a panel data context in which heterogeneity is important, so subsequent columns report dynamic fixed-effect regressions for different subsamples. Comparing column (2) and column (5) confirms the likely upward bias in the estimate of α in the OLS model. Across specifications (3)–(6), short rates and slope show up strongly significantly. The interest rate changes terms appear important too. While different lags are significant for different subgroups, for both major banks and building societies changes in short rates appear to compress margins in the short run. Changes in the slope of the yield curve also show up negatively, and significantly in the case of building societies (column (4)). This makes sense to the extent that liabilities reprice before loans across the maturity spectrum, so we interpret the negative coefficients on $DSLOPE$ terms as further evidence for re-pricing frictions.

Table D reports the average number of observations per bank in our fixed-effects regressions. As it is around 40 quarters, we would expect *a priori* the dynamic panel bias to be small. But it is worth checking these results against a Arellano-Bover-Blundell-Bond GMM approach. Table E does this. But in so doing we have to confront the important issue of instrumentation in the context of a relatively 'large T' panel. As discussed in detail in Roodman (2009), instrument proliferation can result in misleading inference and tests of specification in a dynamic panel data context, especially in using System GMM where the instrument count becomes quartic in T. For this reason, in assessing the robustness of our results using the GMM estimators we adopt a relatively parsimonious specification, including an additional lag of the dependent variable while dropping the other controls except interest rate terms. In addition, to control the instrument count we follow Roodman (2009) and collapse the instrument set as well as controlling carefully the lags used as instruments in the Arellano-Bond style difference equation.[14] The number of instruments is reported at the bottom of Table E for each model. Together with the instrument count, we report Hansen test statistics and p-values along with tests for AR2 dynamics in the first differenced residuals. The Hansen test helps us to assess the validity of the moment conditions, but is known to be weakened by instrument proliferation. Controlling the instrument count helps to alleviate this problem, while the Hansen statistic has the additional benefit of being robust in the presence of a non-spherical error structure. We use one-step GMM with robust standard errors reported throughout. The GMM results in Table E support our main conclusions. Column (1) reports a highly parsimonious Difference GMM estimate focusing on major banks and building societies. Column (2) adds a levels equation to the Difference GMM estimate, while column (3) adds the interest rate difference terms we are interested in identifying. For the pooled sample, short rates and slope affect NIMs significantly positively, while positive changes in either yield curve level or slope compress margins in the short run. These alternative estimation strategies therefore add a sense of robustness to our findings in the space of possible estimation techniques.[15]

[14] See Roodman (2009) for a detailed description.

[15] The results are also robust to the introduction of a deterministic time trend in the regression. The trend tends to reduce the size of the coefficients on R and $SLOPE$, but sign and significance are broadly unchanged. We exclude the trend from our preferred specifications on both theoretical and empirical grounds (our prior is that all income margins are stationary, and the trend is indeed only marginally significant at conventional levels).

6.3 *Alternative characterisations of the yield curve*

We turn next to robustness with respect to measurement. Since the impact of interest rates on net interest income is of key interest to us, we use numerous different interest rate measures. These comprise using (1) an alternative measure of short rates, namely, the three-month interbank rate (2) defining the yield curve slope as the three-year (rather than the ten-year) rate on government bonds and (3) using interest rate factors for the yield curve level and slope from a Nelson-Siegel model. The results for major banks and building societies are reported in Table F. For these exercises we employ the robust one-step System GMM estimator (with collapsed instruments, as Table E) in relatively parsimonious specifications which include interest rate terms and two lags of the dependent variable. All the alternative measures of interest rates and yield curve slope we consider confirm our baseline findings: both short rates and slope matter positively and statistically significantly for UK banks' NIMs, while positive interest rate changes typically enter negatively and significantly. The Hansen and AR2 specification tests give us no further reason to doubt the validity of the identifying assumptions under which the estimation approach is valid.

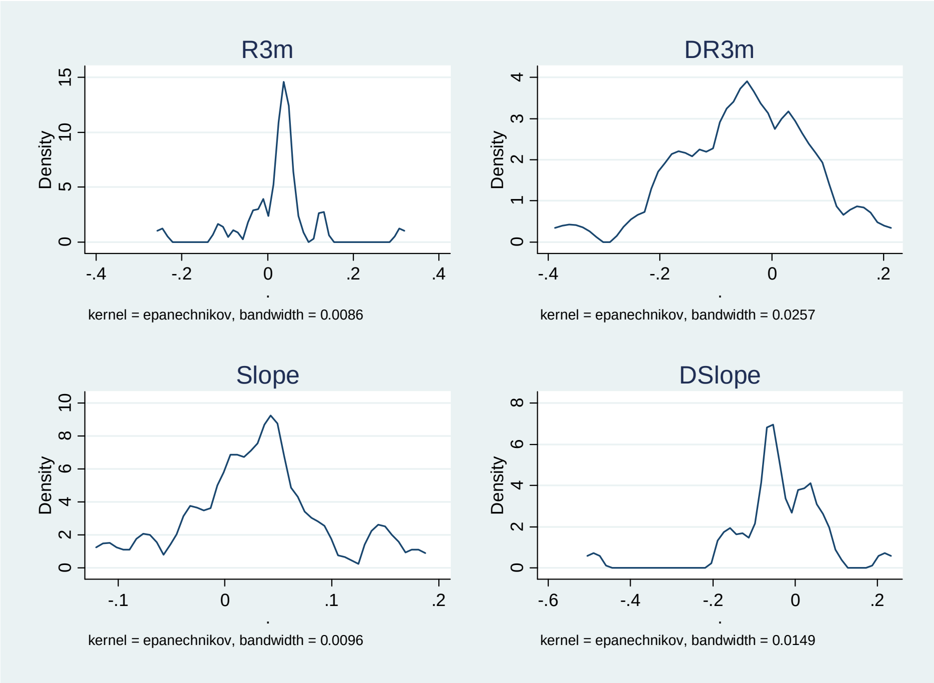
6.4 *Heterogeneity*

The estimates discussed above are based on pooled data, and describe the average features of our population. An interesting question is how 'representative' these numbers really are: does the impact of interest rates differ significantly and systematically across banks? Are there 'fragile' banks? What do they look like? The moderately large-T nature of our panel allows us to investigate the issue by estimating bank-specific models and scrutinising the cross-sectional distributions of the coefficients. We emphasise that, unlike in the previous two sections, the spirit here is not to detect specification problems but to probe the economic interpretation of our results as well as fully exploit the information in our data set.[16] To save on degrees of freedom, we focus on a stripped-down version of equation **(4)** that only includes two autoregressive terms and the R^{3m} and $SLOPE$ regressors (both in levels and differences). Chart 2 shows the distribution of the OLS estimates for major UK banks.[17]

[16]Baltagi and Griffin (1983) and Baltagi *et al* (2000) recommend a 'pragmatic' approach to the issue of poolability. They note that pooling might be more appealing based on *a priori* economic grounds, and show that, even in cases where pooling is rejected by formal statistical tests, an equation based on pooled data can be a better forecasting tool than a set of (more granular but inaccurately estimated) unit-specific equations.

[17]OLS is not efficient (it ignores cross-equation residual correlation), but it is of course consistent and unbiased. All interest rates terms are expressed in basis points rather than percentages, so the coefficients are larger by an order of 100 compared to those in the tables.

Chart 2: Cross-sectional distribution of the estimated interest rate coefficients



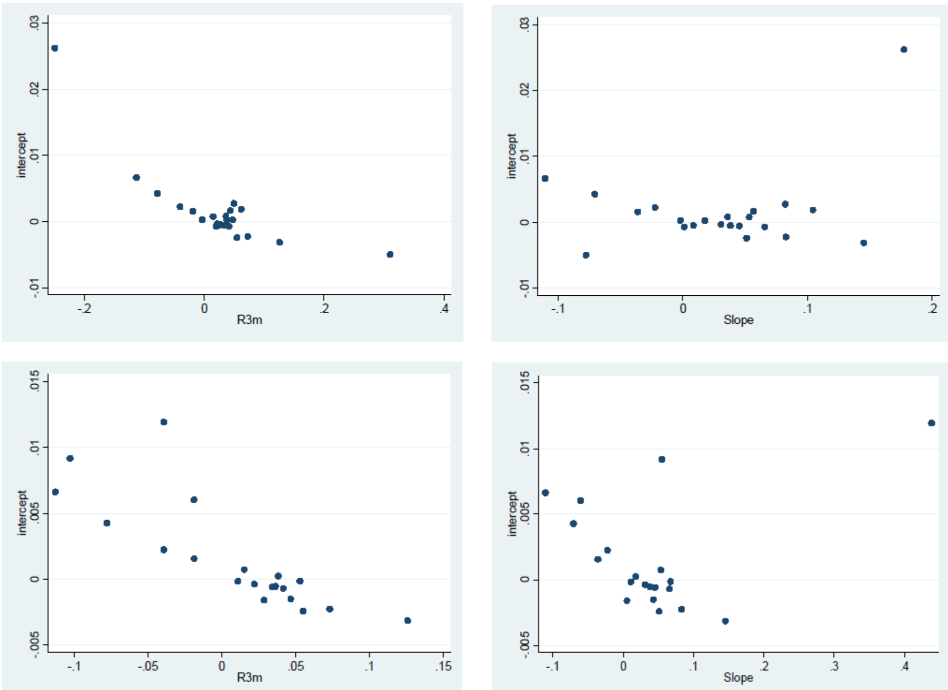
Our pooled estimates appear to be a good summary of the data at least in a qualitative sense: the income margin is indeed positively correlated with R^{3m} and $SLOPE$ and negatively correlated with DR^{3m} and $DSLOPE$ for most banks in the sample. This conclusion is strengthened if the regressions are estimated on post-1997 data (we do not report the results for brevity). However, the variation in the estimated coefficients is relatively large. We can test formally the null that the coefficients are constant across banks using the Roy-Zellner test.[18] The p-value for the null of constant coefficients is, respectively, 0.000 for the sum of the AR coefficients, 0.078 for the R^{3m} coefficient, and 0.970 for the $SLOPE$ coefficient. On post-1997 data, the latter drop to 0.004 and 0.267. The key message is thus that our model is a good description of most, but not all, the banks in the sample, and that some banks are significantly more sensitive to interest rates than the average, representative bank.

