In Good Times and in Bad:
Bank Capital Ratios and Lending Rates

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Abstract: This paper assesses the relation between bank capital ratios and lending rates for the 8 largest UK banks over the period 1998-2011. Our paper differs from previous literature in that we employ a dynamic error correction specification and a unique regulatory database to disentangle long- and short-run effects. There is no long-run link in pre-crisis boom times, but a strongly negative association is revealed during the stressed conditions of 2007-11 when well-capitalised banks may have benefited from lower funding costs. Higher capital ratios also have positive short-run effects on lending rates which are sizeable during crisis times. These results imply that countercyclical variations in bank capital requirements, as envisaged by Basel III, need to be very substantial to offset the procyclical reduction in the supply of bank lending during a crisis. [131 words]

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1. Introduction

The regulatory response to the late 2000s global financial crisis (GFC) includes substantially higher bank capital requirements and a proposal for these requirements to vary countercyclically, rising in boom conditions and falling in busts to dampen excess bank procyclicality and smooth the credit cycle. These measures have fuelled an intense debate on the macroeconomic impact of higher prudential standards. Estimates of the potential impact of increased regulatory capital requirements on the cost of intermediation and the path of economic growth vary greatly (Barrell et al., 2009; BCBS, 2010; Miles et al., 2011; Institute for International Finance, 2010). Some studies refer to the Modigliani and Miller (1958) capital structure theorems to argue that regulatory requirements have little impact on the overall resource cost of bank intermediation (Admati et al., 2010; Kashyap et al., 2010; Miles et al., 2011). This perspective contrasts with that of most practitioners who argue that the higher capital requirements proposed under Basel III will substantially raise bank intermediation costs and that this will pose difficulties for an already vulnerable real economy.[1]

The empirical literature offers similarly conflicting evidence on the magnitude, and indeed the direction, of the relationship between bank capital ratios and loan pricing. While cross-country studies document a positive link between capital ratios and net interest margins (Carbó-Valverde and Rodríguez-Fernández, 2007; Saunders and Schumacher, 2000; Demirgüç-Kunt and Huizinga, 1999), studies utilizing data on individual country (mostly syndicated) loans granted to large businesses find a negative relation (Santos and Winton, 2010; Steffen and Wahrenburg, 2008; Hubbard et al., 2002). Time variation not accounted for in the relation between bank capital and bank loan pricing could serve to rationalize this contrasting evidence. One empirical study which supports this explanation is Fischer et al. (2009) where a negative relation between loan margins and the lender's capital ratio is documented using US individual loans over the period 1988-92, when regulatory changes and market pressure were

[1] For instance, see financial press articles 'We must rethink Basel, or growth will suffer' (Vikram Pandit, Financial Times, 10th November 2010) and 'Jamie Dimon says regulation will stifle economic growth' (Wall Street Journal, 5th April 2011). Also see the impact assessment prepared by the Institute for International Finance (2010).

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forcing bank capital ratios upwards, and a positive correlation during 1993-2005 when banks operated in more benign conditions.

This paper seeks to contribute to the literature on the relation between bank capital and lending with an examination of the 8 largest UK banks during the 14-year period 1998-2011. Various aspects of our research strategy differentiate our work from existing studies. First, the link between capital ratios and lending rates is explicitly broken down into a long-run co-integrating relation and short-run dynamics of capital adjustment, whereas previous studies conflate long- and short-run effects. We exploit a confidential regulatory dataset submitted by banks to the Bank of England (BoE) and FSA which includes monthly effective interest rates on loans and quarterly capital adequacy information. This allows us to depart from most previous studies which rely on low-frequency annual data and hence, cannot distinguish short-run and long-run effects. Second, our research investigates differences between the pre-crisis period ('good times') when there was little pressure on banks to increase capital and the recent crisis period ('bad times') when regulatory capital requirements have been more consistent with market demands and hence, the cost of capital curve was less steep.

Our research strategy can be summarised as follows. An error correction modelling (ECM) framework is adopted to estimate the long-run loan pricing relation. This ECM formulation is able to capture short-run dynamic effects and controls for observed bank-level characteristics such as the Tier 1 capital ratio and portfolio risk, system-wide indicators of the business cycle such as the Bank of England base rate, market interest rates and the output gap, as well as latent bank and time (i.e. two-way) fixed effects. In order to capture inter-temporal differences in the relation caused by financial distress, we estimate a second model in which the long-run effect is allowed to differ between the recent crisis period and earlier years. Finally, we estimate a third model in which we replace the *actual* Tier 1 capital ratio with a *long-run target* Tier 1 capital ratio proxy. This represents a more direct test of the potential impact of capital requirements, since these achieve their affects by altering banks' own long-run capital targets.

Our analysis finds no evidence for the positive long-run relation between capital ratios and loan rates hypothesised during normal (i.e., pre-crisis) conditions. We interpret this as evidence that bank funding costs were not much affected by capital ratios in this

period. But there is a clear difference between ‘good’ and ‘bad’ times: the link becomes significantly negative, economically and statistically, in the crisis period. These findings are robust to whether the actual capital ratio or the target capital ratio is used. We argue this is likely to reflect the reduction in funding costs as banks’ own optimal capital ratios rise due to increased expected bankruptcy costs. In such conditions increases in capital ratios, generated by regulatory and/or market pressures, tend to reduce funding costs (other things equal). We also find a positive short-run relation between capital and lending rates, which becomes stronger during the stressed period, supporting the idea that banks use interest margins as a tool to increase their capital ratios under stress. Finally we show that our results are robust to controlling for banks' relative competitive positions (as proxied by market share).

These findings suggest that estimates of the impact of higher capital requirements on lending rates and the broader economy should be analyzed in a framework that allows the cost of capital requirements explicitly to vary over the business cycle and dynamically over the long- and short-run. These findings also offer some insight into the use of countercyclical bank capital requirements, as proposed in Basel III, as an additional tool to constrain lending growth during booms and encourage lending during busts. It is difficult to directly infer the effects of reductions in capital requirements during a crisis from our sample, since in the recent financial crisis capital requirements were rising rather than falling. However, our finding of a negative long-run link in stressed conditions provides indirect evidence, since it suggests that in such conditions banks have an incentive to increase their capital ratios and this in turn reduces their funding costs. This is consistent with experience following the recent crisis when banks have raised capital ratios far more than they have been required to by the transition to higher Basel III standards, which will not be fully implemented until 2018. We conclude from this that the amplitude (i.e. the range) of counter-cyclical variations in capital requirements needs to be very substantial if they are to offset the cyclical contraction in lending that takes place under stressed conditions.

The remainder of the paper is structured as follows. Section 2 discusses the interrelationship between bank capital and loan interest rates, distinguishing three different effects of bank capital on loan interest rates that we then go on to investigate

empirically. This section also reviews previous empirical literature on the relation between bank capital and loan interest rates. Section 3 outlines our specification, methodology and data. Section 4 presents the estimation results. Section 5 concludes with a summary of our results and their implications.

2. The interrelationship of bank capital and loan interest rates

2.1 CONCEPTUAL AND THEORETICAL BACKGROUND

The main goal of this paper is to estimate the relationship between bank capital and loan interest rates, disentangling short-term dynamics and long-run effects and allowing for the possibility that the balance of costs and benefits of holding bank capital (and hence, the relationship with lending rates) alters substantially from one time period to another. While this is mainly an empirical exercise, it is nonetheless important to provide some conceptual and theoretical background.

It is crucial to be clear what is meant by bank capital. We distinguish between the *capital requirement* which is the minimum capital ratio required by regulators, the *capital ratio* which is the bank's actual capital ratio, and the long-run *target capital ratio* which is the level of capital intended by the bank over the long run which can be defined as the capital requirement plus the long-run desired capital buffer. Actual capital can differ from target capital because of short-run adjustment costs. This target capital might be referred to as the ‘optimal capital ratio’ but this terminology risks confusion with the ‘privately optimal capital ratio’, namely, the capital ratio that minimises funding costs and hence, would be optimal in the absence of capital requirements. Finally, consistent with other studies, we use the term *capital buffer* to refer to the excess of the actual capital ratio over the capital requirement. This buffer is always positive or zero, except on rare occasions when firms are in breach of regulatory requirements.

The empirical models formulated in this paper allow us to test three hypotheses about the relationship between bank capital and loan interest rates:[2]

H_1: Bank capital ratios and loan interest rates are positively related in the long run during normal market conditions (Cost of Capital Effect)

H_2: Under stressed market conditions, the long-run relation weakens or becomes negative (Banking Sector Distress Effect)

H_3: Banks use interest margins as a tool for managing actual capital ratios, implying that there is a separate short-run link between bank capital and lending rates (Weak Bank Effect).

While we do not present a formal theoretical model, these three hypotheses seem to capture most of the empirical predictions that emerge from various theories of bank capital. They can be interpreted as follows. The first *cost of capital* hypothesis can be understood as a prediction of standard capital structure theory. The basic Modigliani-Miller (MM) propositions imply that changes in the funding mixture of firms will make no difference to their funding costs. However, standard corporate finance theory suggests that capital market frictions lead to a cost of capital curve that is U-shaped.[3] First, debt interest payments tend to be tax-deductible so that a lower capital ratio will reduce the tax bill and increase profits, incentivising firms to hold more debt and less equity. On the other hand, expected bankruptcy costs mean that, as the proportion of equity falls, the cost of funding rises, so that a high probability of distress results in a higher cost of debt funding. In the classic trade-off theory, these factors offset one another, producing an optimal capital ratio that minimises funding costs. One alternative is the pecking order theory, in which adverse selection raises the costs of issuing new equity, so that investment in new assets that cannot be financed out of retained earnings will lower capital ratios (Myers and Majluf, 1984).

These theories are relevant to any firm. They have been applied to banks, for example, by Ellis and Flannery (1992), Flannery and Rangan (2006) and Mehran and Thakor (2011). Banks have a number of features suggesting that they will be highly leveraged relative to other firms [Berger et al. (1995)]. A classic theory of why financial

[2] For fuller reviews of the large theoretical literature on bank capital and its relationship with loan pricing see Swank (1996), Bhattacharya and Thakor (1993) and VanHoose (2007).

[3] A vast literature exists on the MM theorems and we do not attempt to summarise it here. Comprehensive reviews are provided by Myers (2001) and Brealey et al. (2010) inter alios.

intermediaries exist is that they earn returns from the information they gather about borrowers [Leland and Pyle (1977), Diamond (1984)] and some argue that in the MM setting there is little rationale for banks to exist at all [Berger et al (1995), Gambacorta and Mistrulli (2004)]. In the pecking order theory, these agency problems imply that equity issuance may be especially costly for banks [Holmstrom and Tirole (1997), Stein (1998)]. Implicit and explicit state guarantees on banks' debt may also help explain why banks are highly leveraged [Merton (1977), Keeley (1990), Berger et al. (1995)].4 On the other hand, Mehran and Thakor (2011) argue that the effect of expected bankruptcy costs could be particularly important for banks, since a higher likelihood of bankruptcy reduces the bank's incentives to monitor borrowers, implying that equity is positively associated with value, other things equal.

