

# On the Behaviour and Determinants of Risk-Based Capital Ratios: Revisiting the Evidence from UK Banking Institutions

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# **On the Behaviour and Determinants of Risk-Based Capital Ratios: Revisiting the Evidence from UK Banking Institutions**

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**Biographical note:** William Francis and Matthew Osborne are economists in the Economics of Financial Regulation team in the Strategy and Risk division of the Financial Services Authority.

**Abstract:** Using bank-level panel data from the United Kingdom, this paper investigates the factors that influence banking institutions' choice of risk-based capital ratios. Special focus is placed on evaluating whether and how institutions respond to changes in regulatory capital requirements and if these responses vary across the economic cycle. This issue is of particular interest to policymakers that rely on capital regulation in conjunction with other supervisory tools to affect bank behaviours and maintain market confidence and financial stability more broadly. The paper also explores the extent to which UK banks' capital management practices were procyclical under Basel I. Understanding whether such practices existed under this less risk-sensitive (and potentially, less procyclical) regulatory capital regime is a useful first step towards determining if banks, in their capital management practices, consider swings in economic conditions on their capital positions and lending capacities, which may, in turn, impact on the severity and duration of such economic cycles.

We find a statistically significant association between banks' risk-based capital ratios and individual capital requirements set by regulators in the UK. We also find that the rate at which banks respond to changing capital requirements depends significantly on certain characteristics of the bank (e.g., size, exposure to market discipline, nearness to regulatory threshold) as well as the direction of the economic cycle. We find a (marginally statistically significant) negative association between capital ratios and the economic cycle, but no association when we focus only on the largest banks in the UK, suggesting that systemically important banks tend to maintain risk-based capital ratios over the cycle (although we note that this finding is based on a sample period which does not contain a significant downturn). Further, we note a positive association between capital ratios and capital quality, suggesting that reliance on capital with relatively higher adjustment costs (e.g., tier 1 capital) may raise the profile of that consideration in capital management practices and lead cost-minimizing banks to maintain higher total risk-based capital ratios overall. Finally, we find a positive marginal effect of market discipline on total risk-based capital ratios held by UK banks. We interpret this result as suggesting that banks mitigate expected market reactions (e.g., on their funding costs or ability to access certain capital markets activities) to their business decisions by holding higher capital ratios.

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**Table of Contents**

1. Introduction and Motivation .....	4
2. Background on Risk-Based Capital Ratios in the UK.....	7
3. Previous Research Findings .....	11
4. Theoretical model and base estimation equation.....	16
5. Empirical results.....	23
6. Considerations for Policymaking and Future Research .....	30
7. Conclusions .....	31
References .....	33

## **1. Introduction and Motivation**

Because of its important role in the payments system as well as in facilitating credit and economic growth more broadly, the banking industry remains one of the most heavily regulated industries overall. Capital regulation, in particular, continues to play a major role in the oversight of these firms and mandates that banks hold minimum amounts of capital as cushions against unexpected losses or adverse shocks that could lead to bank failure.<sup>3</sup> The widespread problems that have plagued the banking industry recently, however, have raised questions about the design of capital requirements and concerns about the level of capital in the banking system more widely. As a result, regulators around the globe are rethinking the more fundamental role of regulatory capital requirements in affecting bank behaviours and market perceptions about (and, therefore, pricing of) bank risk. That role, as suggested by the economic literature, is prompted by the need to address several well-known market failures that threaten financial stability and market confidence more broadly (e.g., see Richardson and Stephenson (2002)). These problems include systemic risk and other negative externalities that derive from bank failures, as well as information asymmetries (e.g., between bank management and depositors) on the financial health of the bank.

This paper examines the efficacy of regulatory capital requirements in that role by specifically testing for how they affect UK banks' capital ratios. In exploring this relationship, this study also considers a host of other factors found useful in explaining banks' capital ratios in previous studies. The issue of what influences capital management behaviour is of interest to policymakers in their ongoing efforts to identify and respond to problems in the banking industry and potential threats to market confidence and financial stability more broadly. A better understanding of the underlying drivers can assist in evaluating the merits of regulatory intervention and in shaping net beneficial policy responses to banking problems.

The banking problems experienced in many countries during the late 1980's and early 1990's demonstrated the critical role of capital as a defence against adverse shocks and, moreover, the importance of robust capital regulation. Setting out a global framework for capital requirements in the banking industry, the 1988 Basel Capital Accord (i.e., Basel I) was an attempt to link mandatory capital levels to the risk profile of the banking institution and, at the time, was seen as a major step forward in the design of capital regulation. It proposed an 8 percent regulatory minimum capital requirement for banks' exposures to credit and (in 1998) market risks. Credit exposures were determined on the basis of a series of risk-weightings designed to reflect the nature and degree of credit risk inherent in various asset classes.<sup>4</sup>

In the UK, the FSA inherited from the Bank of England the practice of supplementing the Basel I approach with individual capital requirements, also known as 'trigger ratios', based on analysis of firm-specific characteristics and management practices, and this practice has been retained under Pillar 2 of Basel II. These firm-specific requirements are periodically reassessed and, where necessary, revised to reflect changing bank conditions and management practices. As part of these reviews, the FSA have considered it to be good practice in the financial services industry for a UK bank to hold an appropriate capital buffer above the individual capital ratios advised by the FSA (FSA (2001)).

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<sup>3</sup> These regulatory minimums are based on, among other things, banks' exposures to credit, market and (under Basel II) operational risks and are designed to help banks respond to adverse shocks without causing undue disruption to consumers or increasing the likelihood of default.

<sup>4</sup> For example, commercial loans were afforded a 100 percent risk weight, thereby requiring that banks hold 8 percent capital against these types of loans. On the other hand, US government bonds/UK gilts were given zero percent risk weighting, indicating that banks were not required to hold capital against these low risk assets.