Chart 3 shows a set of scatter plots of the bank-specific OLS estimates. The intercept is plotted against the coefficient of R^{3m} and $SLOPE$ for both the full sample (top row) and the post-1997

$DR3m$ and $DSlope$ show the sum of the coefficients on, respectively, $(DR3m_t, DR3m_{t-1})$ and $(DSlope_t, DSlope_{t-1})$.

[18]The test treats the unrestricted model as a random-effect version of **(4)** where η_i and v_{it} are normally distributed and independent of one another, and test the null that the slopes are constant over units.

Chart 3: Joint distribution of intercepts and interest rate coefficients. Full sample (top panels) and post-1997 sample (bottom panels)



sample (bottom row). There is clear evidence of a negative correlation between intercept and interest rate coefficients: banks with lower average margins tend to adjust more to changes in both level and slope of the yield curve.[19] Our model offers a possible explanation for this finding. When a bank's average margin is low, so is the bank's average profitability. By decreasing absolute risk aversion, this both reduces the bank's risk-bearing capacity and makes the expected utility of profits more sensitive to interest rate shocks. We present a formal argument, based on Wong's (1997) model, in the separate appendix.

7 Dissecting the interest rate channel: real rates, inflation and term premia

Do the channels discussed above operate through nominal or real interest rates? This is an important question, not least because policymakers have far less control over the latter than the former. The role of inflation and nominal rates in driving banks' returns was at the centre of earlier work on the Nominal Contracting Hypothesis (NCH, see eg Flannery and James (1984)).

[19] The corresponding rank (Spearman) correlation coefficients are negative and significant at the 1% level in both subsamples (ignoring estimation uncertainty). The correlation pattern is also present in the long-run coefficients $\beta/(1-\alpha_1-\alpha_2)$, which take into account the autoregressive part.

The NCH states that if a firm holds assets and/or liabilities whose cash flows are fixed in nominal terms, its value will be sensitive to unexpected changes in inflation and nominal rates. One can think of the NCH as operating through two related channels, namely (i) changes in the discount factor applied to the firm's expected cash flow and (ii) changes in the cash flow itself, both realised and expected (Flannery (1981)). There is an important difference between the two. (i) can arise whenever the firm's cash flow is partly fixed in nominal terms, irrespective of the underlying maturity mismatch. Even a completely fixed and maturity-matched cash flow, for instance, loses value if the discount factor falls. (ii), on the other hand, does require a non-zero maturity mismatch. In either case the mechanism is triggered by changes in nominal yields and discount factors, independently of whether these are driven by changes in real rates or expected inflation (eg Flannery and James (1984)). Empirical analyses of the NCH have not delivered clear-cut results.[20]

By focusing on unexpected shocks, the NCH only rationalises the existence of a nominal channel in the short run. Indeed, at first glance, one might think of the income margin as a real variable whose long-run behaviour should only be determined by real factors. This conclusion, however, is not obvious on closer inspection. Note the presence of a 'capital shield', through the term $1 - \upsilon$, in equation **(3)**. Given that K is a real asset with no fixed nominal payments attached to it, and that R_L and L have by construction the same maturity, this term should indeed be independent of inflation. The expression shows, though, that the margin also depends on the difference between the (average) rates on loans and liabilities. This variable could be interpreted as 'real' if the two rates incorporated the same inflationary component, which in turn would require the average maturities of the underlying exposures to be the same. This is unlikely in this context. In a traditional bank portfolio, expected inflation at long maturities and nominal term premia will widen the gap between the two rates, and potentially boost banks' equilibrium margins.

We investigate the issue by introducing measures of inflation, real rates and term premia in our empirical model. For this we need *ex-ante* estimates of these variables based on information available at the time of pricing. We derive these from the no-arbitrage affine term structure model

[20] A number of papers tested the NCH by examining the correlation between market rates and banks' stock returns - an approach that, by design, does not aim to disentangle (i) and (ii). The conclusions are mixed. Tarhan (1987), for instance, finds no evidence in support of the NCH, whereas Kasman *et al* (2011) and Flannery and James (1984) do. Flannery (1981) focuses on (ii) by looking at the correlation between market rates and banks' net operating earnings, finding no evidence in support of the NCH.

of Joyce *et al* (2010).[21] We also use realised quarterly inflation as an alternative. The results are summarised in Tables G–I.[22] In Table G, real rates and inflation are introduced alongside nominal interest rates. We consider both a two-year maturity (the shortest one for which the decomposition is available, given the lack of short-maturity index-linked bonds) and a ten-year maturity. Inflation, whether measured *ex post* (column (1)) or *ex ante* (columns (2)-(3)), appears to be correlated to the margin, whereas real rates are not (columns (4)-(5)). The coefficients on nominal rates are only marginally affected by the introduction of the new regressors. In Table H, nominal rates are replaced by their estimated components, namely expected real rates, expected inflation and (nominal) term premia. Again the analysis is replicated separately for the two-year rate (first column) and the ten-year rate (second column). The table suggests again that most of the explanatory power is associated to term premia and inflation rather than the real rate.[23]

The standard errors on most of the coefficients in Table H are fairly high though, possibly because of collinearity across regressors. Table I presents some formal tests on the block exclusion of each of the regressors from the models in Table H. The exclusion of the term premium is strongly rejected in both cases, whereas there is no evidence to reject the exclusion of either inflation or real rates. These results cannot be taken at face value because they do not take into account uncertainty in the yield curve decomposition. However, the message is consistent and fairly clear. Income margins are driven mainly by term premia and inflation expectations. The role of the term premium is particularly prominent, and robust across the maturity spectrum. Real rates play essentially no role — which is somewhat puzzling, since from an NCH perspective changes in real rates and expected inflation should have essentially the same implications. All in all, the data support the conclusion that focusing on nominal rates is appropriate.

[21] The model describes the dynamics of the spot and forward yield curve for UK government bonds using three latent factors plus retail price index inflation (which is treated as an additional, observable factor) and inflation expectation measures based on survey data (which are introduced directly in the measurement equation). The factors are assumed to follow a VAR(1) process, and the model is estimated using monthly data for the 1992-2007 period. The estimation uses yields of maturities up to 15 years.

[22] We do not reparameterise the models using levels and differences of inflation, real rates and term premia. Hence the emphasis is on the significance of the new regressors, and the impact they have on our baseline results, rather than on the signs and magnitudes of their coefficients.

[23] Inflation is also found to be significant in Demirguc-Kunt and Huizinga (1999) and Gambacorta (2008). The latter finds that inflation affects both deposit and loan rates but the effect is stronger on the latter, which is consistent with our finding that inflation affects the income margin. In Gambacorta's work inflation is interpreted as a proxy for credit demand.

8 Beyond NII: do interest rates affect profits?

It is all very well claiming that interest rates have systematic effects on net interest margins. But large banks manage their interest rate exposure through trading activities that aim, *inter alia*, to hedge interest rate risk. Were hedging 'complete', no interest rate effects would show up in final profitability, and the link between monetary policy and bank profitability that we are positing would be broken. To assess the extent of hedging activity, we turn next to trading book regressions, before examining operating profits directly.

8.1 The trading book

Trading income in our data set is limited to major UK banks, and our sample only since 1998 Q1. This results in around 27 observations for each of 19 banks. The trading income reported is much less persistent than other income flows. Initial investigation yielded little in the way of autoregressive behaviour, so we have little reason to doubt the validity of simple static fixed-effects regressions. We report these in Table J, which use robust standard errors clustered by bank. Relative to our full NIM specifications, we aim for more parsimonious description of trading income behaviour after experimentation with various intuitively appealing explanatory variables. Our main focus is once again on the role of interest rates.

Columns (1)–(3) report trading income regressions for a truncated sample covering 1998 Q1–2008 Q2, before the major eruption of financial distress in the UK system. Column (1) illustrates the level and slope of the yield curve are negatively but only marginally significantly associated with trading income flows. Column (2) adds the interbank spread to the model of column (1), which shows up strongly significantly and negatively. Column (3) combines the interbank spread and the three-month short rate to form the three-month interbank rate R^{ib}. The explanatory power of the interbank spread and the short-rate compound resulting in a significant negative effect of R^{ib} on trading flows. The yield curve slope also enters negatively and significantly in Column (3).

These negative terms therefore provide a natural offset to the positive effect of interest rates operating through the banking book. As discussed in Gorton and Rosen (1995), commercial banks may have strong incentives to attempt to hedge interest rate risk. Holding interest rate swaps, the income streams on which are reported in our trading income data, is one means of doing this. These typically involve fixed-for-floating rate swaps. In this case, banks with short positions in interest rates pay floating rates and receive fixed rates – making trading income vulnerable to interest rate rises. The negative coefficient on short rates in model (3) is consistent with major banks taking these positions. The motive would be to achieve greater temporal match between interest receipts and payments, matching floating-rate liabilities to floating-rate assets. A second source of this effect may be through valuation effects of the traded securities themselves. As rates rise, future cash flows are more heavily discounted, reducing the mark-to-market value of securities held for trading.

A hedging interpretation may be attached to the negative coefficient on $SLOPE$ as well. The maturity profile of instruments held for hedging will often match that of the underlying exposure intended to be hedged. So where we observe a positive sign on the slope coefficient in the net interest income equation, we would expect, if anything, a negative sign on the slope coefficient in the trading equation to the extent that the bank intends to hedge across the maturity spectrum.