The implications of the trade-off view for a bank's cost of funding are shown in Figure 1, by plotting the cost of funding (vertical axis) against the capital-asset ratio (horizontal axis). This is intended as a graphical illustration rather than a formal model. The cost of funding curve (CF1) is a plausible example to explain the key aspects of the trade-off view. As the capital ratio falls, the cost of funding decreases linearly due to the tax and information advantages of debt and the effects of state guarantees. When capital falls to low levels, expected bankruptcy costs raise the cost of funding. Hence, our example illustrates that the sign and magnitude of the relation between capital and the cost of funding depends on the level of capital. In the absence of regulatory capital requirements, an optimising bank chooses A* as target capital ratio where these factors just offset each other and the cost of funding is minimised. .

[4] It is worth noting that the franchise value of a bank may act as a constraint on the incentives to maximise leverage [Marcus (1984), Keeley (1990), Milne and Whalley (2001)].

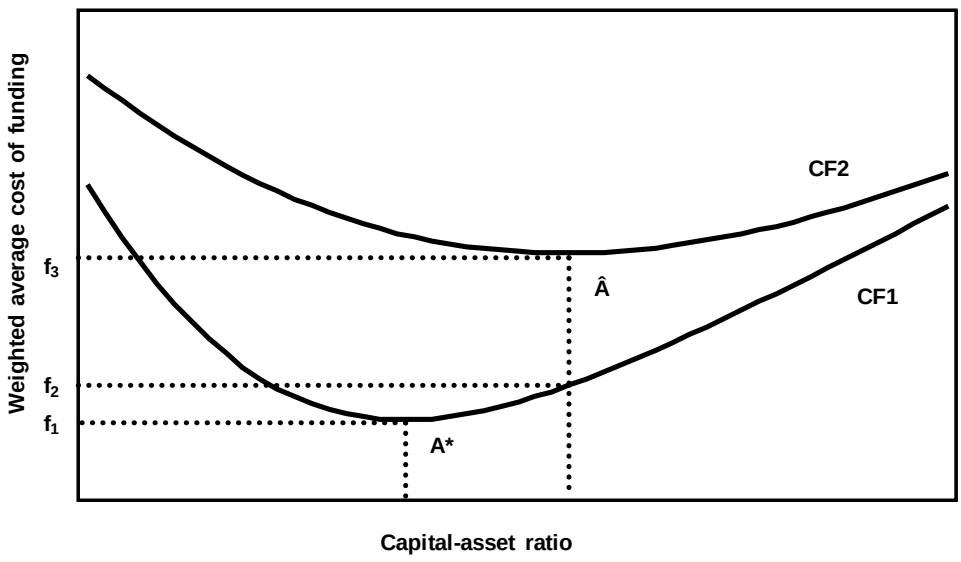

Figure 1. Illustration of long-run cost of capital curve.

This figure illustrates the effects of capital structure on funding costs by plotting the weighted average cost of funding (vertical axis) against the capital-asset ratio (horizontal axis). CF1 and CF2 denote the cost of funding curves in normal and stressed market conditions, respectively. The shift from A* to Â is thus the increase in the target capital ratio from normal to stressed market conditions and the cost of funding increases from f_1 to f_3. This shift from CF1 to CF2 and from A* to Â could also be as the consequence of the imposition of capital requirements. Â is the higher target capital ratio when there is a regulatory capital requirement. In normal conditions imposing a capital requirement raises the cost of funding from f_1 to f_3, but if capital requirements are imposed in stressed conditions the cost of funding remains at f_3 since the bank's target capital ratio is the same with or without capital requirements.

Figure 1 departs from many standard accounts because it does not present the regulatory capital requirements as a continuously binding constraint, with an imposed level of capital higher than the capital ratio A* (the target capital ratio in the absence of a capital requirement) due to regulators' concern for the social as well as private costs of bank failure. Instead this figure assumes that banks seek to hold a buffer over the capital requirement to minimise the probability of unexpected breaches (Milne and Whalley, 2001). Regulatory capital requirements alter the bank's target capital decision since falling below the capital requirement imposes costs on the bank such as additional supervisory surveillance and limits on the bank's activities. Due to these costs, a bank optimally chooses to hold a buffer over the capital requirement to protect against unexpected and costly breaches.

In our illustrative graphical framework, imposing a capital requirement increases the bank's target capital ratio to Â, which equals the capital requirement plus the bank's

desired capital buffer.[5] Still, the empirical predictions of the standard analysis with binding regulatory capital requirements and this buffer capital account are similar. Under the standard account, without buffer capital, banks with binding capital requirements experience higher funding costs and this, in turn, implies a positive link between capital and loan interest spreads (Berger et al., 1995). In a setup that allows for buffer capital, a higher level of the capital requirement that increases the bank's target level of capital implies a positive link in the long-run between bank capital and loan interest spreads during normal market conditions. Note that if capital requirements are to the left of the bank's own optimal capital ratio A* then they are not binding, the bank chooses A*, and the relation between capital and funding costs is flat.

Our second hypothesis is the less standard prediction that, in stressed market conditions, the long-run relation between banks' capital ratios and loan interest rates may weaken (relative to normal times) or be negative. This banking sector distress effect is driven by the observation that banks tend to be under pressure from investors and other market participants to increase capital ratios in crisis periods. When the banking system is in distress, banks with relatively illiquid asset portfolios may be forced to deleverage by the high cost of refinancing their debts (Cornett et al., 2011). Expected bankruptcy costs rise in periods of economic contraction due to an increase in the probability of banks' illiquidity and insolvency distress, and lower expected profits reduce the value of the "tax shield" provided by the tax deductibility of interest expense. Thus in stressed market conditions, both the cost of funding and the target bank capital ratio rise (Estrella, 2004; Hanson et al., 2010). For example, Berger (1995) offers convincing evidence that widespread US bank failures and recession in the late 1980s caused banks' optimal capital ratios to rise so that those with increased capital ratios paid lower rates of return on their debt funding than other banks, and recorded higher profits as a result. An influential recent advocacy of this view in relation to the recent financial crisis is Admati et al (2010) which argues that much higher capital requirements are justified on the basis that risk premia in banks' cost of funding will fall as a result of a reduction in the probability of distress. Yang and Tsatsaronis (2012) present initial empirical support for such a notion, finding that bank stock returns tend to be positively associated with

[5] In the analysis above, we have made the simplifying assumption that the capital ratio demanded by the market (depicted in the curves CF1 and CF2) is independent from the capital requirement imposed by regulators. In practice, capital requirements are likely to influence investors' perceptions of bank riskiness.

business cycles and the level of bank leverage. Hence, the normally positive long-run relation between capital ratios and interest margins is likely to lessen or turn negative in stress scenarios.

This banking distress effect can also be explained through Figure 1. A downward shock to the soundness of the banking sector increases expected bankruptcy costs and therefore shifts the cost of funding curve to the north-east (from CF1 to CF2). To the right of Â the upwards slope of CF2 is less steep than that to the right of A* in CF1. Thus at the margin, small increases in the capital requirement that cause the bank to hold capital ratios in excess of Â do not impose costs (or only small ones) on the bank since this capital ratio is more consistent with market demands.[6] Increases in the capital requirement during stressed market conditions are less costly than in normal conditions.

Assuming that a change in funding costs will be passed on to bank customers through deposit and lending interest rates,[7] this simple graphical illustration can be mapped into two of the above hypotheses: the target capital ratio is positively correlated with the lending rate in the long run ($\boldsymbol{H}_1$) and this relationship grows weaker during stressed market conditions ($\boldsymbol{H}_2$).

Our third hypothesis arises theoretically from the fact that the interest margin set by a bank is not only a source of funds with which to remunerate investors, but it is also a source of new capital via retained earnings (Milne, 2004; Santos and Winton, 2010) and it can also be used to manage the capital ratio via the denominator by influencing the supply of new credit. This implies that the short-run relation between bank capital and lending rates differs from the long-run relation as banks use interest margins for management of short-run deviations (deficit/surplus) of capital from their long-run target capital. Higher loan margins allow a bank to build up capital reserves and reduce growth of new credit, improving both the denominator and numerator of the capital ratio. A weak bank will increase both its lending rates and its capital ratio in the short

[6] It is possible that an increase in capital requirements would be associated with a decrease in the cost of funding in the short run if it is consistent with market demands for higher capital. However, as Berger (1995) points out, this should not be interpreted as support for the counter-intuitive notion that higher capital requirements may reduce funding costs, since in time an optimising bank would increase its capital ratio anyway to meet market demands.

[7] Button et al. (2010) document empirically the increase in funding costs of UK banks during the recent financial crisis and assess its contribution to higher household lending rates.

run, and on this basis we expect that the short-run effect of increases in lending rates on capital ratios, namely the *weak bank effect*, is positive.[8]

In contrast, some previous studies have argued that the *weak bank effect* is negative, since downward shocks to a bank's capital ratio are accompanied by upward spikes in loan interest rates as banks seek to strengthen their balance sheets by extracting a premium from their customers (Hubbard et al, 2003; Steffen and Wahrenburg, 2008; Santos and Winton, 2010). Whether a positive or a negative effect is observed is a matter of timing. If the shock is recorded simultaneously with the adjustment of interest rates, as it would be in annual data such as used by the studies cited above, it is more likely that we will observe a negative relation. If the data separates the period in which the shock occurs from periods in which lending rates and capital ratios adjust upwards, as with higher frequency data such as ours, a positive short-run effect is more likely to be observed. As we will argue below, it is also more likely that the target capital ratio will be positive correlated with the lending rate in the short run than the actual capital ratio, given that it will not reflect unplanned shocks to the actual capital ratio.

Figure 2 below illustrates the short-run relation of bank capital with loan rates. On the vertical axis we show the evolution in interest margin and capital ratio from time t_0 to time t_2 (rebased to use the same scale for simplicity). We first assume that the bank has a target capital ratio which it seeks to maintain, defined as the capital requirement plus the desired buffer. The term "deviation" is used to refer to the short-run fluctuations of the capital ratio around the bank's target capital ratio. This deviation can plausibly be negative (deficit) or positive (surplus) whereas the capital buffer, which is the excess of the capital ratio over the capital requirement, will almost always be positive (the so called 'headroom' of banks).

[8] For the sake of consistency with previous literature we have used the terminology "weak bank effect" to refer to this hypothesis. However, we note that this is equivalent to a "strong bank effect" whereby a bank cuts interest margins in order to reduce its capital ratio, and this makes the same predictions in terms of the sign of the short-run coefficients.