This approach means that in practice the majority of UK banks have capital requirements above the 8 percent Basel minimum. Whether they would hold capital at these levels in the absence of regulatory requirements is an issue that policymakers and researchers have been interested in for several years. If banks would hold higher capital, then it may be the case that capital requirements would not be effective in altering bank behaviour. To affect behaviour, regulators may, in this case, find it more fruitful to focus on other factors that drive banks' capital and risk management practices.

The practice of holding capital in excess of regulatory minimums does not imply, however, that capital requirements are ineffective in altering bank behaviour. Indeed, previous research finds that banks tend to hold buffer capital (i.e., maintain excess capital ratios) for a variety of reasons, offering some clues about how banks may act in the absence of regulation (Alfon et al. (2004); Ayuso et al. (2004); Lindquist (2004); Bikker and Metzmakers (2004); Stolz and Wedow (2005); Jokipii and Milne (2008)). Among the reasons cited, the desire to avoid costly intervention stemming from a breach of regulatory thresholds features prominently. Obviously, this goal implies that capital requirements may be a useful regulatory tool for affecting bank behaviour.

Still, banks highlight other factors – not explicitly linked to capital requirements – as being important drivers in their capital management practices.<sup>5</sup> Market discipline and, in particular, the goal of obtaining a targeted external credit rating (e.g., to reduce the cost of capital or to access key capital markets) are often mentioned.<sup>6</sup> Banks also cite the ability to weather economic downturns and secure access to wholesale deposits and money markets more widely as considerations in their capital management practices. In this arena, they referenced long-term growth and acquisition strategies as factors underlying their decision to hold buffer capital.

Researchers have examined (indirectly) the question of what capital levels and ratios might look like in the absence of regulation. In particular, previous research has evaluated whether and how capital ratios respond to changes in capital regulation (e.g., capital requirements), while also accounting for the potential influence of these other factors. Finding an association between capital ratios and requirements, after taking into consideration these other possible influences, can provide evidence on the efficacy of prudential requirements in shaping bank behaviour.

Results from this research, which is based on the Basel I capital regime, suggest that capital ratios, in fact, respond to changes in capital requirements and, therefore, that capital requirements are effective in influencing bank behaviour.<sup>7</sup> Interestingly, this research also finds that banks do not always respond to capital requirements in a systematic fashion. The evidence is consistent with the idea that some banks may alter capital directly (e.g., by raising new capital or by retaining a higher proportion of earnings), while others may alter risk-weighted assets (e.g., on- and off-balance sheet composition). Researchers have also found that these choices may depend on, among other things, the characteristics and financial condition of a bank (e.g., see Alfon et al. (2004) and Wong et al. (2005)), as well as the state of the economy (e.g., see Ayuso et al. (2004); Lindquist (2004); Stolz and Wedow (2005); and Jokipii and Milne (2008)).

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<sup>5</sup> See, for example, Berger et al. (1995), for a good summary.

<sup>6</sup> Minimum capital requirements under the Basel Accord made these buffers (and their comparisons) more transparent, which, in turn, may have contributed to higher capital ratios more broadly.

<sup>7</sup> See Jackson et al. (1999) for a review of early work in this area. VanHoose (2008) reviews more recent work. Ediz et al. (1998) and Alfon et al. (2004) present results for UK banks.

A key objective of this paper is to provide a better understanding of the characteristics and conditions that contribute to these diverse behaviours. Towards that goal, we extend previous research examining banks' responses to changes in regulatory capital requirements to evaluate the extent to which they depend on bank-level characteristics and economic conditions. These issues are important for understanding the impacts that policy revisions (and supervisory recommendations regarding banks' capital plans under Basel II) may have on bank behaviour and the broader macro economy.

A secondary objective of this paper is to shed light on the extent to which UK banks' capital and risk management practices have been procyclical under Basel I.<sup>8</sup> Owing in part to a lack of research on this topic, there is no conclusive evidence that capital management practices have in fact been procyclical in the UK. This gap makes it difficult to understand the merits of regulatory intervention over this matter. Our research aims to fill this gap and acts as a useful first step towards understanding the extent of the procyclicality problem in the UK.

While, in general, procyclical effects (of risk-based capital requirements) are dampened to the extent that real investment opportunities are worse in a downturn, policymakers and academics remain concerned about this outcome and continue to spend significant time and resources considering ways of dealing with it.<sup>9</sup> These efforts imply that there may, in fact, be a problem and, therefore, a need for regulatory intervention. The implication is that banks may be 'short-sighted' in their capital management practices. That is, banks, when deciding how much capital to hold during good economic conditions, may not adequately consider the costs to the wider economy of their inability to raise capital and supply credit throughout the full economic cycle.

A necessary condition for regulatory intervention to deal with this problem is that there is evidence that banks are, in fact, 'short-sighted' in their capital management practices. However, the extent to which banks do not consider the impacts of economic downturns on their capital resources, including their ability to raise capital, and their lending capacity is not well known. Our research aims to shed light on this issue by examining how banks' capital management practices evolved during the course of previous economic cycles in the UK. It is important to note that we are not directly examining bank behaviour under the more risk-sensitive Basel II capital regime. Nonetheless, we believe that evaluating the extent to which banks may have considered the impact of economic cycles in their capital management practices under Basel I may provide a useful benchmark for understanding behaviour going forward. If banks appear to take these considerations into account, then there may not, in fact, be a good reason to intervene. If, on the other hand, there is evidence that they have not considered this effect, then regulation may be warranted to deal with this problem.