Extremely large moves in trading income were experienced during the crisis. The average trading book margin in our sample halved during the crisis, reflecting large losses experienced by some banks. The coefficient of variation for the whole sample is 7.2. Up to 2008 Q2 it was 6.5 but rose to 24 during the crisis. This extreme jump in volatility is likely to confound the identification of the interest rate effects in column (4), which uses the whole sample running until 2009 Q3.

8.2 Operating profit

Given the hedging motive and the evidence for active hedging through the trading book, what is the net impact of interest rates on operating profitability? We assess this by returning to our full specification running it instead on operating profits (before write-offs) normalised by (lagged) total assets, which forms a return on assets (ROA)-like variable. We report various specifications for major UK banks (for which we also have trading income data) in Table K. All specifications report robust standard errors.

Columns (1) and (2) report static models, estimated via OLS and fixed effects respectively. They both point to positive significant impacts of yield curve level and slope on profitability, suggesting hedging through the trading book is incomplete: rates still matter for profitability. As with our NIM regressions, we next consider dynamic specifications, reported in columns (3) and (4) using OLS and fixed effects respectively. The OLS equation reports small amounts of persistence, while the fixed-effects model fails to reject zero persistence. But we know that these coefficients are potentially biased in opposite directions and their estimators do not fully expunge endogeneity from the right-hand side variables in the presence of unobserved heterogeneity.

We resort to System GMM regressions in columns (5) and (6). Again, we collapse the instrument set and control the lag limits in such a way as to prevent instrument proliferation. Column (5) includes an extra lag of the dependent variable and drops balance sheet growth and leverage as a means of further reducing the instrument count. In this model, the familiar pattern of interest rate effects is present, and, once more, the effects are economically meaningful. Taking column (5) as a benchmark suggests a 100 basis points rise in short rates would raise the operating profit margin by around 0.04 percentage points per quarter. Relative to a mean quarterly operating profit margin of 0.27%, this constitutes a rise in the quarterly flow of profits of 14.4%. A 100 basis points rise in the slope of the yield curve would raise quarterly operating profit by around 18% relative to the mean. Once more, over interest rate cycles where these swings in rates are plausible in magnitude, these constitute economically significant effects.

Of course, over such cycles the level and the slope of the yield curve would move together in general equilibrium. This means that to take a stance on the impact of interest rates on profitability requires one to model the co-evolution of rates at the relevant maturities. We attempt this in an application in the next section.

Our results also point to incomplete hedging: after all, banks retain a residual interest rate exposure that passes through their banking books to their returns on assets. All else equal, this would also pass on to banks' return on equity (ROE). But typically banks will respond in other ways in order to maintain ROE, a subject to which we shall return when we consider a second application of our model.

9 Applications

9.1 Profitability and monetary policy shocks

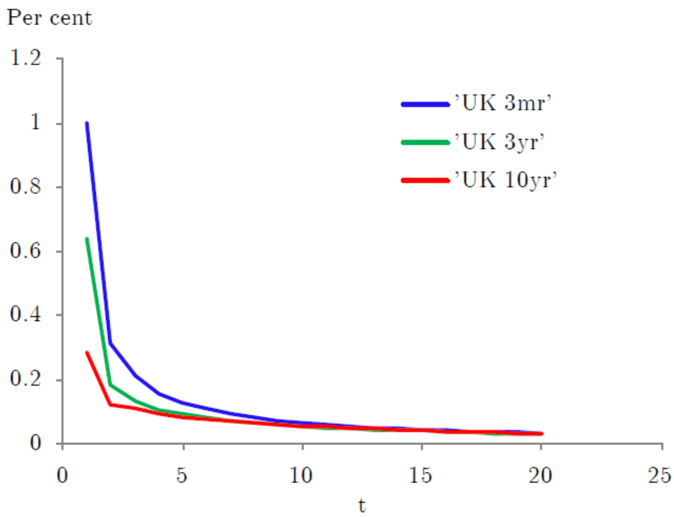
The coexistence of level and slope effects in the net interest income and trading income equations has an important general implication: in order to estimate the impact of changes in interest rates on bank profits, it is necessary to formulate an internally consistent model of how yields of different maturities move in response to economically interpretable macroeconomic shocks. Monetary policy shocks are an obvious candidate for this exercise, not least because they typically account for a significant fraction of the volatility of the yield curve, especially at short maturities.

We identify monetary policy shocks by estimating a medium-size vector autoregression. The model includes real output growth, consumer price inflation, and government bond yields with maturities of three months, three years, and ten years, all of which are measured using the same data as above. To capture the small open economy nature of the United Kingdom, we also include three-month rates, inflation and output for the United States and the euro area. The model is estimated on quarterly data over the 1981 Q1- 2009 Q4 period. We use Bayesian techniques to cope with the relatively large dimensionality of the model, and rely on a standard Minnesota prior (Litterman (1986)). Our identification strategy is based on a minimal set of sign restrictions (see eg Uhlig (2005)). A monetary policy contraction is assumed to (i) have no simultaneous impact on US and euro-area variables; (ii) depress output growth and inflation in the United Kingdom; and (iii) lead to an increase in the three UK yields. The restrictions only apply on impact, and are represented by weak inequalities (eg strictly speaking output and inflation are merely prevented from increasing when the shock hits). Importantly, the slope of the curve is left unrestricted.

The response of the three-month and ten-year rates are displayed in Chart 4.[24] Using these, we construct the impulse response for the net interest margin using the coefficients in Table D model (3) for major UK banks. We assume that the initial shock is unanticipated, and its period one effect is captured by the coefficient on Dr^{3m}_{t-1}. Thereafter, we assume that the model of the economy is known, such that the subsequent time profile for interest rates is known. In this case,

[24]More detailed results are available on request.

Chart 4: Estimated responses of three-year and ten-year rates to 100 basis points positive shock to three-month rates

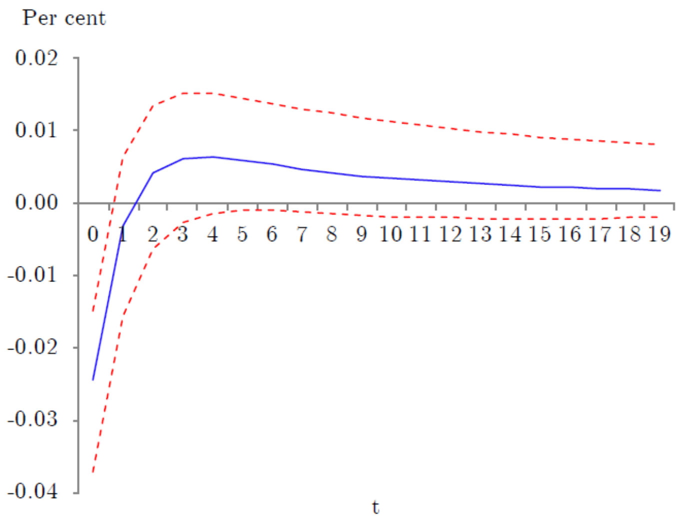


since no further unexpected shocks occur, the path for r_t^{3m} together with the AR(1) dynamics of the estimated equation govern the path for the net interest margin. Chart 5 plots the result, together with a 95% confidence interval computed using the 95% confidence band for interest rates generated by the VAR.[25] As Chart 5 shows, the short-run effect of the rise in interest rates is to compress the bank's interest margin. We interpret this as evidence in favour of repricing frictions. The short-run negative effect is persistent mainly due to the AR(1) nature of the NIM equation, though the flattening of the yield curve also provides a drag on income. As the bank becomes able to reprice, it can pass on higher funding costs to borrowers, and shrink its asset base, raising the margin. In the long run, the effect converges to zero as interest rates return to their equilibrium levels.

The cumulative impact is shown in Chart 6. In cumulative terms, the bank breaks-even only around 1.5 years after the policy shock, while the cumulative impact by the second quarter is relatively severe - a shock of around 10% of mean net interest income. Further out into the future, the bank's margin expands, though it takes around three years for the bank to have raised its cumulative margin by 0.03%, or around 10% of the mean level. *Inter alia*, this suggests the presence of an interaction between monetary and financial stability. For example, if bank capital

[25] That is, the figure abstracts from parameter uncertainty around our estimates of the effects of interest rates on the net interest margin.

Chart 5: Impulse response of net interest margin (NII/A) to 100 basis points positive shock to the three-month rate, accounting for effects on long rates



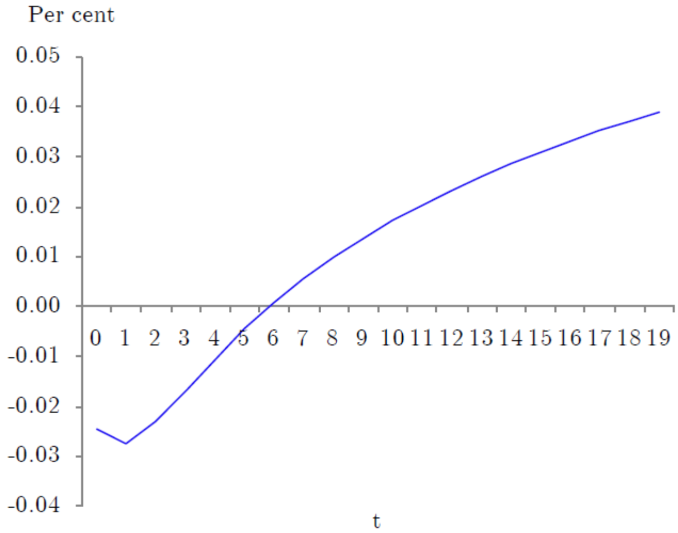
is explained mainly by retained earnings in the short run, then the impact of interest rate changes on income can well have a direct effect on resilience. Our results therefore support the idea that central banks with dual objectives pertaining to monetary and financial stability require multiple instruments to achieve their goals.