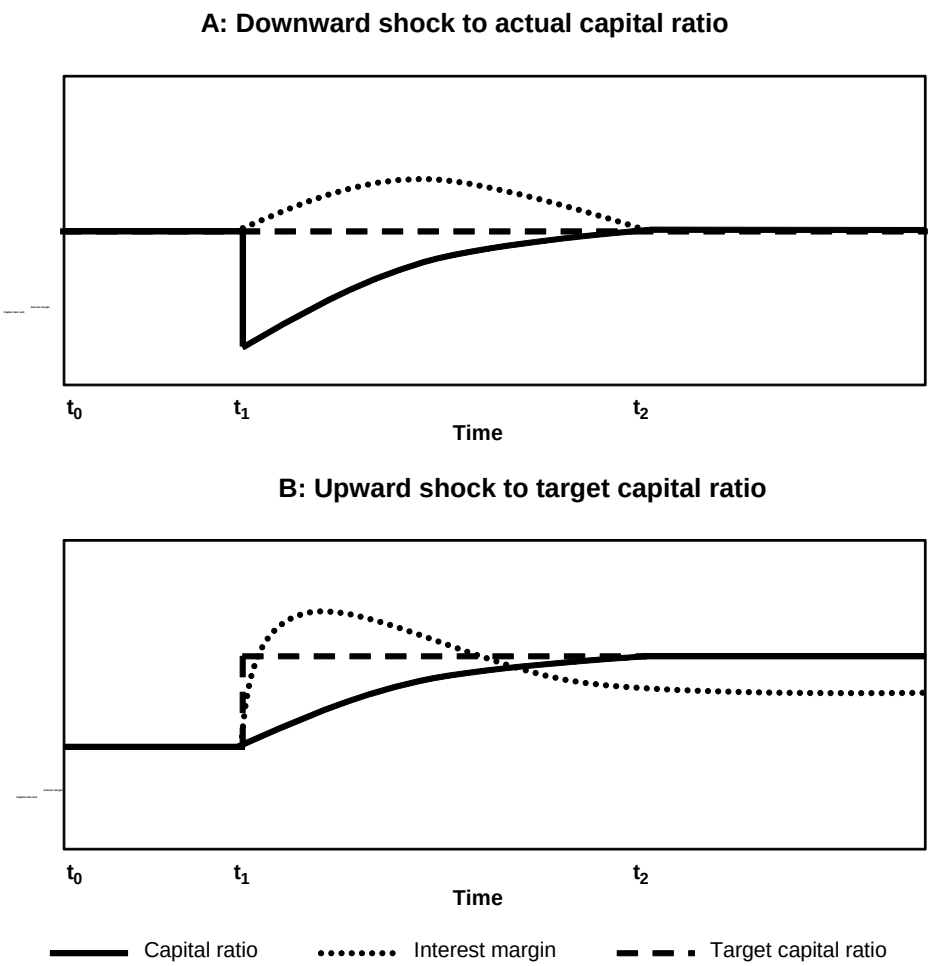

Figure 2: Illustration of short-run relation between capital and interest margins.

The figure illustrates the potential short-run relation between the capital ratio (solid line), target capital ratio (dashed line) and the interest margin (dotted line) over time (horizontal axis), with all series rebased to ease comparison. The actual capital ratio equals the target capital ratio in the long run but deviations (surplus or deficit) can be observed in the short term. In both panels the capital ratio is below the target capital ratio implying a short-term deficit of capital.

At time t_0 the capital ratio equals the target capital so the deviation is zero. An exogenous negative shock to the capital ratio at t_1 creates a short-term deficit (negative deviation) as shown in Panel A. The bank responds by raising interest margins in order to rebuild its balance sheet until actual capital reaches the long-run target capital path again at t_2. This illustrates the ambiguous direction of the short-run relation between actual capital ratio and lending rates, since it is negative around t_1 but later turns positive between t_1 and t_2. In Panel B we show the effects of a sudden increase in capital requirements at time t_1 which again creates a short-term deficit of capital. Here the bank raises its interest margin in order to build up capital, until the actual capital reaches the target capital ratio again at t_2, and the interest margin remains at a higher plateau in order to remunerate the higher capital ratio (consistent with the *cost of capital effect*). In

this case the capital ratio and the interest margins will be unambiguously positively related to one another in the short-run.

Furthermore, as Milne and Whalley (2001) show, if actual capital is reduced by an exogenous shock such as an increase in capital requirements or unexpected loan losses, then the bank may have an incentive to reduce risk quickly in order to avoid a costly breach of the capital requirement. The resulting rebalancing of the portfolio towards less risky assets may reduce loan interest rates, although to some extent this can be controlled for with a measure of portfolio risk.

The short-run relation could confound observation of the long-run effect if not controlled for properly. Hence, it is important to separate out short-run from long-run effects. To the best of our knowledge, our study is the first attempt to do so. This may explain why extant estimates of the relation between bank capital and interest margins (or interest rates), which are summarised in the next section, are so conflicting in sign and/or magnitude. Given that they use annual data and do not separate long- and short-run effects, either the *weak bank effect* or the *banking sector distress effect* could explain the negative relation observed in these studies, although they tend to acknowledge the *weak bank effect* only.

2.2 PREVIOUS EMPIRICAL STUDIES OF BANK CAPITAL AND LOAN INTEREST RATES

Saunders and Schumacher (2000) analyze a large cross-country sample of banks for the period 1988-95, and find that the capital-asset ratio is positively related to net interest margins in most country-year combinations, which they explain using the *cost of capital effect* described above. However, their findings are based on pure cross-section regressions that do not jointly exploit the time series dimension of the data and thus cannot jointly model short- and long-run effects. If capital ratios rise simultaneously in all banks in a particular country, for example, due to higher capital requirements, the effect of capital on margins would not be picked up in a cross-section regression. Hence, they may not capture the full impact of the higher capital standards introduced by the original Basel Accord in this period.

Demirgüç-Kunt and Huizinga (1999) also use a large international sample of banks over the period 1988-95 but, unlike the above study, the regression analysis exploits both the time- and cross-section variation in the data to ascertain the role of the capital ratio and other potential factors as drivers of net interest margins. However, their static panel regressions do not explicitly control for a dynamic "error correction" mechanism, namely, the catch up of actual capital towards the long-run target path. Their findings suggest too that net interest rate margins are significantly positively correlated with capital ratios although this relation is not allowed to vary over time.

Another issue with the above two studies is that they adopt net interest rate margins (NIM) as the dependent variable. This variable is calculated as interest revenue minus interest expense over total assets, and it has an unfortunate property: a shift from debt to equity funding will tend to increase the NIM even in the absence of any difference between the cost of the two funding sources, since interest expense is included in the NIM but returns paid to shareholders in the form of dividends are not. This effect lowers the signal-noise ratio by making it hard to infer the relation between capital ratios and interest rates from the reported relation between capital ratios and NIMs.

Carbó-Valverde and Rodríguez-Fernández (2007) use the interest spread, calculated as the difference between lending and deposit rates, rather than the NIM. Their panel study of European banks over the period 1994-2001 establishes that the capital-to-asset ratio is strongly positively linked with the interest rate spread, although this effect is not permitted to differ between banks or over time. Likewise, employing a large database of syndicated loans issued by US borrowers over the period 1993-2007, Fischer et al. (2009) find that the ratio of total capital to risk-weighted assets is positively correlated with lending spreads.[9] They interpret this as evidence that borrowers prefer to do business with high capitalised banks and that these banks can therefore extract a premium from borrowers. The *cost of capital effect* is supported by these findings.

[9] The use of the risk-weighted capital ratio in Fischer et al 2009 could make it more difficult to uncover a positive association given that higher portfolio risk will tend to reduce the capital ratio and raise the interest spread, though we note that their regressions were also run using the equity-to-assets ratio and produced qualitatively similar results. Nevertheless, we use the capital-asset ratio in our model of lending rates to avoid this effect.

However, other studies using data on syndicated loans have found a negative relation between interest margins and the capital ratio in both the US (Hubbard et al., 2002; Santos and Winton, 2010) and the UK (Steffen and Wahrenburg, 2008). These results are attributed to the existence of the *weak bank effect*, namely, that banks with low capital ratios raise their margins in order to repair their balance sheets and enable access to funding markets. It could be that by not distinguishing between long- and short-run dynamics the studies cited above find a negative relationship because the *weak bank effect* and *cost of capital effect* are then entangled. A negative relation could also be due to a dominance of the *banking sector distress effect*, i.e. banks reduce their cost of funding by raising capital ratios consistent with market demands.

The latter rationale is implicit in the evidence from various papers cited above. Fischer et al. (2009) ran their regressions for the period 1987-92, similar to the sample period of Hubbard et al. (2002) and corresponding to the implementation of Basel I which raised regulatory capital standards and forced increases for many banks. In contrast to their finding of a positive relation for the period 1993-2005 which was noted above, they found a negative relation for the earlier period, when banks were under pressure from regulators and the market to raise capital ratios. In addition, Steffen and Wahrenburg (2008) found that a negative relation only applies during economic downturns which may be periods in which banks are under pressure to strengthen their balance sheets.

Various attempts have been made to measure the short-run impact of capital deficits on the quantity of loans although, to the best of our knowledge, none of them use models that explicitly control for long-run effects. Interest rates are one of the main tools by which banks may seek to reduce loan supply, the others being credit rationing at existing interest rates and/or tighter lending standards. Hence, such studies are likely to be consistent with a negative short-run relation between deviations of the capital ratio from target and the interest rate. For example, Francis and Osborne (2012) show that for UK banks experiencing a deficit of capital relative to the long-run target capital ratio, growth in risk weighted assets is lower and growth in capital higher as banks adjust their balance sheets to move back towards the target capital ratio. Similarly, Berrospide and Edge (2010) show that US banks with capital deficits tend to contract loan supply, and Gambacorta and Mistrulli (2004) find that the imposition of bank-specific capital requirements on “problem banks” in Italy can reduce lending by up to 20%. The

substantial literature on the impact of capital deficits in the US during the late 1980s and early 1990s suggests that a contraction in lending supply is associated with loan losses and higher capital requirements; although overall the inferences on causality are mixed.[10]

Finally, a few studies have tried to measure the long-run effect of higher bank capital requirements on interest rates directly using market price data. Such estimates are obtained by taking figures on the long-run return on debt and equity, then adding the extra costs of a higher equity ratio to the interest charged to banks' customers in order to calculate the change in the lending rate. Since the long-run return to equity tends to be larger than the return to debt, these estimates naturally suggest a positive impact of capital on spreads. Furthermore, a likely source of upward bias in such measures is that, as described above, the required returns on equity and debt are likely to alter when expected bankruptcy costs are reduced. In addition, banks are likely to exploit other ways of offsetting the additional cost, such as reducing administrative expenses. Elliott (2009) concludes that the long-run impact of a one percentage point increase in the ratio of equity to assets on the lending rate is likely to be about 5-18 basis points. Kashyap et al. (2010) put the range lower, at 2-6 basis points. However, these studies make no attempt to jointly model long-run and short-run effects or to assess how the impact of capital requirements on loan spreads may vary over the business cycle. Both of these aspects differentiate our analysis from that conducted in previous research.

One possible interpretation of the mixed findings is as follows. When the banking system is weak and under pressure to raise capital, banks that have (or achieve) relatively high capital ratios, and so are perceived as comparatively safe, enjoy relatively lower funding costs. They may then use this opportunity to increase their market share, by lowering their loan rates relative to market rates of interest. In other times, when investors are more relaxed about the prospects of bankruptcy and banks are constrained by capital requirements, a more standard cost of capital effect dominates, resulting in a positive relationship between capital and loan rates.

[10] See comprehensive reviews by Jackson et al. (1999) and Sharpe (1995).

Another potential explanation is that interest margins may be used as a source of capital or as a lever to alter the supply of new credit in order to manage short-run deviations of actual capital from the desired long-run target capital level. It is possible that long- and short-run effects are to a large extent intertwined in existing estimates, since they do not allow for dynamics in interest rate adjustment, and are based on low-frequency annual data.