Using an unbalanced panel of data on UK banks spanning 1998 to 2006, we examine the determinants of UK banking institutions' choice of risk-based capital ratios in more detail. Our work contributes to the previous research on this topic in three ways. First, we evaluate the extent to which banks' response rates (to regulatory capital changes) depends on various bank level characteristics and the state of the economy. A noted caveat surrounding much of the previous research examining this issue in other countries is that they exclude periods of substantial economic turmoil. Our second contribution to the literature is to supplement analysis for recent years (1998-2006) with further findings for a previous period which included a recession and subsequent recovery in the UK (1990-1995). This was also the period in which the Basel I regime was being implemented in the UK, so the comparison with the later period yields insights into how banks might react to sustained regulatory pressure during a downturn.

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<sup>8</sup> By "procyclical", we mean whether capital management practices act to amplify the duration of economic upturns or downturns.

<sup>9</sup> See, for example, chapters 4 and 7 of FSA (2006) for policymaker views. Academic perspectives include Catarineu-Rabell et al. (2005) and Saurina and Trucharte (2007).



A third contribution of our paper is that we explicitly examine how the composition of regulatory capital influences banks' choice of capital ratios. If higher quality tier 1 capital is more costly (e.g., in the spirit of Myers and Majluf (1984)), then we might expect to observe a trade-off between the quality and quantity of regulatory capital. These trade-offs may be influenced by an institution's ability to raise capital, which may, in turn, depend on firm-specific and market conditions.

The rest of this paper is arranged as follows. Section 2 provides background on risk based capital ratios in the UK. Section 3 reviews relevant literature examining the behaviour of banks' capital and risk management practices as well as the evidence on procyclical effects of risk based capital requirements in other countries. We set out our model, testable hypotheses, data and empirical specification in section 4. Section 5 presents empirical results, while Section 6 highlights a few policy considerations. Section 7 concludes.

## **2. Background on Risk-Based Capital Ratios in the UK**

This section reviews how UK banks' capital ratios have evolved over the period 1991 to 2008. To provide some context, it briefly describes how UK capital requirements are set and the UK's approach to assessing both standalone banks and wider banking groups that may contain other non-banking entities. It also presents some simple descriptive statistics on capital ratios and highlights key movements and differences according to banks within different size categories.

### **2.1. Capital Requirements in the UK**

Since 1991, capital requirements at UK banks have, in large part, been dictated by the 1988 Basel Accord (i.e., Basel I), as agreed by the Basel Committee on Banking Supervision. The purpose of that regime was to make capital requirements more risk sensitive and commensurate with the degree of risk inherent in banks' balance sheets. This regime required banks to hold minimum levels of capital equal to 8% of risk-weighted balance sheets assets. The risk weights assigned to various asset classes were designed to reflect the degree of uncertainty surrounding the payoff of broad asset classes and, in that sense, reflected their intrinsic credit risk.

While Basel I was generally perceived as a step forward in making capital requirements more risk sensitive, the FSA (and the Bank of England as the predecessor supervisor) required additional capital charges to compensate for several recognized shortfalls. The Basel I regime, in particular, did not consider a number of other key risks, including interest rate, legal, reputational and operational risks, that had the potential to produce losses and lead to bank failure.<sup>10</sup> For that reason, UK supervisors set individual capital guidance, also known as "trigger ratios", based on firm-specific reviews and judgments about, among other things, evolving market conditions as well as the quality of risk management and banks' systems and controls. These triggers are reviewed every 18-36 months, which gives rise to considerable variety in capital adequacy ratios across firms and over time.

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<sup>10</sup> Basel I was amended in 1996 to include mandatory capital charges for market risk in banks' trading books. This amendment was important not only since it was a step toward prudential recognition of market risk, but also because it allowed banks for the first time to calculate their market risk exposures by means of their own internal (value-at-risk) models. Basel II, which was adopted by European banks in 2007, addresses many of the shortcomings in Basel I. Reviews of the new Basel II aimed at addressing further issues and shortfalls are ongoing (BCBS (2006)).

An additional feature of the UK capital regime, as it applies to banks within groups, is that requirements are levied on banks both at the solo-level (i.e., standalone or solo-consolidated basis<sup>11</sup>) and at the group-level. This approach is different from that followed by many other regulators that focus almost exclusively on evaluating the position of the consolidated group as a whole and impose few, if any capital requirements on individual firms. The UK approach to assess individual firms' capital on a solo basis is based on several problems that consolidated assessments pose.<sup>12</sup> The most prevalent is that consolidation treats capital as if it were easily transferable among entities in the group. Reliance on a consolidated approach to assessing and setting capital requirements also presumes that a parent company would act as a source of strength to a bank in times of stress and, therefore, would have both the necessary capital and incentives to inject it into the bank as needed. These, however, are not readily apparent or assessable (either by the supervisor or the market). Theories suggest a number of reasons why banks may not act to support subsidiary banking entities in times of stress. Indeed, the decisions of Spanish banks not to support their troubled subsidiary banks in Argentina during the 1980's support these ideas and illustrate the issues regulators face in assessing capital adequacy in groups.

The uncertainties around both the transferability of capital and group behaviours/incentives provide the basis for the UK approach of setting capital requirements on a solo basis as well as at the group level. The effect of this approach is that it limits groups' freedom to choose how they allocate capital around the group. It means that the capital required by a bank, if a member of a group, is held by the bank itself and not elsewhere within its group. This step reduces the risk that, if a firm within the group fails, the group may be unwilling – or unable, for a range of legal and other reasons – to move capital to where it is needed. The unique approach of the UK in assessing and requiring solo-level bank capital requirements is the reason that we focus on examining solo-level banking data in evaluating the determinants of capital ratios in the UK.<sup>13</sup>

## **2.2. Trends in Risk-Based Capital Ratios in the UK**

This subsection reviews key trends in risk-based capital ratios for UK banking institutions since the introduction of Basel I in the UK. Following an increase in capital requirements (similar to that which occurred under Basel I), we might expect a bank close to its regulatory minimum to raise its risk-based capital ratio. Banks could make this adjustment by changing the numerator or the denominator of the ratio, or altering both. The numerator can be changed by raising capital (e.g., by new rights issues, retaining profits, issuing subordinated debt or qualifying hybrid securities). The denominator can be changed either by reducing assets or by shifting the asset portfolio into lower risk-weighted categories (e.g., by cutting back on lending and investing more in government securities).