9.2 Net interest margins and bank behaviour since 1992

Our empirical results allow us to construct an historical decomposition of UK banks' NIMs. For example, we can use our estimated model to examine the main drivers of UK banks' declining NIMs over the sample period. We have shown that interest rates were a significant determinant of interest margins. How much of the variation in margins was due to this factor, and how did this prompt banks to respond?

Chart 7 decomposes major UK banks' NIMs using model (3) in Table D. There has been a clear downward trend in the average NIM. An interest rate cycle is clearly visible. In the beginning of the sample, reductions in short rates following the early 1990s recession pushed down on margins, but a steepening yield curve provided an offsetting source of revenue. The yield curve 'buffer' declined as rates rose in the lead up to Bank of England independence in 1997, while during the late 1990s an inverted curve largely offset the positive effect of short rates. As

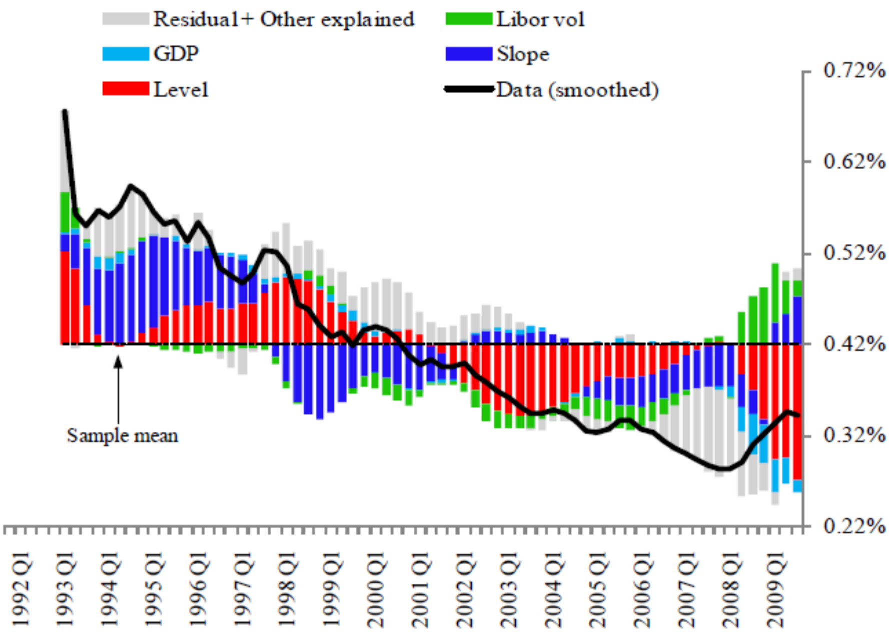
Chart 6: Cumulative response of net interest margin (NII/A) to 100 basis points shock to three-month rates, accounting for impact on long rates



inflationary pressures subsided in the early 2000s, short rates came down and margins were further compressed, reinforced by a further period of yield curve inversion in the mid-2000s. The fitted values of the model suggest aggressive falls in short rates following the financial turmoil in 2008 should have compressed margins still further. But the data and the model diverge around this exceptional period: banks' margins were maintained above the level predicted by the model. It is likely that banks were unwilling to pass on rate cuts to borrowers as the crisis continued and credit risk was anticipated to rise. The green bars in the figure point to an upward impact of Libor volatility on bank margins during this period, as financial uncertainty increased banks' loan risk premia leaving them unwilling to pass on declining short rates to borrowers.

We also know that the period under study exhibited a significant build up in financial vulnerability. The long cycle in rates and the concomitant decline in bank margins may have prompted banks to adopt riskier business models, principally through taking on higher leverage. As our empirical results show, declining interest rates fed through into bank profitability, compressing banks' return on assets (ROA). But return on equity (ROE) did not decline, partly due to a well-known increase in leverage. Table M decomposes profitability for the 'average' major UK bank into the contributions made by NIM, leverage and ROE. It is a simple decomposition of the data expressed in percentage changes. As the table shows, for example, the

Chart 7: Decomposition of major UK banks' mean NIM, 1992-2009, based on model (3) in Table D. The chart shows contributions of various macro and balance sheet factors in driving the NIM away from its sample mean



NIM declined by around 70% over the full sample, consistent with Chart 7.

The table presents the decomposition over various subperiods. While the NIM declined substantially over 1997-2009, leverage was roughly flat over this period, such that ROE and ROA both fell too. But of course this covers periods of both expansion and crisis. The subsample covering the period 1997-2006 illustrates banks' response to downward pressure on their NIMs. While ROA fell by around 24% over this period, ROE remained stable. To maintain this steady ROE, leverage increased substantially. In our sample, it grew by around 30% between 1997 and 2006. When the crisis struck, the pattern was reversed: the effects on ROE of a strong deleveraging were resisted by growth in the average NIM. But the scale of losses incurred elsewhere in the portfolio of banking activities ensured that ROE fell dramatically.

These changes suggest that increasing leverage generated significant (non risk adjusted) private returns during the expansion. Our profits equation allows us to obtain a rough estimate of the magnitude of this private incentive. When we normalise profits before write-offs by equity and run our panel model, we find a positive and significant effect of leverage on this ROE-like variable (Table N). We estimate the private incentives to raise leverage to be strong. For example, based on the fixed-effects regression reported in column (2), a doubling of leverage from five to ten would raise ROE by around 19% relative to the quarterly sample mean. A further doubling from ten to 20 would raise ROE before write-offs by around 10% relative to the quarterly sample mean. Our estimates support the idea that the private non risk adjusted returns to risk-taking through excessive leverage were significant.

10 Conclusion

We investigate the systematic effect of interest rates on bank profitability using a new, unique panel data set containing information on the UK activities of UK and foreign banking groups for 1992 Q1 - 2009 Q3. The distinguishing features of our empirical analysis are that we model both interest income and trading income, we explicitly disentangle long-run and short-run dynamics, and we link our analysis of interest income flows to a partial-equilibrium model of bank behaviour. We find that high interest rates are associated with large interest income margins, and that the slope of the yield curve matters for interest income. Level and slope affect net interest income and trading income in the opposite direction, which is consistent with banks hedging interest rate risk through derivatives. Even after accounting for hedging, though, large banks appear to retain a residual exposure to UK interest rates.

We also provide evidence that maturity mismatches and repricing frictions matter, and that a rise in interest rates can temporarily decrease banks' income margins. Thanks to the coexistence of (a) level and slope effects and (b) long and short-run multipliers, our model provides a rich picture of the implications of a monetary policy shock on banks' profits. A typical policy tightening raises short-term rates and flattens the yield curve, thus depressing banks' income through two distinct channels. This effect is fairly short-lived, and somewhat attenuated by hedging. Higher rates have an unambiguously positive effect on bank profits in the long run. Our work suggests that monetary policy – set for the economy as a whole – can have systematic effects on banks' profitability, and hence on their capital. This conclusion provides one possible motivation for the use of an independent macroprudential tool, and points to the existence of non-trivial interactions between the two instruments that should ideally be internalised by the policymaker.

Appendix

Robustness to sample period and public bailouts

We checked the robustness of our main findings to the sample period used and to public bailouts. The results are reported in Table L. All estimates used fixed-effects with robust standard errors clustered by bank, for major UK banks. Column (1) repeats our baseline fixed-effects regression for the NIM. Column (2) excludes the crisis period, using data up to 2007 Q4 only. If anything, excluding the crisis period strengthens the economic significance of our findings. The coefficient on the short rate rises by a factor of 1.2, while the coefficient on the slope remains unchanged. The same exercise for operating profit reveals similar results. The effect of the short rate rises by a factor of around 1.3, while the effect of the slope declines slightly.

We also ran models excluding those banks that received public sector support *ex post,* reported in columns (3) and (6). In general, excluding these banks reveals much larger effects of short rates and slope. The effect of short rates is larger by a factor of around 1.7 for both NIM and operating profits. The effect of the slope rises by a similar factor for both NIM and operating profits.

Table A: Descriptive statistics

Variable	No. Obs	Mean	Std. Dev.	Min	Max
NIM	2074	0.374	0.366	-0.189	6.109
Trading/TA	1207	0.029	0.210	-0.811	1.281
OpProf/TA	1508	0.267	0.403	-0.697	3.819
OpProf/K	1463	2.738	4.807	-13.146	40.656
GTA	3976	4.527	51.709	-100.0	28.0
LEV	3971	0.904	0.120	0.012	1.612
GDP	4367	0.547	0.580	-2.398	1.423
R^{3m}	4367	6.064	2.816	0.400	14.500
$SLOPE$	4367	0.330	1.674	-4.566	3.861
VOL^{libor}	4209	0.155	0.163	0.013	1.301
$CONC$	4095	0.077	0.013	0.059	0.104
$GFTSEvolume$	4169	0.038	0.157	-0.236	0.812

All variables in per cent, except LEV (ratio of debt liabilities to assets).

Table B: Net interest margin: key results. 'FE' denotes fixed-effects estimation. 'SysGMM' denotes System GMM estimation. 'MUK' and 'BSOCs' denotes 'major UK banks' and 'building societies' respectively.