3. Methodology, Data and Variables

3.1 EMPIRICAL STRATEGY

Our analysis unfolds in three sequential steps. First, we estimate a loan pricing equation which aims to disentangle short- and long-run effects via an error correction modelling (ECM) methodology. Second, we re-estimate the model allowing the long- and short-run effects of banks' capital ratios to differ between normal and crisis periods. Thirdly, we re-estimate the loan pricing equation using an estimated long-run target capital ratio measure in place of the observed actual capital ratio. Finally, we extend our analysis to investigate the role of market share as an additional determinant of loan margins.

Step 1: Estimating loan pricing equations using an error-correction model

In the first step we estimate a loan pricing equation following the error correction modelling (ECM) framework adopted by Fuertes et al. (2009, 2010) for analyzing the long-run relation between UK retail bank interest rates and the BoE base rate. We extend their ECM by considering other control variables such as regulatory capital requirements and portfolio risk. This framework is adopted since it allows us to separately identify the short- and long-run effects of bank capital ratios on lending rates.

In this formulation, changes in lending interest rates (Δl_{it}) are expressed as a function of their deviation from the long-run path ($l_{it} - l_{it}^{*}$) and of a set of variables driving the short-run dynamics. The variables included as determinants of the long-run path of lending rates, l_{it}^{*}, also called the cointegrating relation, are confirmed as unit root non-

stationary and the presence of cointegration is supported empirically.[11] The intuition behind the concept of cointegration is that the long-run path l_{it}^{*} acts as an attractor for the interest rate l_{it}. Thus the term $\gamma_i(l_{it} - l_{it}^{*})$ in the ECM equation below has the interpretation of an "error correction" or "catch-up" mechanism that restores the loan rate sooner or later close to its long run path in the wake of exogenous shocks:

$$\Delta l_{it} = c_i + \theta_t + \gamma\left(l_{i,t-1} - l_{i,t-1}^{*}\right) + \beta^{L}\Delta l_{i,t-1} + \sum_{j=1}^{1}\beta_j^{K}\Delta k_{i,t-j} + \sum_{j=0}^{1}\boldsymbol{\beta_j'}\Delta \boldsymbol{Z}_{i,t-j} + e_{it} \tag{1}$$

where i denotes banks and t denotes time periods. The vector $\boldsymbol{Z}_{it} \equiv (b_t, f_t, g_t, r_{it})'$ gathers both system-wide and bank-level covariates such as the BoE base rate (b_t), the spread of 1 year LIBOR over the base rate (f_t), the output gap defined as the deviation of actual from "potential" real GDP (g_t), and the bank's ratio of write-offs to loans (r_{it}).[12] The deviation of the loan rate from its long-run path is represented by the error term u_{it} in the following cointegration model:

$$l_{it} = A_i + Bb_t + Ff_t + Gg_t + Kk_{it} + Rr_{it} + u_{it} \tag{2}$$

and thus $l_{it} - l_{it}^{*} = u_{it}$ with $l_{it}^{*} \equiv A_i + Bb_t + Ff_t + Gg_t + Kk_{it} + Rr_{it}$ defining the long-run interest rate path. By allowing the latter to be driven not only by the capital ratio (k_{it}), but also by covariates that capture the stage of the UK economy in the business cycle we can control for endogeneity arising from the common shocks that drive both the lending rates and capital ratios in Equation (2), namely, the fact that both capital and lending rates "ride" over the same cycle.[13]

[11] We test the null hypothesis of a unit root using the Augmented Dickey Fuller (ADF) panel unit root test and fail to reject the null hypothesis for the variables which are included in the long-run Equation (2). We also carry out a Fisher panel co-integration test (a modified version of the standard Johansen test) which confirms the presence of at least one co-integrating vector (although we were unable to reject the null hypothesis that there may be more than one). The findings are similar for Equation (4).

[12] The choice of one lag maximum is based on the Akaike and Bayesian Information Criteria, and likelihood ratio tests. However, we checked up to 6 lags and our main findings remain unchanged.

[13] Since many loans have interest rates that are fixed for a period of time and banks may wish to reflect expectations of future interest rates, we considered including the forward interest rate at 5, 10 and 20 years. This variable did not add any significant explanatory power over the base rate plus LIBOR spread.

The ECM can be estimated by pooled Ordinary Least Squares (OLS) with fixed effects by re-parameterizing it as the following reduced-form equation:

$$\Delta l_{it} = \pi_i + \theta_t + \gamma l_{i,t-1} + \delta^K k_{i,t-1} + \boldsymbol{\delta}' \boldsymbol{Z}_{i,t-1} + \beta^L \Delta l_{i,t-1} + \sum_{j=0}^{1} \left(\beta_j^K \Delta k_{i,t-j} + \boldsymbol{\beta_j}' \Delta \boldsymbol{Z}_{i,t-j} \right) + e_{it} \quad (3)$$

where $\boldsymbol{\delta} \equiv (\delta^B, \delta^F, \delta^G, \delta^R)'$. The main measure of interest, the long-run effect of the capital ratio on loan rates, is given by $K = -\delta^K/\gamma$. The long-run effects of the other covariates gathered in $\boldsymbol{Z}_{it}$ are given, similarly, by the corresponding coefficient in $\boldsymbol{\delta}$ **s**caled by γ. Short-run effects are captured by the differenced explanatory variables, contemporaneously and lagged one time period. The total short run effect of capital ratio on lending rates is given by the coefficient $\beta^K = \sum_j \beta_j = \beta_0 + \beta_1$.

The inclusion of the covariate vector $\boldsymbol{Z}_{it}$ in Equation (3), in levels and differences, is important to isolate the long-run and short-run effect of bank capital, respectively, from that of other plausible drivers of loan rates. The most obvious of these is the BoE base rate (expressed as a monthly average, b_t above). In practice, interest rates for interbank lending (which, in turn, drive broader market interest rates) can diverge from the base rate due to expected losses, which increase in periods of stress, together with premia associated with lending of longer maturities. This motivates as control covariate the spread of the 1-year LIBOR over the base rate (average for each month, denoted f_t above). As a control for portfolio risk associated with the bank's lending activities, we include the ratio of write-offs to total loans denoted r_{it} above. Clearly these control variables are plausibly expected to have a positive long-run relation with loan interest rates in the long run, i.e. $(\delta^B, \delta^F, \delta^R)' > 0$. Our last long-run control variable, output gap (g_t), is defined as the percentage difference between the levels of actual GDP and estimated potential GDP, both in real terms.[14] In contrast to the other control variables, the output gap has an ambiguous impact on lending interest rates. Slow or negative growth relative to trend may reduce the demand for loans and induce banks to offer more competitive rates, producing a positive association, but it may also increase banks' expectations about future losses, producing a negative association with lending rates.

[14] The source of the output gap data is OECD Economic Outlook. For details on the methodology for calculating potential GDP, see Notes to the Economic Outlook Annex Tables on the OECD website.

We estimate Equation (3) in panel form which restricts the coefficients to be identical across banks but allows for unobserved two-way bank and time fixed effects, denoted π_i and θ_t, respectively, which are confirmed as statistically significant by likelihood ratio tests. The bank effects π_i capture latent factors which are essentially constant over the time period under study but specific to each bank such as the business model. The time effects θ_t capture common shocks that may influence the lending rates for all banks such as any residual business cycle component not captured by the system-wide controls in the model such as increases in capital requirements following the financial crisis. The inclusion of a lagged dependent variable can induce a bias, although this is likely to be small given the large T dimension of our sample (about 150 months). The conventional method of dealing with this bias by general method of moments (GMM) estimators is precluded by the small number of cross-section units (8 banks). Instead we re-estimate Equation (3) using the Corrected Least Squares Dummy Variable estimator due to Bun and Kiviet (2003) and Bruno (2005) and confirmed that the coefficients are very close to those initially obtained by standard panel fixed effects.[15] Given the lack of any material difference in the coefficients, we report below the fixed effects results since it is not possible to obtain analytical standard errors for the corrected fixed effects estimator.

Step 2: Allowing time-heterogeneity in the bank capital and interest rate relation.

The *banking sector distress effect* is examined by allowing the long-run relation between target capital ratios and loan interest rates to differ between non-crisis and crisis periods. To do so, we include in Equation (3) a variable $k_{it} \times C_t$ that interacts the capital ratio with a crisis dummy C_t equal to 1 from July 2007 onwards and 0 otherwise. We take the beginning of the crisis to be July 2007, when financial markets first began to show signs of stress triggered by the problems with sub-prime lending (Brunnermeier, 2009). This date is confirmed by an examination of CDS spreads, as the time when they begin to rise for the banks in our sample. The long-run effect of capital on loan rates during normal times is then given by the coefficient K whereas the effect during crisis is captured by $K + K^{CRISIS}$, where K^{CRISIS} is the coefficient of the crisis interaction variable. The *banking sector distress effect* predicts a negative coefficient ($\boldsymbol{H_2}$: $K^{CRISIS} < 0$).

[15] The results from the corrected fixed effects estimator (implemented using the Stata command *xtlsdvc*) are available from the authors on request.

We also test for differences in the short-run relation between crisis and non-crisis periods by interacting the differenced capital variables with the crisis dummy, $C_t \times \Delta \mathrm{k}_{it}$ and $C_t \times \Delta \mathrm{k}_{i,t-1}$ with coefficients $\beta_0^{K,CRISIS}$ and $\beta_1^{K,CRISIS}$, respectively. The extent to which the short-run relation is different in normal and crisis periods is then tested by formulating the null hypothesis that the sum of the coefficients on these two interaction variables is significantly zero, i.e. $\beta^{K,CRISIS} = \beta_0^{K,CRISIS} + \beta_1^{K,CRISIS}$. The total short-run effect in the crisis period is given by $\beta^K + \beta^{K,CRISIS}$.

Step 3: Re-estimate the loan pricing equation using a target capital ratio

Our study is primarily motivated by the potential impact of capital requirements on lending rates, and these achieve their effects by influencing banks' own internal long-run capital targets. The relationship between target capital and lending rates is plausibly different from that between actual capital and lending rates. As we noted in section 3.1, the short-run effect of shocks to target capital is more likely to be positive than the short-run effect of actual capital given that the latter is affected by shocks to the actual capital ratio. With regard to the long-run effects, the actual capital ratio modelled in step 2 will fluctuate around the target capital ratio due to shocks to either target or actual capital which generate surpluses or deficits relative to target. Our ECM specification takes some account of these shocks given that it allows changes in the lending rate and capital ratio to be correlated in the short run. Note also that bank and time effects are controlled for in our specification. However, transitory bank-specific shocks to the *level* of the lending rate or capital ratio could plausibly be picked up by the long-run co-integrating relation. For example, a bank with a temporary competitive advantage from new market opportunities could benefit from a one-off reduction in the cost of funding from the availability of cheap internal funds, prompting a temporary increase in the desired level of capital. Alternatively, a temporary aggressive business strategy aimed at gaining market share could be associated with low capital ratios and lower lending rates.