Figure 1 reports the total risk-based capital ratio (i.e., total eligible regulatory capital for the aggregate banking industry divided by aggregate risk weighted assets) for all UK banks reporting at a solo (or unconsolidated) level for the period 1989-2008, as well as the percentage year-on-year GDP growth for the same period. While the capital adequacy ratio started this period at a relatively low level compared to the Basel minimum of 8%, it rose rapidly during the early 1990's when the UK economy suffered a notable downturn.<sup>14</sup> Also of note is a modest rise in the capital ratio in the late 1990's and a persistence of these relatively high levels into the early part of this century, a period characterized by

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<sup>11</sup> By solo consolidation, we mean that banks are allowed to incorporate one or more subsidiaries into its solo capital calculation, thereby avoiding full deduction of these in the calculation of capital resources. For more details on solo consolidation and the criteria for application, see the FSA's Prudential Sourcebook, BIPRU 2.1.

<sup>12</sup> For a good review of these problems, see FSA Discussion Paper 07/7.

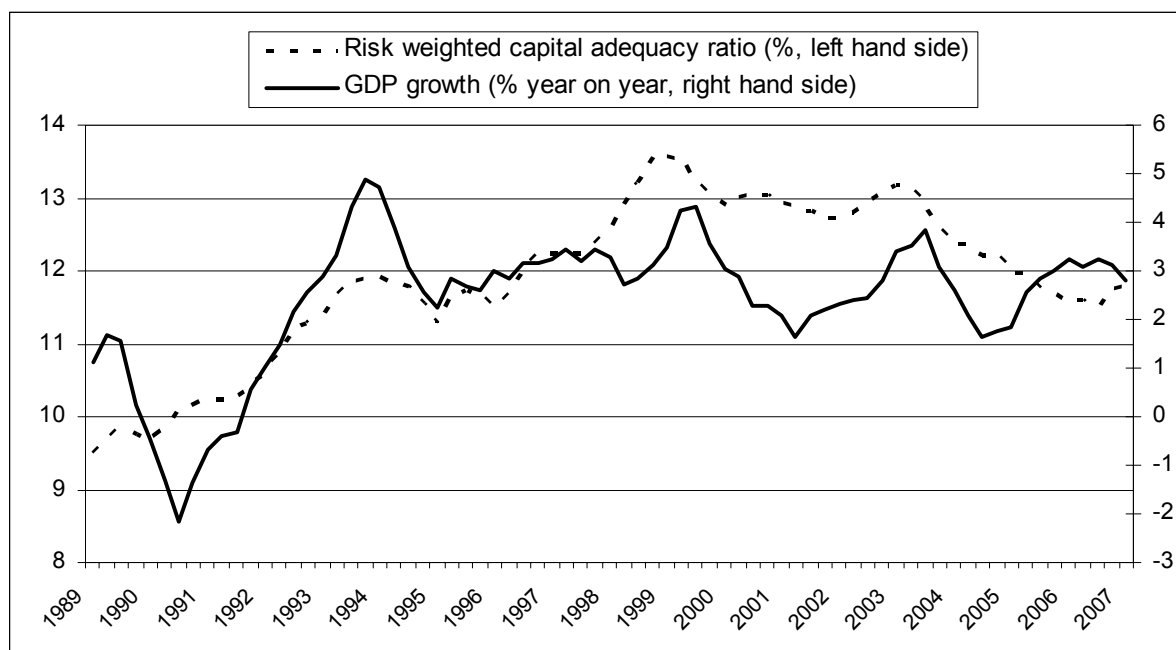
<sup>13</sup> A natural extension of this research would be to examine how group capital requirements impact group capital ratios in the UK.

<sup>14</sup> The general upward trend in bank capital ratios during this period is also found in other developed countries as noted in Jackson et al. (1999).

both relatively robust economic conditions and bank earnings. The figure also shows a moderate downturn in the capital ratio from 2003 to the end of 2006, a period also characterized by a relatively favourable economic climate. Finally, the figure shows an increase in the aggregate capital adequacy ratio in 2007 and 2008 (through the end of the second quarter). This upturn is due, in part, to the adoption of Basel II (known as the Capital Requirements Directive in Europe) in 2007 and the generally favourable impact it had on many UK banks (i.e., reducing risk-weighted assets for a large number of banks). This effect was especially pronounced on retail loans, including mortgages, where risk weights fell considerably relative to Basel I levels. For this reason, our regression analysis below focuses on the period up to the end of 2006 (and prior to the implementation of Basel II).

While looking at movements in the industry-wide capital adequacy ratio is interesting, aggregate ratios can sometime mask firm-level behaviours. In addition, the diverse trends reported in Figure 1 make it difficult to infer whether or how UK banks' capital management practices may have been associated with economic conditions. Our econometric analysis (below) overcomes these shortcomings by examining firm-level behaviour explicitly.