	(1) FE MUK	(2) FE BSOCs	(3) FE MUK+BSOCS	(4) SysGMM MUK+BSOCs
NII/TA_{t-1}	0.35533***	0.49684***	0.38803***	0.19045**
	(4.51)	(6.11)	(5.34)	(2.40)
NII/TA_{t-2}				0.35521***
				(4.32)
GTA_{t-1}	-0.00248***	-0.00281***	-0.00265***	
	(-4.22)	(-3.44)	(-4.53)	
LEV_{t-1}	0.01153*	-0.00243	0.00901	
	(1.82)	(-0.86)	(1.33)	
GDP	0.00031	0.00008	0.00025*	
	(1.63)	(1.17)	(1.72)	
GDP_{t-1}	-0.00021	0.00002	-0.00009	
	(-1.38)	(0.38)	(-0.88)	
R^{3m}	0.00035**	0.00016***	0.00028***	0.00021**
	(2.48)	(3.92)	(2.77)	(2.15)
DR^{3m}	0.00015	-0.00028**	0.00002	-0.00006
	(0.57)	(-2.49)	(0.15)	(-0.38)
DR^{3m}_{t-1}	-0.00055*	-0.00002	-0.00041*	-0.00030**
	(-2.00)	(-0.17)	(-1.90)	(-2.13)
$SLOPE$	0.00030***	0.00019**	0.00025***	0.00019**
	(3.06)	(2.94)	(3.74)	(2.33)
$DSLOPE$	-0.00013	-0.00017**	-0.00013	-0.00019**
	(-1.00)	(-2.90)	(-1.69)	(-2.02)
$DSLOPE_{t-1}$	-0.00025	-0.00015**	-0.00022*	-0.00026**
	(-1.40)	(-2.25)	(-1.74)	(-2.27)
VOL^{libor}	0.00147**	0.00004	0.00093*	
	(2.13)	(0.12)	(1.82)	
$CONC$	-0.02876***	-0.00664*	-0.01640***	
	(-3.81)	(-2.15)	(-3.16)	
Const	-0.00754	0.00354	-0.00628	0.00054*
	(-1.34)	(1.32)	(-1.01)	(1.80)
N	739	548	1223	1224
Units	23	11	32	32
AvgT	32.13	49.82	38.22	38.25
Instruments				32
Hansen				26.87
Hansen p-value				0.26
AR2				-1.22
AR2 p-value				0.22

***,** ,* denote significance at 1%, 5%, and 10% respectively.

Table C: Net interest margin estimation results: static models. 'OLS' denotes ordinary least squares estimation. 'FE' denotes fixed-effects estimation. 'MUK' and 'BSOCs' denotes 'major UK banks' and 'building societies' respectively. 'All' includes MUK, BSOCs and foreign-owned banks operating in the United Kingdom.

	(1) OLS MUK+BSOCs	(2) FE MUK	(3) FE BSOCs	(4) FE MUK+BSOCs	(5) FE All
GTA_{t-1}	-0.00076***	-0.00101*	-0.00177**	-0.00101**	-0.00027**
	(-3.19)	(-1.95)	(-2.65)	(-2.19)	(-2.26)
LEV_{t-1}	-0.01830**	0.02267*	-0.00914	0.02001	-0.00091
	(-2.10)	(1.90)	(-1.51)	(1.43)	(-0.26)
GDP	-0.00005	0.00020	0.00015**	0.00021	0.00006
	(-0.36)	(1.05)	(2.38)	(1.37)	(0.34)
GDP_{t-1}	-0.00045	-0.00048*	0.00012	-0.00028	-0.00015
	(-1.64)	(-1.72)	(1.75)	(-1.29)	(-0.84)
R^{3m}	0.00071**	0.00083***	0.00038***	0.00067***	0.00065***
	(2.72)	(4.23)	(12.63)	(4.23)	(3.95)
DR^{3m}	0.00001	-0.00009	-0.00051***	-0.00020	-0.00004
	(0.07)	(-0.34)	(-5.11)	(-1.21)	(-0.17)
DR^{3m}_{t-1}	-0.00030	-0.00046*	-0.00012	-0.00035*	-0.00026
	(-1.60)	(-2.05)	(-1.74)	(-1.97)	(-0.94)
$SLOPE$	0.00041***	0.00055***	0.00043***	0.00045***	0.00063***
	(2.87)	(4.58)	(7.56)	(6.02)	(4.14)
$DSLOPE$	0.00003	-0.00005	-0.00028***	-0.00009	-0.00006
	(0.20)	(-0.24)	(-5.57)	(-0.58)	(-0.36)
$DSLOPE_{t-1}$	-0.00009	-0.00014	-0.00023***	-0.00013	-0.00022
	(-0.88)	(-1.01)	(-3.98)	(-1.25)	(-1.07)
VOL^{libor}	0.00090*	0.00095*	0.00003	0.00049	0.00078
	(1.94)	(1.93)	(0.14)	(1.37)	(1.45)
$CONC$	-0.01167	-0.04209***	-0.01249**	-0.02469***	-0.01261
	(-1.03)	(-3.70)	(-2.26)	(-2.86)	(-1.37)
Const	0.01806*	-0.01720	0.01061*	-0.01607	0.00209
	(1.89)	(-1.55)	(1.81)	(-1.21)	(0.56)
N	1236	751	549	1236	1957
R^2_{adj}	0.27	0.28	0.63	0.28	0.09

***,** ,* denote significance at 1%, 5%, and 10% respectively.

Table D: Net interest margin estimation results: dynamic models. 'OLS' denotes ordinary least squares estimation. 'FE' denotes fixed-effects estimation. 'MUK' and 'BSOCs' denotes 'major UK banks' and 'building societies' respectively. 'All' includes MUK, BSOCs and foreign-owned banks operating in the United Kingdom.

	(1) OLS BSOC+MUK	(2) OLS BSOC+MUK	(3) FE MUK	(4) FE BSOC	(5) FE MUK+BSOC	(6) FE All
NII/TA_{t-1}		0.70602***	0.35533***	0.49684***	0.38803***	0.43840***
		(6.73)	(4.51)	(6.11)	(5.34)	(8.38)
GTA_{t-1}	-0.00076***	-0.00405***	-0.00248***	-0.00281***	-0.00265***	-0.00203***
	(-3.19)	(-4.85)	(-4.22)	(-3.44)	(-4.53)	(-3.92)
LEV_{t-1}	-0.01830**	-0.00511***	0.01153*	-0.00243	0.00901	-0.00042
	(-2.10)	(-2.90)	(1.82)	(-0.86)	(1.33)	(-0.21)
GDP	-0.00005	0.00016	0.00031	0.00008	0.00025*	0.00009
	(-0.36)	(1.24)	(1.63)	(1.17)	(1.72)	(0.68)
GDP_{t-1}	-0.00045	-0.00012	-0.00021	0.00002	-0.00009	0.00003
	(-1.64)	(-1.40)	(-1.38)	(0.38)	(-0.88)	(0.29)
R^{3m}	0.00071**	0.00008	0.00035**	0.00016***	0.00028***	0.00024***
	(2.72)	(0.72)	(2.48)	(3.92)	(2.77)	(3.27)
DR^{3m}	0.00001	0.00031	0.00015	-0.00028**	0.00002	0.00021
	(0.07)	(1.37)	(0.57)	(-2.49)	(0.15)	(1.01)
DR^{3m}_{t-1}	-0.00030	-0.00037	-0.00055*	-0.00002	-0.00041*	-0.00051**
	(-1.60)	(-1.39)	(-2.00)	(-0.17)	(-1.90)	(-2.56)
$SLOPE$	0.00041***	0.00006	0.00030***	0.00019**	0.00025***	0.00027***
	(2.87)	(0.74)	(3.06)	(2.94)	(3.74)	(3.62)
$DSLOPE$	0.00003	-0.00003	-0.00013	-0.00017**	-0.00013	-0.00014*
	(0.20)	(-0.42)	(-1.00)	(-2.90)	(-1.69)	(-1.85)
$DSLOPE_{t-1}$	-0.00009	-0.00020	-0.00025	-0.00015**	-0.00022*	-0.00036***
	(-0.88)	(-1.44)	(-1.40)	(-2.25)	(-1.74)	(-2.81)
VOL^{libor}	0.00090*	0.00124*	0.00147**	0.00004	0.00093*	0.00107**
	(1.94)	(1.85)	(2.13)	(0.12)	(1.82)	(2.02)
$CONC$	-0.01167	-0.00556*	-0.02876***	-0.00664*	-0.01640***	-0.00796
	(-1.03)	(-2.03)	(-3.81)	(-2.15)	(-3.16)	(-1.60)
Const	0.01806*	0.00572***	-0.00754	0.00354	-0.00628	0.00160
	(1.89)	(3.32)	(-1.34)	(1.32)	(-1.01)	(0.77)
N	1236	1223	739	548	1223	1915
Groups			23.00	11.00	32.00	54.00
AvgT			32.13	49.82	38.22	35.46
R^2_{adj}	0.27	0.64	0.35	0.72	0.39	0.29

***,** ,* denote significance at 1%, 5%, and 10% respectively.

Table E: Net interest margin estimation results: GMM models. 'DGMM' denotes Difference GMM estimation. 'SysGMM' denotes System GMM estimation. Results are for a pooled major UK banks and building societies sample.

	(1) DGMM	(2) SysGMM	(3) SysGMM
NII/TA_{t-1}	0.27911***	0.29149***	0.19045**
	(4.51)	(4.30)	(2.40)
NII/TA_{t-2}	0.29241***	0.41503***	0.35521***
	(5.72)	(5.76)	(4.32)
R^{3m}	0.00038***	0.00026*	0.00021**
	(3.14)	(1.89)	(2.15)
DR^{3m}			-0.00006
			(-0.38)
DR^{3m}_{t-1}			-0.00030**
			(-2.13)
$SLOPE$	0.00024**	0.00020**	0.00019**
	(2.41)	(2.26)	(2.33)
$DSLOPE$			-0.00019**
			(-2.02)
$DSLOPE_{t-1}$			-0.00026**
			(-2.27)
Const		-0.00030	0.00054*
		(-0.46)	(1.80)
N	1187	1224	1224
Units	32	32	32
AvgT	37.09	38.25	38.25
Instruments	35.00	39.00	32.00
Hansen	29.11	29.50	26.87
Hansenp-value	0.56	0.69	0.26
AR2	-1.09	-1.29	-1.22
AR2p-value	0.28	0.20	0.22

***,** ,* denote significance at 1%, 5%, and 10% respectively.

Table F: Net interest margin estimation results: System GMM models, alternative interest rate measures. Column (1) uses the interbank rate in place of the three-month government rate. Column (2) uses three-year rates for long rates in place of the ten-year rate. Column (3) uses Nelson-Siegel factors in place of both short rates and slope.