In order to isolate the effects of target capital, we re-estimate Equation (3) replacing the actual capital ratio k_{it} with a proxy for the long-run target capital ratio k_{it}^* level around which the former fluctuates, i.e. $k_{it} \equiv k_{it}^* + \varepsilon_{it}$ where ε_{it} is a zero mean innovation representing random temporary fluctuations of the bank's actual capital around its long-

run target capital level. The long-run target capital ratio is defined as the fitted values of the following auxiliary regression for quarterly data:

$$k_{it} = \alpha_i + \vartheta_t + \boldsymbol{\beta}' \boldsymbol{X}_{it} + \varepsilon_{it} \qquad (4)$$

where $\boldsymbol{X}_{it}$ is a the 3×1 vector of covariates comprising the ratio of *risk-weighted assets to total assets*, the ratio of *corporate loans to total loans* and the ratio of *trading book assets to total assets*. Equation (4) is also estimated by fixed effects allowing for unobserved bank-specific factors α_i and time effects ϑ_t.[16]

We compute the target risk-weighted capital ratio for each bank and time quarter as the fitted values $\hat{\alpha}_i + \widehat{\boldsymbol{\beta}}' \boldsymbol{X}_{it} + \widehat{\boldsymbol{\vartheta}}_{\boldsymbol{t}}$ multiplied by the ratio of risk-weighted assets to total assets. The resulting measure denoted k_{it}^* represents the un-weighted target capital-to-assets ratio (or the target "leverage ratio" in standard regulatory jargon) that is used in the subsequent analysis as the bank's long-term target capital. The reason for converting the risk-weighted ratio into a target leverage ratio is that the former conflates the effects of portfolio risk and capitalisation in a way that is unhelpful for our analysis, and therefore it is preferable to separate out the effects of portfolio risk and capitalisation.

Step 4: Extension to consider market structure

Finally, we extend our analysis to examine the effects of market structure. One might intuitively argue that banks with a more dominant market position will have higher lending rates and be more able to alter lending rates without altering market share. To the extent that the competitive position of each bank is time-constant, the mark-up will be captured by the bank fixed effects π_i in our loan pricing Equation (3). However, Equation (3) does not allow the bank's competitive position to vary over time, and it also does not allow the long-run and short-run effects of capital on the lending rate to

[16] Previous research has shown that bank- and time-varying capital requirements imposed by the FSA in excess of the Basel minimum 8% are significant determinants of the total (i.e. Tier 1 + Tier 2) capital ratio (Francis and Osborne, 2012). We tested whether this is also true of the Tier 1 capital ratio. The relation was not significant in the pre-crisis period, implying that banks chose Tier 1 capital according to internal targets and then adjusted Tier 2 capital to meet regulatory total capital requirements (this is consistent with detailed analysis of capital adjustment in Francis and Osborne (2012)). In the crisis period, an implausibly large coefficient is observed implying that changes in the capital ratio were several multiples of changes in capital requirements. We believe this could be attributed to simultaneous market and regulatory pressure on banks' capital ratios during the crisis. These issues imply that capital requirements are not necessarily good predictors of target Tier 1 capital ratios and hence we do not use them in our model of long-run target capital.

vary according to the competitive position of each bank. As a check on this, we re-estimate Equation (3) with two additional covariates in $\boldsymbol{Z}_{it}$, one consisting of the bank's loans divided by total lending by UK financial institutions as a simple proxy for a bank's competitive position denoted M_{it}, with long-run coefficient μ, and an interaction between market share and actual capital, $k_{it} \times M_{it}$ with long-run coefficient denoted Λ and short-run coefficient denoted $\beta^{k,M}$.

3.2 DESCRIPTION OF DATA AND VARIABLES

The analysis is based on observations for the 8 largest UK commercial banks over the period 1998-2011. Our monthly sample for the individual estimation of the ECM specification (Step 2) comprises a maximum of T=148 months from October 1998 to June 2011. The sample is unbalanced with a maximum T of 148 months and a minimum of 126 months. Nevertheless, most banks are present for the whole sample, and the mean and median T are 145 and 147, respectively. The time dimension of the data has the advantage of spanning two sharply contrasting periods, one of "irrational exuberance" in credit conditions and benign macroeconomic performance (1998-2006) and another of extreme financial market stress and an economic recession (2007-2011).

In statistical terms, the sample cross-section dimension is small (N=8 banks) but it should be noted that the UK has a very concentrated banking sector with the top ten banks accounting for around 90% of total assets. Hence, from an economic viewpoint, our sample is fairly representative of the UK banking sector as the banks included are the largest[17] which play the most important role in facilitating the flow of credit to the real economy.

We use confidential data submitted by banks to the FSA and the BoE. Banks authorised to conduct banking business in the UK are required to submit data on their capital adequacy on a quarterly basis. During the period 1998-2011, a set of returns containing

[17] The main constraint on our sample size is the effective interest rates data. In order to select which firms should report this data, the BoE applies cost-benefit analysis to choose a small number of banks that account for the vast majority of the UK bank lending on aggregate. We also drop from our sample banks which exit or enter the sample due to changes in criteria for inclusion (i.e., rather than because those banks have ceased to exist due to a merger or acquisition).

information on effective loan and deposit interest rates were submitted to the BoE, and separate returns on capital adequacy were submitted to the FSA.[18]

Loan interest rates (l_{it}) are defined as annualised effective interest rates, and are calculated on a monthly basis using the following formula:

$$l_{it} \equiv \frac{interest\ received\ during\ month}{average\ loan\ balances\ during\ month} \cdot \frac{number\ of\ days\ in\ year}{number\ of\ days\ in\ month} \qquad (5)$$

while many previous studies resort to quoted interest rates which represent the interest rates advertised for new business (Fuertes and Heffernan, 2009; Fuertes et al., 2010). Effective rates are more appropriate for the present analysis, firstly, because they are calculated using existing as well as new loans. Since it is in general more costly to alter interest rates on old businesses (e.g., due to pre-agreed or fixed interest rates) we would expect the effective rates to adjust more slowly than quoted rates following changes in underlying determinants.[19] Also, unlike quoted rates, the effective rate includes only interest which has actually been received, so it is net of arrears in interest payments. Thus the effective rate has embedded into it an ex-post measure of credit risk based on actual credit losses, and this must be borne in mind when assessing the economic significance of the write-offs variable in the estimated loan pricing equations.

Under the international regulatory framework established by the Basel Committee for Banking Supervision (BCBS), total regulatory capital is set at a minimum of 8% of the bank's risk-weighted assets. Regulatory capital has two components: i) Tier 1 capital which consists of common equity, reserves and certain hybrid equity-like securities, and ii) Tier 2 capital which consists of subordinated debt and other permitted debt instruments. Total regulatory capital is then calculated as the sum of Tier 1 and eligible Tier 2 capital (Tier 2 must be less than 50% of the total) less certain required deductions

[18] One practical issue we face is that the frequency of the observations on actual capital ratios (k_{it}), the output gap (g_t) and write-offs (r_{it}) is quarterly, but those on the rest of the covariates such as loan rates (l_{it}), the base rate (b_t) and spread of 1-year LIBOR over the base rate (f_t) are monthly. Thus the quarterly variables are converted to monthly using linear interpolation so that they can be incorporated into the monthly ECM Equation (3). Our quarterly panel for estimating the target capital Equation (4) is unbalanced but most banks are observed over the entire period 1998Q4-2011Q2; the average (median) number of quarters is 44 (50) ranging from 26 to a maximum of 50.

[19] It is possible to run the analysis using effective rates for new business alone but this data is not available prior to 2004 and hence, we prefer to proceed with the longer dataset.

such as intangible assets and investments in subsidiaries. In our analysis, we only use the Tier 1 capital ratio. The reasons for this are two-fold. Firstly, Tier 2 is equivalent, economically speaking, to subordinated debt funding and will therefore have a similar required rate of return to such junior debt.[20] Altering the amount of Tier 2 capital is therefore unlikely to be very costly and so, since our hypotheses are based on the idea that capital is loss-absorbing and therefore affects the cost of funding, Tier 2 capital is irrelevant to our analysis. Secondly, Tier 1 capital is now of more interest to regulators than total capital given that Tier 2 capital proved to be ineffective in stemming a loss of confidence in banks during the financial crisis.

In order to calculate the risk-weighted assets, which constitute the denominator of the capital requirement, the bank's assets are multiplied by risk weights which are set to capture the level of risk that the bank is exposed to. In the standardized-weights approach prescribed by the Basel I framework from 1989-2006, assets are allocated into a number of risk "buckets" and then added together with pre-specified weights. Basel II, introduced in the UK in 2007, permits and encourages banks to use, with approval from the supervisor, their own internal models to measure credit risk (and, in turn, the risk weight) of each loan. An additional component of risk-weighted assets is the trading book in which market risk is incorporated through the Value-at-Risk approach. Reviews of Basel II aimed at addressing further issues and shortfalls are ongoing (see footnote 22), although a floor to the Basel II rules based on Basel I was in force in the European Union from 2007 and beyond the end of our sample period.

The above regulatory setting has been superseded as additional measures were introduced in the aftermath of the late 2000s GFC. From 2008, Tier 1 capital ratios rose substantially as the FSA set higher benchmark expectations for firms in the context of the government support package for major banks.[21] In 2010, the Basel Committee announced new international capital standards which raised the minimum Tier 1

[20] See FSA Consultation Paper *Strengthening Capital Standards 2 (*2006) for relevant pre-crisis estimates of the required rate of return on different types of regulatory capital.

[21] Formally, this was not an increase in capital requirements. In the context of the package of bailout and guarantees announced in the autumn of 2008 following the disastrous collapse of Lehman Brothers, the FSA announced that the benchmark expectations following the package would be a Tier 1 capital ratio of 8% and core Tier 1 of 4% following deduction of losses associated with a hypothetical stress scenario. Clearly, the consequences of breaching these expectations imply that banks may in practice have treated them as higher capital requirements.

requirement from 8% of risk-weighted assets to 11%.[22] Though these will not take effect immediately (on current plans, they will be phased in by 2018), they have come to be seen as benchmark minima by the market and many banks are targeting the future requirements now in order to prove their resilience to the market or to satisfy supervisors.[23]

4. Empirical results

We begin by providing summary statistics of the main covariates in our analysis. We then discuss inferences on the long-run and short-run effects hypothesized in Section 2.1.

4.1 DESCRIPTIVE STATISTICS

Four main variables in our analysis, regulatory Tier 1 capital ratio (aggregated across banks), lending rates (aggregated), the BoE base rate and the 1-year LIBOR rate are plotted in Figure 3. The path of the base rate, b_t, is well-known: following a period until 2007 in which it moves only by small amounts to counteracting movements in inflation, it then drops down to an historic low of 0.5% in 2008 and remains there until the end of our sample in 2011. The lending rate, l_{it} averaged across i=1,…,8 large UK banks, exhibits a broadly similar long-run path albeit it does not fall as much as the base rate in 2008, which implies incomplete interest rate pass-through. Button et al. (2010) provide a discussion of possible reasons for the significant widening of the spread between lending rates and the base rate observed from 2008 onwards. It may reflect higher credit risk as the credit quality of borrowers deteriorates and banks require larger risk premia to compensate. It may also be because banks were trying to repair their balance sheets by raising capital via margins, partly to offset the losses incurred during the crisis and partly in response to tighter regulatory standards. Over the same period, the output gap drops substantially during 2008-2009 and stays negative henceforth, suggesting that

[22] See the first consultative document on the new Basel III package, December 2009, http://www.bis.org/publ/bcbs164.htm, and press release from the Basel Committee on Banking Supervision announcing agreed calibration, September 2010, http://www.bis.org/press/p100912.pdf.