**Figure 1: GDP growth and risk-based capital adequacy ratios of UK banks, 1989-2008**

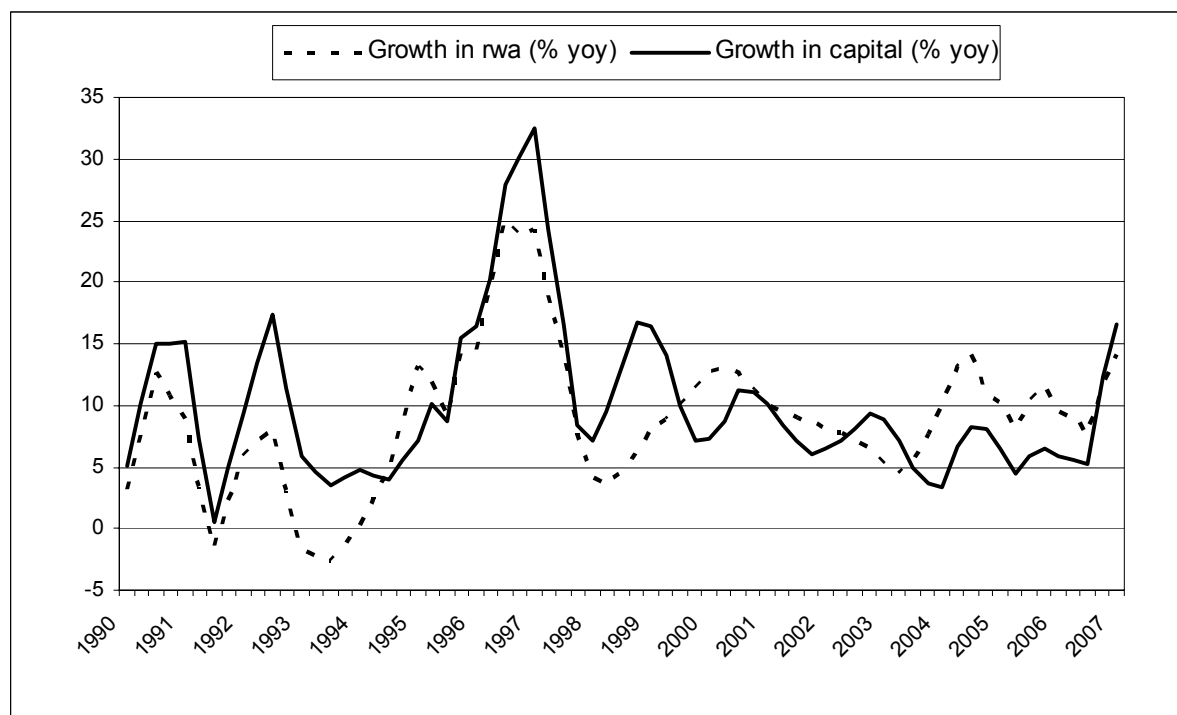


Source: FSA Banking Supervision Database

Notes: GDP is measured by the percentage growth in GDP year on year. Risk-weighted assets are calculated on a Basel I basis throughout, although some firms may move to Basel II calculations during 2007.

To gain more insight into what drives the trends in the capital ratio, we plotted, in Figure 2 below, the annual percentage growth in aggregate regulatory capital and risk-weighted assets. As might be inferred from Figure 1 above, capital grew at a faster rate than risk-weighted assets in the early 1990s, resulting in an increase in the capital adequacy ratio. A rapid rise in capital in 1996-1997 contributed to the peak in the capital adequacy ratio in the late 1990s, while in the early 2000s the growth in capital and risk-weighted assets are very similar, resulting in little change in the capital adequacy ratio during that time. After 2004, risk-weight assets grew at a faster rate than capital, resulting in the fall in the capital adequacy ratio observed in Figure 1 above. Figure 2 suggests that, at least broadly, growth in capital and risk-weighted assets are closely correlated, suggesting that banks may actively manage capital and assets together to maintain capital ratios.

**Figure 2: Growth in capital and risk-weighted assets of UK banks, 1990-2007**



Source: FSA Banking Supervision Database

Note: Risk-weighted assets are calculated on a Basel I basis throughout, although some firms may move to Basel II calculations during 2007.

Looking at the aggregate (weighted-average) capital ratio for all banks may conceal important differences between banks and over time. This issue is especially true for our sample, which, as the standard deviation reported in Table 1 suggests, contains capital ratios that are relatively highly dispersed across banks each year. To give a better sense of the distribution, Table 1 shows a finer breakdown of capital ratios for the sample of solo-level banks used in our regression analysis below, as well as the average ratio for large banks (defined as those with a significant share of aggregate banking sector assets) over time. The table shows that half the banks in our sample held capital ratios in excess of 17-20 percent over this period, well above the 8 percent Basel solvency standard. Those in the top quartile tended to hold even higher capital ratios (generally above 30 percent). The table suggests that larger banks tend to fall towards the bottom of the distribution. In particular, larger banks report significantly lower risk-based capital ratios of between 13 to 17 percent. These lower ratios may stem from more sophisticated risk mitigation techniques, diversification benefits or other economies of scale at larger banks. It may also be the case that these banks are more heavily exposed to market discipline prompting them to be more efficient with capital resources. We explore these possibilities in more detail below.

Also of interest, the table shows that ratios in the bottom of the distribution (including those for large banks) were relatively stable over the full period 1998-2006. The lack of a clear trend in the ratios at these banks contrasts with a notable upward movement in ratios for banks in the top half of the distribution and the largest banks in the early 2000s, and a significant fall in the period 2003-2006, reiterating trends observed in Figure 1 above.