	(1) Interbank for R^{3m}	(2) 3y for long rates	(3) Nelson-Siegel factors
NII/TA_{t-1}	0.20208***	0.18681**	0.17936**
	(2.60)	(2.25)	(2.23)
NII/TA_{t-2}	0.35862***	0.35159***	0.34855***
	(4.54)	(3.98)	(4.46)
R^{ib}	0.00020**		
	(2.36)		
DR^{ib}	0.00005		
	(0.29)		
DR^{ib}_{t-1}	-0.00032***		
	(-3.22)		
$SLOPE$	0.00017**		
	(2.20)		
$DSLOPE$	-0.00015		
	(-1.22)		
$DSLOPE_{t-1}$	-0.00027***		
	(-2.85)		
R^{3m}		0.00020**	
		(1.99)	
DR^{3m}		-0.00009	
		(-0.51)	
DR^{3m}_{t-1}		-0.00030*	
		(-1.87)	
$SLOPE^{3y}$		0.00028**	
		(2.17)	
$DSLOPE^{3y}$		-0.00029***	
		(-3.06)	
$DSLOPE^{3y}_{t-1}$		-0.00022***	
		(-2.73)	
NSshort			0.00023**
			(2.47)
DNSshort			-0.00011
			(-0.68)
DNSshort$_{t-1}$			-0.00029*
			(-1.95)
NSslope			0.00017**
			(2.52)
DNSslope			-0.00009
			(-0.76)
DNSslope$_{t-1}$			-0.00026**
			(-2.08)
Const	0.00046*	0.00062**	0.00050
	(1.66)	(2.26)	(1.64)
N	1224	1224	1224
Units	32	32	32
AvgT	38.25	38.25	38.25
Instruments	32	32	32
Hansen	27.38	27.61	24.72
Hansenp	0.24	0.23	0.36
AR2	-1.22	-1.19	-1.21
AR2p	0.22	0.23	0.23

***,** ,* denote significance at 1%, 5%, and 10% respectively.

Table G: Net interest margin estimation results with inflation measures, GMM regressions. Lagged dependent variable (2 lags) and constant not reported. $xE(r^{real})_t$ denotes spot expected real risk-free rates at maturity x and time t. $xE(\Pi)_t$ denotes spot expected inflation at horizon x and time t.

	(1) Realised inflation	(2) 2y expected inflation	(3) 10y expected inflation	(4) 2y real rates	(5) 10y real rates
R^{3m}	0.00021**	0.00027**	0.00030**	0.00018**	0.00018**
	(1.97)	(2.42)	(2.37)	(1.97)	(1.98)
DR^{3m}	0.00009	-0.00037**	-0.00039**	-0.00030**	-0.00031**
	(0.40)	(-2.47)	(-2.43)	(-2.18)	(-2.12)
DR^{3m}_{t-1}	-0.00035**	-0.00015	-0.00023	-0.00010	-0.00011
	(-2.57)	(-0.81)	(-1.39)	(-0.71)	(-0.82)
$SLOPE$	0.00018**	0.00024***	0.00029***	0.00024***	0.00024***
	(2.04)	(2.77)	(2.78)	(2.71)	(2.69)
$DSLOPE$	-0.00010	-0.00024**	-0.00028**	-0.00022**	-0.00023**
	(-1.05)	(-2.26)	(-2.27)	(-2.16)	(-2.16)
$DSLOPE_{t-1}$	-0.00026***	-0.00014	-0.00021*	-0.00011	-0.00012
	(-2.62)	(-1.29)	(-1.70)	(-1.16)	(-1.18)
CPI	-0.00008				
	(-0.97)				
CPI_{t-1}	0.00018**				
	(2.13)				
CPI_{t-2}	0.00014				
	(1.28)				
Const	0.00046	0.00058*	0.00078	0.00052*	0.00040
	(1.55)	(1.70)	(1.44)	(1.72)	(1.38)
$2yE(\Pi)$		0.00002			
		(0.18)			
$2yE(\Pi)_{t-1}$		0.00001			
		(0.06)			
$2yE(\Pi)_{t-2}$		-0.00013			
		(-1.64)			
$10yE(\Pi)$			0.00002		
			(0.06)		
$10yE(\Pi)_{t-1}$			0.00017		
			(0.54)		
$10yE(\Pi)_{t-2}$			-0.00044**		
			(-2.21)		
$2yE(r^{real})$				0.00006	
				(0.63)	
$2yE(r^{real})_{t-1}$				0.00005	
				(0.46)	
$2yE(r^{real})_{t-2}$				-0.00001	
				(-0.11)	
$10yE(r^{real})$					0.00016
					(0.70)
$10yE(r^{real})_{t-1}$					0.00011
					(0.46)
$10yE(r^{real})_{t-2}$					-0.00006
					(-0.30)
N	1224	1209	1209	1209	1209
Units	32	32	32	32	32
AvgT	38.25	37.78	37.78	37.78	37.78
Instruments	35.00	35.00	35.00	35.00	35.00
Hansen	26.19	23.18	23.89	25.06	25.18
Hansenp-value	0.29	0.45	0.41	0.35	0.34
AR2	-1.24	-0.94	-0.99	-0.97	-0.98
AR2p-value	0.21	0.35	0.32	0.33	0.33

***,** ,* denote significance at 1%, 5%, and 10% respectively.

Table H: Net interest margin estimation results: decomposition of nominal rates, GMM regressions. Lagged dependent variable (2 lags) and constant not reported. $xE(r^{real})_t$ denotes spot expected real risk-free rates at maturity x and time t. $xE(\Pi)_t$ denotes spot expected inflation at horizon x and time t.

	(1) 2-year rates	(2) 10-year rates
$2yE(r^{real})$	-0.00004	
	(-0.40)	
$2yE(r^{real})_{t-1}$	0.00021	
	(1.23)	
$2yE(r^{real})_{t-2}$	-0.00004	
	(-0.39)	
2yNomTermPrem	-0.00004	
	(-0.10)	
2yNomTermPrem$_{t-1}$	0.00078**	
	(2.14)	
2yNomTermPrem$_{t-2}$	-0.00026	
	(-0.86)	
$2yE(\Pi)$	-0.00012	
	(-1.37)	
$2yE(\Pi)_{t-1}$	0.00024*	
	(1.73)	
$2yE(\Pi)_{t-2}$	-0.00012	
	(-1.37)	
$10yE(r^{real})$		-0.00011
		(-0.54)
$10yE(r^{real})_{t-1}$		0.00054
		(1.42)
$10yE(r^{real})_{t-2}$		-0.00012
		(-0.53)
10yNomTermPrem		0.00005
		(0.22)
10yNomTermPrem$_{t-1}$		0.00032
		(1.37)
10yNomTermPrem$_{t-2}$		-0.00008
		(-0.42)
$10yE(\Pi)$		-0.00031
		(-1.36)
$10yE(\Pi)_{t-1}$		0.00054
		(1.64)
$10yE(\Pi)_{t-2}$		-0.00028
		(-1.36)
N	1209	1209
Units	32	32
AvgT	37.78	37.78
Instruments	35	35
Hansen	22.59	22.48
Hansenp-value	0.49	0.49
AR2	-1.10	-1.10
AR2p-value	0.27	0.27

***,** ,* denote significance at 1%, 5%, and 10% respectively.

Table I: Significance tests for decomposition of nominal rates reported in Table H

	$E(r^{real})$	Nom Term Premium	$E(\Pi)$
2-year rates			
$\chi^2(3)$	2.66	24.83	3.23
p-value	0.4471	0.000	0.358
10-year rates			
$\chi^2(3)$	3.12	18.01	3.17
p-value	0.374	0.000	0.367

$E(r^{real})$ denotes expected real risk-free rates. $E(\Pi)$ denotes expected inflation.

Table J: Trading income. Major UK banks

Sample:	(1) 1998-2008:2	(2) 1998-2008:2	(3) 1998-2008:2	(4) 1998-2009:3
GTA_{t-1}	0.00105***	0.00094***	0.00103***	0.00093**
	(3.26)	(3.01)	(3.22)	(2.43)
LEV_{t-1}	-0.00825	-0.00674	-0.00807	-0.00797$^+$
	(-1.34)	(-1.23)	(-1.31)	(-1.60)
R^{3m}	-0.00024$^+$	-0.00014		
	(-1.70)	(-0.86)		
$SLOPE$	-0.00022$^+$	-0.00026*	-0.00033**	-0.00026
	(-1.51)	(-1.87)	(-2.66)	(-1.46)
VOL^{FTSE}	-0.00075	0.00050	-0.00050	-0.00050
	(-0.73)	(0.38)	(-0.52)	(-0.31)
VOL^{ERI}	-0.00034	-0.00002	-0.00004	-0.00087
	(-0.32)	(-0.02)	(-0.04)	(-0.66)
Const	0.00866$^+$	0.00691$^+$	0.00886$^+$	0.00875*
	(1.67)	(1.53)	(1.66)	(2.05)
IB-Spread		-0.00107**		
		(-2.58)		
R^{ib}			-0.00031***	-0.00028$^+$
			(-3.01)	(-1.71)
N	511	511	511	558
Units	19	19	19	19
AvgT	26.89	26.89	26.89	29.37

***,**,*,$^{+}$ denote significance at 1%, 5%, 10% and 15% respectively.

Table K: Operating profit. Major UK banks. 'OLS' denotes ordinary least squares estimation. 'FE' denotes fixed-effects estimation. 'SysGMM' denotes System GMM estimation.