[23] The interim report of the Institute of International Finance (2010) summarises possible reasons for banks' adjustment to Basel III standards ahead of formal implementation.

increased loan margins may be explained in part by the economic contraction following the financial crisis, which may have affected banks' estimates of expected arrears as well as their desire to build up their capital as a cushion for future losses.

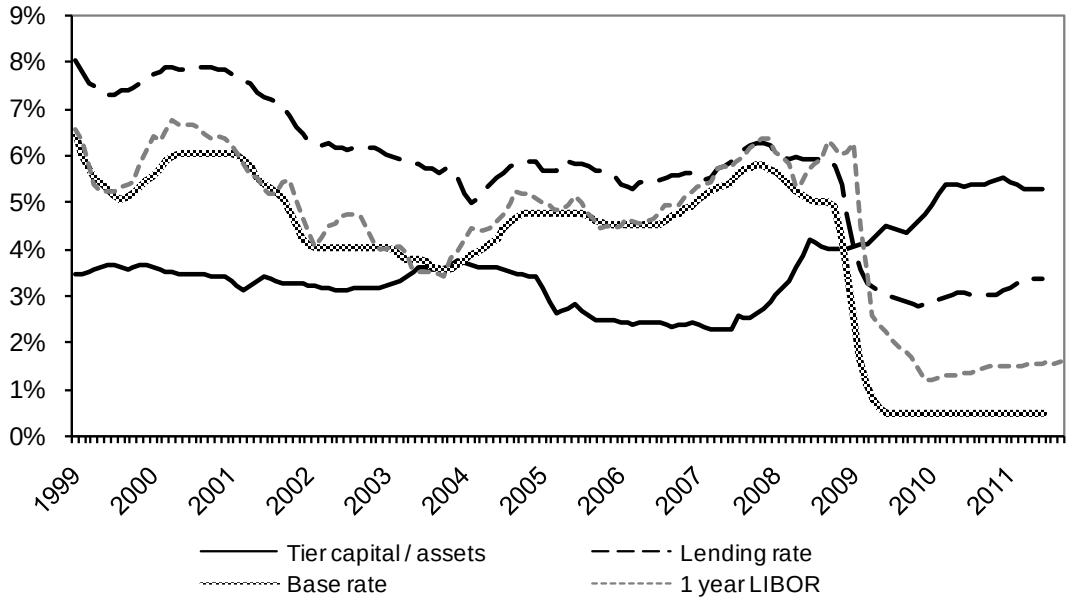

Figure 3: Trends in UK capital ratios and lending rate.

The figure plots the monthly evolution 1998:10-2011:06 in the ratio of Tier 1 capital to assets (aggregate across banks), the lending rate (aggregate across banks), the Bank of England base rate, 1-year LIBOR rate and the output gap. All variables correspond to the left vertical axis except the output gap which refers to the right axis. A positive output gap signals that the economy is running above potential so domestic demand is expanding. Quarterly Tier 1 ratios are mapped into monthly figures using linear interpolation. The aggregated Tier 1 ratio and lending rate are calculated by adding stocks and flows over all banks in the sample at each time period.

Figure 3 also shows that the increase in the spread over base rate occurs roughly at the same time as a substantial increase in the aggregate actual Tier 1 capital ratio, k_{it}, across i = 1,…,8 banks; the latter more than doubles from 2% in early 2008 to 5.5% in mid 2011. These trends are consistent with an increase in the cost of funding accompanying higher capital ratios. It is also possible that they are influenced by other factors, for example, an increase in the cost of debt associated with a higher probability of bank distress, as suggested by the widening spread of 1-year LIBOR over base rate during the same period, or higher loan losses resulting from the late 2000s recession.

In order to choose the period for our crisis dummy in equation (3), we analysed CDS prices for the banks in our sample since these are likely to reflect investor sentiment about each bank. We calculate an average price for each bank based on 1 year and 5

year maturities and senior and subordinated debt and compute an index by dividing the CDS price by the average price over the pre-crisis period 2004-06. The CDS indices for each bank, shown in Figure 4 below, sharply increase from July 2007 onwards, coinciding with public concerns about the valuation of structured products and a drying up of the market for short-term asset-backed commercial paper (Brunnermeier, 2009). This motivates our definition of the crisis dummy equal to 1 from July 2007 onwards.

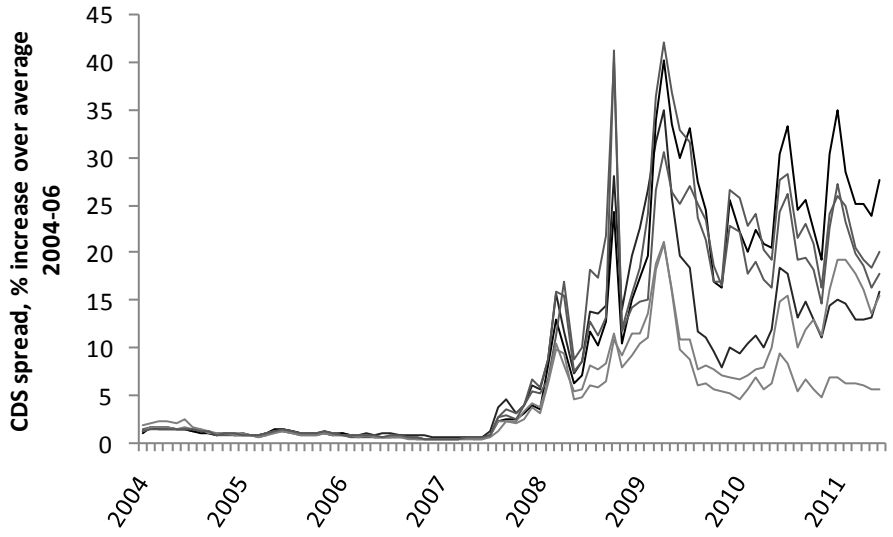

Figure 4. CDS indices for banks in the sample.

The CDS index plotted for each bank is obtained by by (i) calculating the average of CDS prices over 1 year senior, 1 year subordinated, 5 year senior and 5 year subordinated CDS contracts; (ii) calculating the ratio of this composite price to the average composite price over the pre-crisis period 2004-2006 for each bank. We show the series for 6 banks in the sample since the other 2 banks did not have sufficient data. Historical CDS prices are obtained from Credit Market Analysis (CMA) and Thomson Reuters.

Table 1 sets out descriptive statistics for the covariates in the ECM specification for loan interest rates, Equation (3), namely, lending rates (l_{it}), capital ratios (k_{it}), target capital ratios (k_{it}^*), the bank rate (b_t), 1 year LIBOR spread (f_t), the output gap (g_t) and the ratio of write-offs to total loans (r_{it}). We also include covariates used in the target capital, Equation (4), namely, the ratio of corporate loans to total loans, the ratio of risk-weighted assets to total assets, and the ratio of trading book assets to total assets. Alongside the mean, the table reports the overall range and three other measures of variation, the *overall* variation across banks and quarterly periods ($N \times T$ observations), the *between* variation which represents dispersion across banks (N observations) on each quarter averaged over the sample quarters, and the *within* variation captures the volatility in each bank's lending rate (T observations) on average across banks.

Table 1. Summary statistics for bank-specific covariates in loan pricing ECM equation.

All variables are reported in percentages. The monthly and quarterly observations span the same period, i.e. 1998:10-2011:06, and 1998:Q4-2001Q2, respectively, for the 8 largest UK banks. Lending rate is annualised loan interest received over average loan balances in each month. Bank rate is a monthly average of the base interest rate set by the Bank of England and 1y LIBOR spread is the difference between the 1 year LIBOR interest rate and the bank rate. The output gap is the quarterly deviation of output from potential output calculated by the OECD. Tier 1 capital ratio is the ratio of Tier 1 capital to total assets. Target capital ratio is the fitted values from Equation (4) estimated by two-way fixed effects and subsequently un-weighted. Annualised write-offs of loans are expressed as a proportion of loans. Corporate loans are expressed as a percentage of total loans. Risk-weighted assets (RWA) are expressed as a percentage of total assets. Trading book (TB) assets are expressed as a percentage of total assets. The quarterly variables that appear in the ECM Equation (3) (output gap, capital ratios, write-offs/loans) are mapped to monthly data by linear interpolation.

	Source	Mean	Range	Standard deviation		
				Overall	Between	Within
Monthly variables (T=151)						
Lending rate (l_{it})	BOE/FSA	6.5	[1.9 - 10]	1.6	0.8	1.4
Bank rate (b_t)	Datastream	4.0	[0.5 - 6.4]	1.8	-	-
1y LIBOR spread (f_t)	Datastream	0.1	[-4.5 - 3.9]	2.3	-	-
Quarterly variables (T=51)						
Output gap (g_t)	Datastream	0.5	[-0.7 - 1.7]	0.5	-	-
Tier 1 capital ratio (k_{it})	BOE/FSA	4.0	[1.3 - 8.6]	1.3	0.8	1.1
Target capital (k_{it}^*)	BOE/FSA	4.0	[1.5 - 9.1]	1.2	0.8	1.0
Write-offs/loans (r_{it})	BOE/FSA	0.9	[0.1 - 11.1]	1.1	0.8	0.9
Corporate loans/loans	BOE/FSA	22.7	[0 - 61.7]	15.1	14.9	6.5
RWA/assets	BOE/FSA	45.0	[8.9 - 76.7]	14.2	10.5	10.2
TB assets/assets	BOE/FSA	14.7	[0 - 64.4]	16.7	15.9	7.5

4.2 TESTS OF HYPOTHESIS ON THE RELATION BETWEEN CAPITAL RATIO AND LOAN RATES

The estimation results of the loan interest rate ECM Equation (3) using monthly data are set out in Table 2. For the sake of brevity, we focus the discussion on the parameters of

interest, namely, the long-run coefficients (B, F, G, K and R) and the short-run coefficient on the covariate representing deviations of actual capital from target capital (β^K). The results of our base specification are shown in column (1); we then show the results of interacting the capital ratio with a crisis interaction variable in column (2), and finally in column (3) we re-run the specification in column (2) replacing the actual capital ratio with the long-run target capital ratio.

The results make interesting reading. First, the long-run coefficient of the bank's capital ratio (K) is negative in the base model shown in column (1) and this coefficient is both statistically and economically highly significant. This is in contrast to the *cost of capital effect* which predicts that maintaining higher capital ratios will raise the cost of funding and therefore drive higher lending rates in the long-run. Since our sample period includes both a benign period and a period of acute distress, it is possible that the negative relation observed on average across the sample period could be driven by the *banking sector distress effect* dominating in the crisis period. We test this in column (2), which separates the long-run coefficient on the capital ratio into a base effect (K) corresponding to normal or 'good times' and a crisis period effect ($K+ K^{CRISIS}$) corresponding to 'bad times'. Our results are consistent with the *banking sector distress effect*. The interaction effect K^{CRISIS} is negative and economically large in magnitude as well as highly statistically significant. In contrast, the long-run link between capital ratios and loan rates in good times, measured by K, is far smaller and statistically insignificant.