**Table 1: Distribution of risk-based capital ratios for UK banks, 1998q1-2006q4**

Year	25 <sup>th</sup> Percentile	Median	75 <sup>th</sup> Percentile	Mean for large banks* only	Standard deviation (overall)
1998	13	18	28	16	19
1999	13	18	29	17	20
2000	13	18	30	16	18
2001	13	18	30	16	20
2002	13	20	36	18	22
2003	14	20	34	18	21
2004	13	19	32	16	20
2005	13	18	30	14	18
2006	13	17	27	13	16

Source: FSA Banking Supervision Database, using cleaned sample as described below

\* We define large banks as those greater than 0.1% of banking sector assets (as defined by the Bank of England) on average over the reporting period, which is roughly half of the sample

In sum, UK banks have tended to hold capital ratios well in excess of the Basel 8 percent solvency standard since 1990. This behaviour is particularly evident at the smallest banks in the UK, and capital ratios at the largest banks have been significantly lower over this period. Movements in aggregate capital ratios over this period demonstrated some inconsistencies that require more in-depth analysis to get a better handle on firm-level behaviour and the cyclical nature of risk-based capital ratios. In particular, during the early 1990's, when the UK suffered and recovered from a significant recessionary period, aggregate capital ratios exhibited a clear upward trend over that entire period. A similar trend, however, is not evident most recently (from 2003) in the face of another (albeit less pronounced) period of economic expansion as aggregate capital ratios generally declined during this period. We explore these relationships at the firm level in more detail below in our econometric analysis of the determinants and cyclicity of capital ratios.

### 3. Previous Research Findings

The links between prudential capital requirements, banks' capital management practices and the broader macroeconomy have received a lot of attention by policymakers and researchers. This section reviews research on two key issues and discusses the implications for our study. The first is the idea that regulatory capital requirements are one of a host of factors considered by banks and that these considerations depend both on firm-specific and broader macro-economic conditions. One key firm-specific factor, for example, is how close a bank may be to its minimum capital requirement. How banks respond to changes in such key variables depends on the costs of raising additional capital, which, as will be discussed, vary according to bank-specific and economic conditions.

This dependence links capital management practices to the economy and, as such, provides the basis for empirical testing of the second issue. That second issue is the potential for capital regulation to contribute to procyclical variations in total credit supply and, therefore, to more pronounced and longer-term economic cycles. In that sub-section, we specifically review prior research that examines the extent to which capital management practices have been procyclical in other countries.

### **3.1. What factors influence banks' capital and risk management practices?**

Much has been written on the factors that influence banks' choice of capital levels and capital management practices. In many of these papers, banks are generally characterized as facing a series of trade-offs when choosing capital levels or ratios. The trade-offs involve weighing a number of influences on the costs and benefits of holding too much versus too little capital, with the bank's choice optimized where the marginal costs and benefits are equal. Estrella (2004) develops a theoretical explanation for banks' choice of capitalization, while Alfon et al. (2004), for instance, presents both survey and empirical evidence on several of these influences for UK banks and building societies. That evidence suggests several reasons for why these institutions hold capital ratios above regulatory minimums.<sup>15</sup>

#### **3.1.1. Firm-specific factors and behaviours**

Survey results from Alfon et al. (2004) indicated that, not surprisingly, banks set capital according to internal risk assessments. The authors examine banks' behaviour empirically by regressing risk-based capital ratios on various proxies for risk, also controlling for capital requirements. They find that capital ratios are negatively associated with risk and positively associated with capital requirements and interpret this as being consistent with the idea that the higher the risk appetite of a firm, the lower the capital it holds, but that the potential for costly regulatory intervention dampens that effect.

Survey findings also noted that long-term strategic considerations (i.e., the ability to remain flexible to take advantage of growth opportunities) factored into banks' decisions to hold excess capital. Banks stated that excess capital allows them to maintain a degree of operational flexibility and avoid adjustment costs (e.g., transaction and signalling costs discussed in more detail below) associated with raising capital to fund unexpected business opportunities. Our study also explores the role of adjustment costs in influencing bank's capital management practices.

This practice of holding excess capital implies that value-maximizing banks consider the costs of holding it. A critical consideration is the opportunity cost of capital, which should act to dissuade banks from holding excess capital positions. Empirical findings from Alfon et al. (2004), however, are inconclusive regarding this effect. They report a positive, although statistically insignificant, coefficient on the variable return on equity, which in their analysis proxies for the opportunity cost of capital. Their analysis, however, is based on a limited sub-sample of banks that report profit and loss information as part of their regulatory returns, and, therefore, it is not apparent whether this sample may have imparted any selection biases. In our analysis, we examine this issue using the same proxy but compute profit and loss data from public financial statements which allows for a more comprehensive sample over a longer period of time.

In addition to opportunity costs, the costs of raising additional capital were key considerations mentioned by banks for holding excess capital. Banks indicated that these costs included transactions costs (e.g., fees to investment banks and lawyers) as well as indirect costs (e.g., movement in share prices through signalling affects) of raising new capital. Although difficult to quantify, these latter costs are ostensibly more material and especially sensitive to the state of the economy.<sup>16</sup> During an economic downturn when banks are likely to need additional capital (e.g., due to ongoing losses and capital erosion), these costs are more pronounced. Accordingly, banks,

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<sup>15</sup> Richardson and Stephenson (2000) and Berger et al. (1995) also discuss some possible explanations for why banks hold capital above regulatory requirements.

<sup>16</sup> During periods of severe economic stress, information asymmetries regarding the underlying values of banks' asset portfolios and subsequent cash flows and, therefore, signalling costs of issuing equity, may be at their height.

in their attempt to minimize such costs, may build up capital cushions during favourable economic conditions as a defence against having to tap the capital markets during more trying times. Indeed, survey results reported in Alfon et al. (2004) suggested that this practice may be the norm, as banks regarded maintaining capital cushions to deal with the impacts of an economic downturn as important. However, empirical results from that study and from others that examined the same question were not consistent with this notion. Our analysis revisits this issue in more depth.