	(1) OLS	(2) FE	(3) OLS	(4) FE	(5) SysGMM	(6) SysGMM
$OpProf/TA_{t-1}$			0.23386**	0.01318	-0.07610	-0.03769
			(2.34)	(0.21)	(-0.67)	(-0.45)
$OpProf/TA_{t-2}$					0.00899	
					(0.15)	
GTA_{t-1}	-0.00034	-0.00051	-0.00085	-0.00033		
	(-0.45)	(-0.61)	(-0.82)	(-0.43)		
LEV_{t-1}	-0.01808**	0.00466	-0.01519***	-0.00013		
	(-2.54)	(0.57)	(-4.00)	(-0.02)		
GDP	0.00032	0.00056**	0.00035	0.00059**	0.00052*	
	(1.25)	(2.22)	(1.24)	(2.19)	(1.92)	
GDP_{t-1}	-0.00030	-0.00017	-0.00015	-0.00008	0.00003	
	(-0.94)	(-0.69)	(-0.56)	(-0.37)	(0.10)	
R^{3m}	0.00041**	0.00039**	0.00017	0.00025	0.00039**	0.00048***
	(2.10)	(2.39)	(1.02)	(1.55)	(2.10)	(3.20)
DR^{3m}	0.00030	-0.00006	0.00045	0.00001	0.00022	-0.00020
	(0.86)	(-0.19)	(1.34)	(0.03)	(0.70)	(-0.48)
DR^{3m}_{t-1}	-0.00006	-0.00023	-0.00020	-0.00033	-0.00062***	-0.00034
	(-0.24)	(-1.20)	(-0.67)	(-1.25)	(-2.59)	(-1.22)
$SLOPE$	0.00039**	0.00034**	0.00019	0.00027**	0.00048***	0.00052***
	(2.21)	(2.44)	(1.36)	(2.21)	(2.71)	(2.71)
$DSLOPE$	0.00006	-0.00011	-0.00005	-0.00017	-0.00034	-0.00037*
	(0.31)	(-0.52)	(-0.31)	(-0.85)	(-1.62)	(-1.78)
$DSLOPE_{t-1}$	-0.00003	0.00001	-0.00000	-0.00004	-0.00030	-0.00032
	(-0.15)	(0.05)	(-0.00)	(-0.18)	(-1.43)	(-1.29)
VOL^{libor}	0.00146	0.00109	0.00219	0.00142	0.00223*	
	(1.24)	(0.90)	(1.61)	(1.18)	(1.82)	
$GFSTEvolume$	0.00009	0.00034	-0.00012	0.00020	-0.00032	
	(0.20)	(0.84)	(-0.27)	(0.51)	(-0.75)	
Const	0.01662**	-0.00413	0.01447***	0.00071	-0.00009	0.00012
	(2.43)	(-0.52)	(3.74)	(0.12)	(-0.10)	(0.12)
N	720	720	702	702	677	702
Units		22		21	21	21
AvgT		32.73		33.43	32.24	33.43
Instruments					17.00	15.00
Hansen					3.14	5.55
Hansenp					0.37	0.48
AR2					-1.37	-0.25
AR2p					0.17	0.80

Sample is major UK banks (MUK). ***,** ,* denote significance at 1%, 5%, and 10% respectively.

Table L: Robustness to sample length and bailouts. Major UK banks. Columns (1)-(3) present results for the NIM. Columns (4)-(6) present results for operating profit. Columns (2) and (5) report results for the pre-crisis sample only. Columns (3) and (6) exclude recipients of major public sector support.

	(1) NIM baseline	(2) Up to 2007Q4	(3) Excl. bailout	(4) Op Prof baseline	(5) Up to 2007Q4	(6) Excl. bailout
NII/TA_{t-1}	0.35533***	0.31415***	0.26430***			
	(4.51)	(4.64)	(4.75)			
$OpProf/TA_{t-1}$				-0.07610	-0.06037	-0.11076
				(-0.67)	(-0.52)	(-0.73)
$OpProf/TA_{t-2}$				0.00899	0.02825	0.03261
				(0.15)	(0.42)	(0.33)
GTA_{t-1}	-0.00248***	-0.00232***	-0.00279***			
	(-4.22)	(-4.06)	(-9.20)			
LEV_{t-1}	0.01153*	0.00969	0.01041*			
	(1.82)	(1.16)	(1.79)			
GDP	0.00031+	0.00042*	0.00035	0.00052*	0.00040	0.00050+
	(1.63)	(1.74)	(1.38)	(1.92)	(0.98)	(1.60)
GDP_{t-1}	-0.00021	-0.00010	-0.00032	0.00003	-0.00020	-0.00038
	(-1.38)	(-0.39)	(-1.47)	(0.10)	(-0.42)	(-1.01)
R^{3m}	0.00035**	0.00043***	0.00061***	0.00039**	0.00050***	0.00067***
	(2.48)	(3.63)	(4.40)	(2.10)	(2.85)	(2.96)
DR^{3m}	0.00015	0.00007	-0.00013	0.00022	0.00018	0.00019
	(0.57)	(0.21)	(-0.43)	(0.70)	(0.51)	(0.40)
DR^{3m}_{t-1}	-0.00055*	-0.00063**	-0.00041*	-0.00062***	-0.00064**	-0.00086***
	(-2.00)	(-2.13)	(-1.77)	(-2.59)	(-2.45)	(-3.01)
$SLOPE$	0.00030***	0.00031***	0.00052***	0.00048***	0.00041**	0.00079***
	(3.06)	(3.09)	(7.85)	(2.71)	(2.37)	(3.40)
$DSLOPE$	-0.00013	-0.00012	-0.00013	-0.00034+	-0.00025	-0.00052*
	(-1.00)	(-0.75)	(-0.78)	(-1.62)	(-1.12)	(-1.75)
$DSLOPE_{t-1}$	-0.00025	-0.00028	-0.00023	-0.00030	-0.00014	-0.00051+
	(-1.40)	(-1.33)	(-1.24)	(-1.43)	(-0.67)	(-1.62)
VOL^{libor}	0.00147**	0.00138	0.00148*	0.00223*	0.00005	0.00260*
	(2.13)	(1.10)	(1.94)	(1.82)	(0.04)	(1.68)
$CONC$	-0.02876***	-0.02480**	-0.02775**			
	(-3.81)	(-2.68)	(-2.94)			
Const	-0.00754	-0.00659	-0.00735	-0.00009	-0.00013	-0.00183*
	(-1.34)	(-0.93)	(-1.38)	(-0.10)	(-0.14)	(-1.70)
$GFSTEvolume$				-0.00032	-0.00011	-0.00019
				(-0.75)	(-0.23)	(-0.35)
dum1997				0.00057	0.00045	0.00101*
				(1.43)	(1.16)	(1.78)
N	739.00	674.00	501.00	677.00	615.00	448.00
Units	23.00	23.00	15.00	21.00	21.00	14.00
AvgT	32.13	29.30	33.40	32.24	29.29	32.00
Instruments				17.00	17.00	17.00
Hansen				3.14	3.39	0.00
Hansenp				0.37	0.34	1.00
AR2				-1.37	-1.37	-1.18
AR2p				0.17	0.17	0.24

Sample is major UK banks (MUK). ***,** ,* denote significance at 1%, 5%, and 10% respectively.

Table M: Major banks mean profitability; % changes in components over different time periods

	OpProf/TA	OpProf/K	Leverage (TA/K)	NIM
Full sample	-68.5%	-82.2%	-43.6%	-70.7%
1997-2009	-46.7%	-47.7%	-1.9%	-28.9%
2002-09	-47.6%	-52.3%	-9.1%	-15.0%
Pre-crisis (1997-2006)	-24.2%	-2.7%	28.4%	-35.9%
Crisis (2007-09)	-20.0%	-34.5%	-18.1%	14.5%

TA = total assets; K = equity; NIM = net interest margin; OpProf = operating profits before write-offs.

Table N: Operating profit over equity ('ROE') regressions. 'OLS' denotes ordinary least squares estimation. 'FE' denotes fixed-effects estimation. 'SysGMM' denotes System GMM estimation.

	(1) OLS	(2) FE	(3) FE	(4) SysGMM	(5) SysGMM
$OpProf/K_{t-1}$	0.40900***	0.29181***	0.29064***	0.17472*	0.20118*
	(5.08)	(3.31)	(3.36)	(1.84)	(1.96)
$OpProf/K_{t-2}$				0.13506***	0.15868***
				(4.50)	(5.92)
GTA_{t-1}	-0.00370*	-0.00268	-0.00176	-0.00096	-0.00039
	(-1.93)	(-1.28)	(-0.83)	(-0.55)	(-0.20)
LEV_{t-1}	0.01917*	0.05246***	0.05089***	0.05955**	0.04610^{+}
	(1.94)	(4.00)	(3.86)	(2.29)	(1.51)
R^{3m}	-0.00067	0.00061	0.00042	-0.00075	-0.00079
	(-0.62)	(0.61)	(0.38)	(-0.55)	(-0.62)
$SLOPE$	-0.00091	0.00034	0.00015	-0.00078	-0.00082
	(-0.74)	(0.41)	(0.21)	(-0.48)	(-0.57)
GDP			0.00308		
			(1.11)		
GDP_{t-1}			-0.00256		
			(-1.16)		
VOL^{libor}			0.01425		
			(1.07)		
VOL^{FTSE}			-0.00379		
			(-0.21)		
VOL^{ERI}			-0.01271^{+}		
			(-1.63)		
$GFSTEvolume$			0.00189		
			(0.44)		
$CONC$			-0.11048		
			(-0.80)		
Const	0.00069	-0.03295**	-0.02129^{+}	-0.03296	-0.02195
	(0.06)	(-2.34)	(-1.48)	(-1.40)	(-0.77)
N	1353	1353	1331	1302	1302
Units		40	40	40	40
AvgT		33.83	33.27	32.55	32.55
Instruments				236	45
Hansen				30.09	32.78
Hansenp				1.00	0.71
AR2				-1.03	-1.18
AR2p				0.30	0.24

Whole sample. ***,** ,* ,$^{+}$ denote significance at 1%, 5%, 10% and 15% respectively.