In terms of our theoretical analysis of the long-run relation in Section 2.1, the lack of a significant link between capital ratios and lending rates in the pre-crisis period indicates that banks on average may be close to their privately optimal capital ratios where increasing or decreasing the capital ratio has little or no effect on the cost of funding. This further suggests that Tier 1 capital requirements may not have been binding on banks during the pre-crisis period.[24] The lack of binding capital requirements may explain why we do not find a positive relation consistent with the *cost of capital effect*, since this hypothesis relies on banks being on the upwards-sloping part of the cost of funding curve where they are being forced to hold more capital than they would choose

[24] A notion that is given additional support by the lack of significant correlation between Tier 1 capital requirements and capital ratios in this period (see footnote 16)

for themselves. In contrast, the strongly negative long-run relation observed for the crisis period suggests that in this period, optimal capital ratios may have increased so that banks that increased their capital ratios reduced their funding costs (other things equal) and passed this on to their borrowers via a lower cost of funding, consistent with the *banking sector distress effect*.

Next in order to obtain the results shown in column (3) of Table 2, we need first to approximate the long-run target capital level k_{it}^{*} which will then replace the actual Tier 1 capital ratio k_{it} in the loan interest rate ECM Equation (3). As noted above, we do this in order to isolate the effects of bank capital targets, since these are likely to be closer to the effects of capital requirements which achieve their aims by influencing banks' own internal capital targets. We estimated the target capital ratio as described in Section 3.1 via Equation (4). The coefficients for the ratio of risk-weighted assets to total assets, the share of corporate loans in total loans and the ratio of trading book assets to total assets were -0.17, 0.11 and -0.08 respectively, and all of these were significant at the 5% level or better. The ratio of risk-weighted assets to total assets (i.e., risk ratio) is negatively linked with the capital ratio. Prima facie this result is surprising as it implies that riskier business models have lower long-term target capital ratios ceteris paribus, but it is probably due to the fact that the capital ratio has already been adjusted using appropriate risk weights. Hence, the negative coefficient of the risk ratio covariate reflects that riskier banks tend to hold less capital against a given set of risk assets. The capital ratio varies positively with the proportion of corporate loans in total loans, suggesting that this is an indicator of riskier business models. The ratio of trading book assets to total assets is negatively related to the capital ratio, suggesting that banks choose to hold less capital against trading book activities, plausibly because these are more actively hedged than banking book assets. Finally, we plot the estimated time-effects ϑ_t from the reduced-form target capital ratio Equation (4) in Figure 5 below. Reassuringly, these estimates confirm that capital ratios rose simultaneously and sharply across the banks in our sample following the onset of the crisis in late 2007, which can be attributed to regulatory and market pressure and decline in the demand for loans.

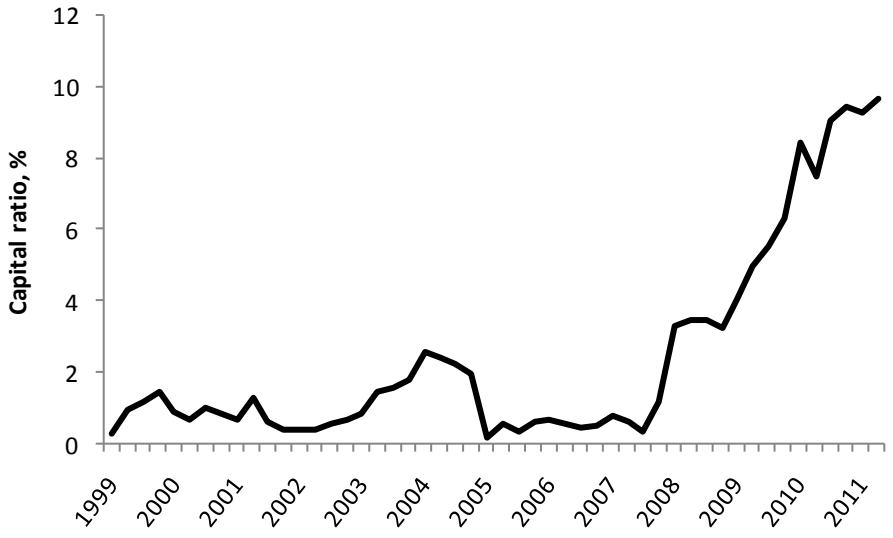

Figure 5. Coefficients on time dummies from estimation of target capital ratio.

The risk-weighted Tier 1 capital ratio was modelled using two-way (bank and time) fixed effects, the ratio of risk weighted assets, the ratio of trading book assets to total assets, and the ratio of corporate loans to total loans, all expressed as percentages, using quarterly data on 8 banks from 1998Q4 to 2011Q2. We cannot plot individual fitted capital ratios from the model due to data confidentiality restrictions.

The results shown in the last column of Table 2 using the long-run target capital level k_{it}^{*} support qualitatively those reported earlier in column (2) on the basis of the possibly noisier actual capital level k_{it}. For concreteness, the long-run coefficient on the capital ratio K is not significantly different from zero in normal times, but the total crisis effect as measured by $K+ K^{CRISIS}$ is negative and highly significant, and in a similar ballpark as that previously obtained in column (2). Since the target capital ratio proxies a long-run trend and hence, removes completely the effect of short-run fluctuations in capital, these findings add robustness to our interpretation of the negative long-run relation between capital and loan rates in the crisis period, inferred from the model in column (2), as supportive evidence of the long-run *banking sector distress effect* hypothesis rather than the *weak bank effect* hypothesis.

Turning to the short-run link between capital ratios and lending rates (β^{K}), in the baseline model that conflates the good times and bad times, column (1) in Table 2, this is positive though only weakly significant. This is consistent with the idea that banks may temporarily raise interest margins in order to build up capital ratios through retained earnings and contracting credit supply. When the short-run link between

lending rates and capital ratios is permitted to differ between good times and bad times, column (2) in Table 2, the positive effect is only statistically significant during the crisis period. This is likely to be a reflection of banks resorting to interest margins as lever to build up capital following both regulatory and market pressures in crisis times.

However, the coefficient estimates in column (2) of Table 2 based on the actual Tier 1 capital may underestimate the short-run effect since, as we noted in Section 3.1, negative shocks to capital may be accompanied by simultaneous temporary increases in margins, and these may "contaminate" the positive effect arising from interest margins being used as a lever in capital management. The coefficient estimates in column (3) of Table 2, based on the long-run target capital instead, serve to filter out those temporary fluctuations and so one would expect the short-run association inferred in this case to be stronger. This is what we observe in column (3) where the positive short-run coefficient in the crisis period is economically and statistically more significant than that previously.

As Table 2 shows, all other covariates generally have their expected signs and are statistically significant at conventional levels. In particular, the positive coefficient *R* suggests that higher write-offs are associated with higher interest rates, which is possibly due to banks requiring higher risk premia for taking on riskier borrowers. The coefficient of the base rate (*B*) is positive and insignificantly different from one, as expected, in line with the evidence reported in Fuertes et al. (2009, 2010). The coefficient of the spread of 1 year LIBOR over the base rate (*F*) is also positive, confirming the expected positive association with market interest rates. The coefficient of the output gap (*G*) is negative corroborating that fast economic growth, i.e. positive gap, comes accompanied by lower lending interest rates over the long run.

Table 2. Estimation of loan interest rate ECM equation 1998:10-2011:06.

Monthly observations on 8 large UK banks are used to estimate the ECM Equation (3), using two-way (bank and time) fixed effects. K is the long-run coefficient of the bank's capital ratio (k_{it}) or target capital ratio (k_{it}^{*}), K^{CRISIS} is the coefficient of the target capital ratio interacted with a crisis dummy variable equal to 1 from July 2007 onwards and 0 otherwise, B is the long-run coefficient of the monthly average policy rate set by the Bank of England (b_t), R is the long-run coefficient of the annualized loans write-offs over total loans (r_{it}), F is the long-run coefficient of the spread of 1-year LIBOR over base rate (f_t), G is the long-run coefficient of the output gap (g_t). The dependent variable for these long-run coefficients is the lending rate, defined as annualised loan interest received over average loan balances in each month. β^{K} is the short-run coefficient of the capital ratio calculated as the sum of coefficients on the first difference and lagged first difference of the capital ratio (Δk_{it} and $\Delta k_{i,t-1}$), $\beta^{K,CRISIS}$ is the short-run coefficient interacted with a crisis dummy variable equal to 1 from July 2007 onwards and 0 otherwise. The dependent variable for these short-run coefficients is the change in the lending rate. We also show total short-run and long-run effects of capital in the crisis (i.e., $K+K^{CRISIS}$ and $\beta^{K}+\beta^{K,CRISIS}$). The target capital ratios used in column (3) are estimated on quarterly data via two-way fixed effects and then converted to un-risk-weighted capital ratios, as described above. All variables are expressed as percentages. Standard errors are in parentheses. *, ** and *** denote significance at the 10%, 5% and 1% levels, respectively.

		(1) Using actual capital ratio	(2) Using actual capital ratio, with crisis interaction dummy	(3) Using target capital ratio, with crisis interaction dummy
Dependent variable = L_{it}		*Long-run coefficients*		
B	Base rate	1.35***	0.93*	1.23
		(0.43)	(0.47)	(0.75)
F	1-year LIBOR spread	1.9**	0.76	-0.06
		(0.83)	(1.39)	(1.53)
R	Write-offs/loans	0.22*	0.29**	0.43***
		(0.13)	(0.12)	(0.11)
G	Output gap	-0.63	-0.69*	-1.1**
		(0.4)	(0.38)	(0.48)
K	Capital ratio	-0.33***	-0.07	-0.25
		(0.11)	(0.13)	(0.18)
K^{CRISIS}	Capital ratio x crisis dummy		-0.4**	-0.12
			(0.16)	(0.18)
$K+K^{CRISIS}$	Total		-0.46***	-0.36***
			(0.13)	(0.14)
Dependent variable = ΔL_{it}		*Short-run coefficients*		
β^{K}		0.1*	0.04	0.13
		(0.05)	(0.08)	(0.14)
$\beta^{K,CRISIS}$			0.1	0.37**
			(0.09)	(0.15)
$\beta^{K}+\beta^{K,CRISIS}$			0.14**	0.5***
			(0.07)	(0.13)
No. of observations		1184	1184	1172
No. of banks		8	8	8
R-squared				
- within		0.42	0.42	0.41
- between		0.41	0.26	0.18
- overall		0.38	0.38	0.38

The contrasting direction of the 'bad times' relation between capital ratios and lending rates uncovered in the short run (positive) and long run (negative) is possibly a reflection of the different drivers at work. The fact that the long-run and short-run effects operate in different directions confirms the importance of adopting a dynamic specification, since in static models such as those used by previous studies cited above, the long-run and short-run effects tend to be conflated.[25] We illustrate the dynamic adjustment in

[25] In order to explore this issue further, we also ran a simple static specification similar to those used in previous studies, in which the dependent variable l_{it} is regressed on the components of Z_{it}, all in levels. This was estimated in a panel using bank-effects but not time effects, in order to stay consistent with

Figure 6, which uses the coefficients in columns (2) and (3) to predict the path of the lending rate based on a one percentage point upwards shock to the capital ratio. We assume that initially (time 0) the lending rate and capital ratio are equal to their median values in 2011, and we isolate the effects of the capital ratio by assuming that the system is initially in equilibrium (more specifically, we force the constant A_i in Equation (2) in order to set the cointegrating error u_{it} to zero at time 0). In panel A we use the model parameters based on actual capital (i.e., column (2) in Table 2), while in panel B we use the model based on the long-run target capital proxy (i.e., column (3) of Table 2). The simulations rely on the model parameter estimates corresponding to the crisis period, i.e. $K + K^{CRISIS}$ measuring the long-run relation, and $\beta^K + \beta^{K,CRISIS}$ measuring the short-run association.