A related question is whether banks, when deciding on their capital structures, make a trade-off between the quality and quantity of capital. Myers and Majluf (1984) point out several market frictions that explain why (better quality) tier 1 regulatory capital is more costly than tier 2 regulatory capital for banks. These reasons also suggest that banks will have an optimal capital structure (or mix of tier 1 and 2 elements) that maximizes their value given their chosen risk profile. Regulatory and market constraints on this mix, however, can force optimizing banks to make trade-offs between the quality and quantity of capital to hold. Indeed, Ediz et al. (1998) finds some empirical support for this behaviour. More specifically, they find that for UK banks, increases in regulatory capital requirements tend to impact lower-quality, tier 2 capital first and then higher-quality (and possibly more costly) tier 1 at a later stage. This finding suggests that banks may adjust towards an optimal balance between the cost and quality of capital. As discussed more fully below, we consider this effect by including a measure of the quality of capital (i.e., the ratio of tier 1 capital to total eligible regulatory capital) in our analysis. Information on this association provides useful background for understanding this trade-off.<sup>17</sup>

### **3.1.2. Market-discipline**

Prior research has found evidence that market discipline affects banks' funding costs and access to key capital markets activities (see, for example, Flannery and Nikolova (2003)). Banks' stakeholders, including depositors and creditors, can act to contain bank risk-taking if they demand higher rates of return (or withdraw funds) as banks assume additional risk. It is well known that insured depositors may not have the incentive to exert market discipline on banks.<sup>18</sup> On the other hand, uninsured depositors (and other general creditors for that matter) have appropriate incentives to take action, since they are exposed to losses in the event of a bank's failure (Nier and Baumann (2002)). In response, value maximizing banks would optimally consider these actions in their risk-taking and capital management practices. To offset the pressure from market discipline, banks may, for example, elect to hold higher levels of capital to reduce leverage and therefore the likelihood of failure.

Previous research suggests that this behaviour may be more pronounced at banks that are rated by external credit rating agencies. That research finds that rated banks have capital ratios 0.5 percentage points higher than non-rated banks (Nier and Baumann (2002)). Those studies also find that banks (rated or not) that disclose more information limit the adverse affects of market discipline by choosing higher capital ratios. Importantly, however, they also find evidence that these effects are weaker at institutions that the market believes the government would bail out (e.g., large, systemically important institutions). Market discipline from rating agencies may also have implications for banks' access to important capital market activities. For example, Nier and Baumann (2002) examines how bank ratings influence access to the swap market. They find that banks rated below 'A' have lower than average swap liabilities and interpret this as suggesting that the market constrains lower rated banks' access to this market. In this case, market practice may not allow banks to access (in a cost efficient way) the swap markets if they were downgraded below 'A'.

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<sup>17</sup> The information will also prove useful to impact assessment of proposals relating to the definition of capital.

<sup>18</sup> While insured, such depositors may face an opportunity cost in the event that there is a time delay in obtaining their funds in the event of bank failure. If material, this cost could provide sufficient incentive to affect market discipline. Recent runs by insured depositors at Northern Rock in the UK and Indy Mac in the US suggest that these costs may indeed be significant.

We explore this issue in more depth below by controlling for a measure of market discipline (i.e., the extent to which a bank uses subordinated debt) and examining interactions between this measure and capital requirements.

### **3.1.3. Regulatory environment**

Banks may also hold higher capital to reduce the costs associated with increased regulatory intervention and oversight as capital levels approach regulatory minimums. Such costs may include, for example, additional management time in responding to heightened supervisory scrutiny as well as lost business (opportunity cost).<sup>19</sup> Survey evidence and econometric findings from Alfon et al. (2004) are consistent with the conjecture that the avoidance of such costs is a key factor driving banks' capital management practices. They find a statistically significant positive relationship between capital ratios and requirements and, interestingly, that this association is more pronounced at banks closer to their minimum requirement. An authoritative review of evidence on the impact of Basel I by Jackson et al. (1999) finds a broad consensus around the result that banks with relatively low capital ratios tend to increase capital levels more quickly than other banks in response to regulatory pressure.

Ediz et al. (1998) explicitly examine for these effects using UK bank data from 1989 to 1995. They regress capital adequacy ratios on a set of explanatory variables which include a dummy variable for banks that experienced an increase in capital requirements in the last three months. In their specification, the coefficient on the dummy variable is meant to measure the sensitivity of capital ratios to increases in capital requirements. Although this dummy is itself not significant in their complete sample, they also include a dummy for banks with a capital ratio within a 'regulatory pressure zone', defined as banks with a capital ratio within one standard deviation of the required capital ratio. They find this variable to be significant at the 1% level, implying that firms in the pressure zone experience increases in capital ratios that are larger than other banks. They interpret this finding as suggesting that banks closer to their regulatory minimums are more sensitive to increasing capital requirements and respond by increasing their capital ratios in an attempt to reduce the probability of a breach.

An additional way for banks to respond to pressure from regulatory capital requirements is to alter the denominator of the capital ratio, the sum of risk-weighted assets. Following Thakor (1996), a large body of research examined the question of whether the transition to Basel I may have caused US banks to substitute low-risk assets, such as treasury securities, for lending, potentially causing a contraction in credit supply. Other studies show that the composition of banks' balance sheets changes when a bank moves close to the regulatory capital constraint (Mommel and Raupach (2007); Shrieves and Dahl (1992); Jacques and Nigro (1997); Aggarwal and Jacques (1998); Rime (1988)).