References

Adrian, T and Shin, H (2009), 'Money, liquidity and monetary policy', *American Economic Review*, Vol. 99, No. 2, pages 600–05.

Aikman, D, Alessandri, P, Eklund, B, Gai, P, Kapadia, S, Martin, E, Mora, N, Sterne, G and Willison, M (2009), 'Funding liquidity risk in a quantitative model of systemic stability', *Bank of England Working Paper*, *No. 372*, June.

Albertazzi, U and Gambacorta, L (2009), 'Bank profitability and the business cycle', *Journal of Financial Stability*, Vol. 5, No. 4, pages 393–409.

Alessandri, P and Drehmann, M (2010), 'An economic capital model integrating credit and interest rate risk in the banking book', *Journal of Banking and Finance*, Vol. 34, No. 4, pages 730–42.

Alessandri, P, Gai, P, Kapadia, S, Mora, N and Puhr, C (2009), 'Towards a framework for quantifying systemic stability', *International Journal of Central Banking*, Vol. 5, No. 3, pages 47–81.

Altunbas, Y, Gambacorta, L and Marques-Ibanez, D (2010), 'Does monetary policy affect bank risk-taking?', *BIS Working Papers*, *No. 298*, March.

Andreasen, M, Ferman, M and Zabczyk, P (2012), 'The business cycle implications of banks' maturity transformation', *Bank of England Working Paper No. 446*, March.

Arellano, M and Bond, S (1991), 'Some tests of specification for panel data: Monte Carlo evidence and an application to employment equations', *The Review of Economic Studies*, Vol. 58, No. 2, page 277.

Arellano, M and Bover, O (1995), 'Another look at the instrumental variable estimation of error-components models', *Journal of Econometrics*, Vol. 68, No. 1, pages 29–51.

Bagehot, W (1873), *Lombard Street: a description of the money market*, Cosimo Classics.

Baltagi, B and Griffin, J (1983), 'Gasoline demand in the OECD: an application of pooling and testing procedures', *European Economic Review*, Vol. 22, No. 2, pages 117–37.

Baltagi, B, Griffin, J and Xiong, W (2000), 'To pool or not to pool: homogeneous versus heterogeneous estimators applied to cigarette demand', *Review of Economics and Statistics*, Vol. 82, No. 1, pages 117–26.

Banbura, M, Giannone, D and Reichlin, L (2007), 'Bayesian VARs with large panels', *CEPR Discussion Papers, 6326*.

Bank of England (2009), 'The role of macroprudential policy', *Bank of England Discussion Paper*.

BCBS (Basel Committee on Banking Supervision) (2004), *Principles for the management and supervision of interest rate risk*, Bank for International Settlements.

Beckmann, R (2007), 'Profitability of Western European banking systems: panel evidence on structural and cyclical determinants', *Discussion Paper Series 2: Banking and Financial Studies 2007, 17*.

Berger, A (1995), 'The relationship between capital and earnings in banking', *Journal of Money, Credit and Banking*, Vol. 27, No. 2, pages 432–56.

Blundell, R and Bond, S (1998), 'Initial conditions and moment restrictions in dynamic panel data models', *Journal of Econometrics*, Vol. 87, No. 1, pages 115–43.

Bond, S (2002), 'Dynamic panel data models: a guide to micro data methods and practice', *Portuguese Economic Journal*, Vol. 1, No. 2, pages 141–62.

Borio, C and Shim, I (2007), 'What can (macro-) prudential policy do to support monetary policy?', *BIS Working Papers*, *No. 242*.

Borio, C and Zhu, H (2008), 'Capital regulation, risk-taking and monetary policy: a missing link in the transmission mechanism?', *BIS Working Papers*, *No. 268*.

Bourke, P (1989), 'Concentration and other determinants of bank profitability in Europe, North America and Australia', *Journal of Banking and Finance*, Vol. 13, No. 1, pages 65–79.

Corvoisier, S and Gropp, R (2002), 'Bank concentration and retail interest rates', *Journal of Banking and Finance*, Vol. 26, No. 11, pages 2,155–89.

De Nicolò, G, Dell'Ariccia, G, Laeven, L and Valencia, F (2010), 'Monetary policy and bank risk taking', *IMF Staff Position Note 10/09*.

Delis, M and Kouretas, G (2011), 'Interest rates and bank risk-taking', *Journal of Banking and Finance*, Vol. 35, No. 4, pages 840–55.

Demirguc-Kunt, A and Huizinga, H (1999), 'Determinants of commercial bank interest margins and profitability: some international evidence', *The World Bank Economic Review*, Vol. 13, No. 2, page 379.

Drehmann, M, Sorensen, S and Stringa, M (2010), 'The integrated impact of credit and interest rate risk on banks: a dynamic framework and stress testing application', *Journal of Banking and Finance*, Vol. 34, No. 4, pages 713–29.

Flannery, M (1981), 'Market interest rates and commercial bank profitability: an empirical investigation', *The Journal of Finance*, Vol. 36, No. 5, pages 1,085–101.

Flannery, M and James, C (1984), 'The effect of interest rate changes on the common stock returns of financial institutions', *The Journal of Finance*, Vol. 39, No. 4, pages 1,141–53.

Gambacorta, L (2005), 'Inside the bank lending channel', *European Economic Review*, Vol. 49, No. 7, pages 1,737–59.

Gambacorta, L (2008), 'How do banks set interest rates?', *European Economic Review*, Vol. 52, No. 5, pages 792–819.

Gambacorta, L and Mistrulli, P (2004), 'Does bank capital affect lending behavior?', *Journal of Financial Intermediation*, Vol. 13, No. 4, pages 436–57.

Gerali, A, Neri, S, Sessa, L and Signoretti, F (2010), 'Credit and banking in a DSGE model of the euro area', *Journal of Money, Credit and Banking*, Vol. 42, pages 107–41.

Gertler, M and Karadi, P (2011), 'A model of unconventional monetary policy', *Journal of Monetary Economics*, Vol. 58, No. 1, pages 17–34.

Gorton, G and Rosen, R (1995), 'Banks and derivatives', *NBER Macroeconomics Annual*, Vol. 10, pages 299–339.

Hancock, D (1985), 'Bank profitability, interest rates, and monetary policy', *Journal of Money, Credit and Banking*, Vol. 17, No. 2, pages 189–202.

Hanson, S, Kashyap, A and Stein, J (2010), 'A macroprudential approach to financial regulation', *Journal of Economic Perspectives*, Vol. 25, pages 3–28.

Joyce, M, Lildholdt, P and Sorensen, S (2010), 'Extracting inflation expectations and inflation risk premia from the term structure: a joint model of the UK nominal and real yield curves', *Journal of Banking and Finance*, Vol. 34, No. 2, pages 281–94.

Kashyap, A and Stein, J (2000), 'What do a million observations on banks say about the transmission of monetary policy?', *American Economic Review*, pages 407–28.

Kasman, S, Vardar, G and Tunç, G (2011), 'The impact of interest rate and exchange rate volatility on banks' stock returns and volatility: evidence from Turkey', *Economic Modelling*, Vol. 28, No. 3, pages 1,328–34.

Keen, B and Wang, Y (2007), 'What is a realistic value for price adjustment costs in New Keynesian models?', *Applied Economics Letters*, Vol. 14, No. 11, pages 789–93.

Lehmann, H and Manz, M (2006), 'The exposure of Swiss banks to macroeconomic shocks - an empirical investigation', *Swiss National Bank Working Paper No. 2006-4*.

Lepetit, L, Nys, E, Rous, P and Tarazi, A (2008), 'Bank income structure and risk: an empirical analysis of European banks', *Journal of Banking and Finance*, Vol. 32, No. 8, pages 1,452–67.

Litterman, R (1986), 'Forecasting with Bayesian vector autoregressions: five years of experience', *Journal of Business and Economic Statistics*, Vol. 4, No. 1, pages 25–38.

Purnanandam, A (2007), 'Interest rate derivatives at commercial banks: an empirical investigation', *Journal of Monetary Economics*, Vol. 54, No. 6, pages 1,769–808.

Roodman, D (2009), 'A note on the theme of too many instruments', *Oxford Bulletin of Economics and Statistics*, Vol. 71, No. 1, pages 135–58.

Saunders, A and Schumacher, L (2000), 'The determinants of bank interest rate margins: an international study', *Journal of International Money and Finance*, Vol. 19, No. 6, pages 813–32.

Smith, R, Staikouras, C and Wood, G (2003), 'Non-interest income and total income stability', *Bank of England Working Paper No. 198*.

Stiroh, K (2004), 'Diversification in banking: is noninterest income the answer?', *Journal of Money, Credit and Banking*, Vol. 36, No. 5, pages 853–82.

Stiroh, K and Rumble, A (2006), 'The dark side of diversification: the case of US financial holding companies', *Journal of Banking and Finance*, Vol. 30, No. 8, pages 2,131–61.

Tarhan, V (1987), 'Unanticipated interest rates, bank stock returns and the nominal contracting hypothesis', *Journal of Banking and Finance*, Vol. 11, No. 1, pages 99–115.

Uhlig, H (2005), 'What are the effects of monetary policy on output? Results from an agnostic identification procedure', *Journal of Monetary Economics*, Vol. 52, No. 2, pages 381–419.

Van den Heuvel, S (2007), 'The bank capital channel of monetary policy', *mimeo*.

Wong, K (1997), 'On the determinants of bank interest margins under credit and interest rate risks', *Journal of Banking and Finance*, Vol. 21, No. 2, pages 251–71.

Zellner, A (1962), 'An efficient method of estimating seemingly unrelated regressions and tests for aggregation bias', *Journal of the American Statistical Association*, Vol. 57, No. 298, pages 348–68.