The long-run effect of the increase in the capital ratio (shown in a dashed line) is a smooth decline in the lending rate, reflecting the negative long-run effect reported in Table 2, which provides empirical evidence in support of the *banking sector distress effect* hypothesis.[26] In the short-run, the lending rate (shown by a full black line) temporarily increases for a few months, as banks adjust upwards the capital ratio, before settling back down to its long-run level. Consistent with the results in Table 2, the positive short-run effect is larger in the target capital simulation (panel B), while the negative long-run effect is larger in the actual capital equation (panel A).

previous studies. The coefficient on the capital ratio is positive in the pre-crisis period and negative in the crisis period, consistent with the findings of other studies reported above (although they are based on different stress periods). What these findings do not tell us is that the positive effect in good times is only a short-run phenomenon (*weak bank effect*), and the negative effect in bad times is driven by a negative long-run effect (*banking distress effect*) and is actually offset by a positive effect in the short run (*weak bank effect*).

[26] It may seem odd that the lending rate is falling during a crisis, contrary to recent experience, but note that this shows the *marginal* effect of capital. In practice lending rates would be rising substantially in a crisis due to economic and financial factors captured by the other covariates in our model.

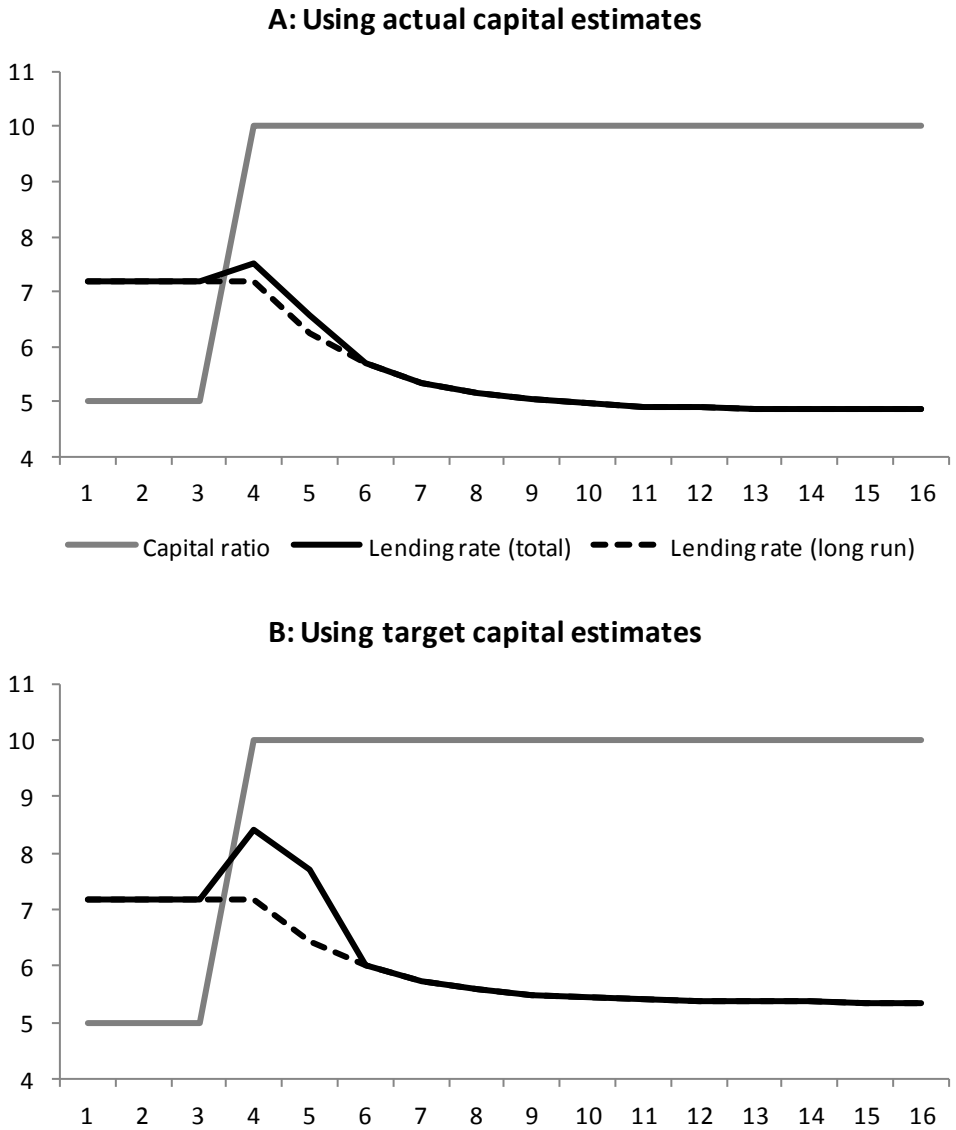

Figure 6. Illustration of short- and long-run effects of capital ratio on lending rates in crisis.

Shows the short-run and long-run impact on the lending rate of a 1 percentage point increase in the capital ratio, assuming that the lending rate and capital ratio are at their median levels in 2011 (4% and 5%, respectively). Panel A and Panel B use estimates of the total short-run and long-run effects in the crisis from column (2) and column (3) of Table 2, respectively.

We next extend the analysis to test whether the competitive position of each bank, as proxied by market share, may affect the lending rate, and whether it might affect the size or direction of the relation between capital and lending rates. The market share variable has a significantly negative effect in the long-run ($\mu < 0$), possibly reflecting the fact that higher bank's lending rates reduce demand for loans and, conversely, that aggressive business strategies entail lower interest rates and greater market share. The long-run effect of the interaction term is positive ($\Lambda > 0$) and significant in the long run and this result emerges both in normal and in crisis periods, which shows that the total effect of

the capital ratio on lending rates ($\Lambda \cdot \mathrm{M_{it}} + K$) is increasing in a bank's market share. The base effect of capital on lending rates (K) is negative and significant in non-crisis and crisis periods though it is more negative in the crisis period as in the main analysis above, consistent with the *banking sector distress effect*.

These results indicate that the sign of the total effect of the capital ratio ($\Lambda \cdot \mathrm{M_{it}} + K$) depends not only on crisis conditions but also on the bank's market share, i.e. the total effect is negative for banks with a small market share and positive for banks with a large market share. These findings are consistent with the idea that banks with a higher market share are more able to pass costs onto customers, since the long-run effect of capital is always more positive (or less negative) for these banks. When the effect is positive, dominant banks pass more of the costs of capital onto borrowers. When it is negative, i.e. increases in capital reduce costs, these banks pass less of the cost savings through into borrowing rates than more competitive banks.

Our findings on the short-run effect of the capital ratio are unaffected by the inclusion of M_{it} and $k_{it} \times M_{it}$, i.e. they remain positive and significant. However, the coefficient on the interaction variable $k_{it} \times M_{it}$ suggests that banks with a large market share have a smaller (i.e., less positive) short-run effect. This is surprising as intuitively it seems that more dominant banks would be more able to "hold up" their customers to raise additional capital. However, less elastic loan demand at these banks also means that lending rates are a less effective way of managing the supply of new credit, which is the other mechanism by which lending rates affect capital ratios in the short run. [27]

5. Conclusions and implications

The relation between the level of capital that banks hold and the cost of credit in the economy is a crucial input to debates on the costs and benefits of regulatory capital. Theory predicts that when capital requirements force banks' capital holdings above their own capital targets, in the long run this raises their cost of funding which will have

[27] Mindful that the effects of the competitive position of the bank may also vary over non-crisis and crisis periods we also interacted these variables with the crisis dummy and confirmed that their long- and short-run effects were not significantly different during the crisis.

knock-on effects on the interest rates set for borrowers and depositors and hence, it may hurt the real economy. However, in stressed market conditions this relation is likely to become weaker as capital requirements are more consistent with the demands placed on banks by the market. Furthermore, short-term shortages of actual capital from target capital may result in banks raising interest margins in order to strengthen their balance sheets and manage the level of capital via retained earnings. All of these considerations suggest that the relation between capital and loan interest rates is driven by market conditions, and that there may also be different mechanisms in the short run versus the long run. This goes some way towards rationalizing the conflicting evidence in the empirical literature on the sign and magnitude of the relation.

This study exploits the most recent available 14-year sample period 1998-2011 of data on the 8 largest UK retail banks to test three hypotheses stemming from theory: the *cost of capital effect*, the *banking sector distress effect* and the *weak bank effect*. An error correction modelling (ECM) framework is adopted to separate out long-run from short-run dynamics, and we permit time (within) heterogeneity in the relation between bank capital ratios and lending rates by distinguishing between normal and stressed market conditions.

In contrast to the *cost of capital effect* which is often cited as a reason for holding back on regulatory reform efforts, we do not find any significant long-run link between capital ratios and lending rates in ‘good’ or normal times. We interpret this as evidence that UK banks' holdings of high quality (i.e., Tier 1) capital were on average close to their own cost-minimising, optimal capital ratios during the pre-crisis period and therefore capital requirements were not binding. This contrasts with previous research showing that requirements at the total capital level (i.e., including low quality, debt-like Tier 2 capital) were strongly binding on banks (Francis and Osborne, 2012). However, we do find evidence in support of the notion that the long-run link between bank capital and loan interest rates is negative during stressed market conditions. This is likely to reflect an increase in banks’ optimal capital ratios in ‘bad’ or crisis times, driven by an increase in expected bankruptcy costs, which we have termed the *banking sector distress effect*. With a higher optimal capital ratio, banks may be able to reduce the cost of funding in the long-run by increasing their capital ratios, holding other things equal.

We provide evidence consistent with a significantly positive short-run link between capital and lending rates which is particularly strong during crisis times. We interpret this as evidence that banks rely on interest margins as a convenient tool for adjusting their high-quality Tier 1 capital ratio in the short-run, both by raising the numerator via retained earnings and by reducing the denominator via downwards shifts in the supply of new assets. Taken together, our findings suggest that increases in capital targets of the magnitude seen during the recent crisis may result in a temporary upwards hike in lending rates, but have a negative effect in the long-run.

These findings suggest that estimates of the impact of higher capital requirements on lending rates and the broader economy could be improved by allowing the cost of capital requirements explicitly to vary over the business cycle and over the long and short run. Our analysis is also relevant to the design of the dynamic countercyclical capital requirements promoted by Basel III to improve the resilience of the banking sector to financial and economic shocks. Such macroprudential reforms are aimed at dampening procyclicality by constraining lending growth during a credit boom using higher capital requirements, and then incentivising higher lending growth during a downturn via reductions in capital requirements. Consistent with these aims, our findings suggest that the short-run effects of changes in capital targets is positive. However, our findings also suggest that the long-run effects of such policies are highly sensitive to market conditions and, in particular, to market expectations of an individual bank's capital ratio. In particular, the results of reductions in capital requirements during a crisis may be muted if banks have incentives to minimise their cost of funding by sustaining high capital ratios. This is illustrated by the recent crisis, when banks have increased their capital ratios significantly more than they were required to do by international standards. It is likely that very substantial counter-cyclical variations in capital requirements (i.e. large increases during booms and large reductions in a downturn) would be necessary in order to achieve the aim of easing credit supply in such conditions.

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