With respect to this question, we evaluate how sensitive risk-based capital ratios are to changes in individual capital guidance. As described in more detail below, we use information on bank trigger ratios and a number of bank-specific and macro-economic control variables to estimate the relationship between risk-based capital ratios and prudential capital requirements. Information on this association is useful for understanding how effective capital regulation is in affecting bank behaviour and, therefore, for refining impact assessments of altering capital requirements.

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<sup>19</sup> Regulators may also step in to limit or restrict dividend payouts or asset growth at institutions that breach capital requirements.



### **3.2. Economic conditions and procyclical capital requirements**

Debate about the procyclical features of capital requirements is widespread and has been given heightened attention in light of Basel II which ties capital requirements much more closely to movements in macroeconomic conditions. Under that regime, capital requirements will increase during economic downturns and decrease during upturns. Whether and how this may affect banks' capital management practices are of particular interest to policymakers. Of primary concern is that during economic downturns banks may reduce lending (rather than raise additional capital) to meet increased capital requirements.<sup>20</sup> Also of concern is that during economic upturns when capital requirements decline, banks may respond by increasing their lending supply beyond a socially optimal point. These (procyclical) impacts have the potential to accentuate and prolong economic cycles, making it potentially more difficult for policymakers to maintain economic stability.

A number of previous studies find that economic conditions significantly influence banks' capital management practices either with respect to their choice of capital buffers or capital ratios (see, for example, Ayuso et al. (2004); Lindquist (2004); Bikker and Metzmakers (2004); Stolz and Wedow (2005); Jokipii and Milne (2008)). Credit risk and losses are negatively correlated with the economic cycle. If banks are forward-looking in their capital management practices, then we would expect to observe a positive association between risk-based capital ratios and GDP. Under this scenario, banks hold higher capital ratios during more favourable economic conditions as a way of dampening the effects of losses during downturns. In this case, such capital management practices are said to be counter-cyclical, since they act to lessen the duration and impact of economic cycles. By contrast, if banks are short-sighted in their capital management practices, we would expect to observe a negative association between risk-based capital ratios and GDP. Such banks reduce (increase) capital ratios during upturns (downturns), potentially magnifying the extent of economic cycles. These capital management practices are said to be procyclical.

A key issue is whether banks, in their capital management practices, consider these cyclical influences on their expected capital resources – especially their ability to raise capital during more trying economic times -- and, moreover, lending capacities are issues of particular interest to policymakers. Failure to consider such effects could have wider implications for aggregate lending capacity that could, in turn, increase the duration and magnitude of economic cycles. To investigate the procyclicality hypothesis, several previous studies explicitly examine whether and how economic conditions have influenced banks' capital management practices. These studies typically focus on examining what factors, including proxies for the business cycle, explain banks' choice of capital ratios and buffers. Bikker and Metzmakers (2004), for example, explore the determinants of banks' internal capital targets and potential sensitivity of these levels to the business cycle. Using annual report data on leverage ratios (i.e., equity to assets) and BIS risk-based capital ratios across banks in 29 OECD countries for the years 1990 to 2001, they find a significantly negative association between the risk-based capital ratios and business cycle proxies. They interpret this result as evidence that the capital management practices of banks in OECD countries may be procyclical. They note, however, that when focusing only on banks in the EU and US, there is no significant association between capital ratios and economic conditions. The mixed findings lead them to conclude that capital management practices may be only moderately procyclical.

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<sup>20</sup> Banks may indeed be more likely to follow this route as they may find it relatively more costly to raise capital during more trying economic conditions.

Ayuso, et al. (2004), Lindquist (2004), Stolz and Wedow (2005) and Jokipii and Milne (2008), on the other hand, undertake somewhat similar studies of the behaviour of banks' capital buffers in Spain, Norway, Germany and Europe, respectively. They all find a statistically significant negative association between banks' capital buffers and various measures of the business cycle. Their findings suggest that banks' capital buffers increase during downturns and decrease during upturns, and therefore, that there may be evidence of procyclical behaviour in these countries.

There are, however, some important caveats with respect to some of these studies that may raise questions about whether this interpretation holds in general. For instance, Ayuso et al. (2004) find some evidence that the capital buffers of commercial banks are less procyclical than savings banks and go on to suggest that a subset of Spanish commercial banks may increase buffers during expansions and reduce them during recessions. This behaviour is in contrast with that under procyclicality. Additionally, the study by Lindquist (2004) does not encompass a full economic cycle and therefore excludes important behaviours. Stolz and Wedow (2005) point out that in their study of German banks, low capitalized firms do not reduce loan supply during economic downturns. Again, this behaviour contrasts with that of concern under procyclicality. Our analysis of procyclicality addresses these issues by focusing on the behaviour of commercial banks over a full economic cycle while also controlling for bank-specific features, including the level of capitalization.

#### **4. Theoretical model and base estimation equation**

The data for the years 1990 to 2006 indicate that UK banks have tended to hold capital ratios well above the Basel 8 percent solvency standard. This observation is, in part, due to the way in which regulatory capital requirements are set for banks in the UK. As described earlier, these requirements are tailored to reflect a bank's individual risk profile and supervisory judgements about other features (e.g., management quality, systems and controls) not sufficiently captured by the Basel framework. This framework results in capital requirements higher (sometimes significantly) than the Basel minimum.

While we are specifically interested in understanding the association between banks' capital ratios and regulatory requirements, we are also interested in understanding the key drivers underlying capital management practices in general. Towards that end, in this section we review a simple theoretical model of the drivers of banks' capital ratios, and then set out our key research questions. We also discuss our data and methodology.

##### **4.1. Model of banks' capital ratios**

A simple partial adjustment model has commonly been adopted by many researchers (see, for example, Ayuso et al. (2004); Estrella (2004); Bikker and Metzmakers (2004); and Jokipii and Milne (2008)). This model adjusts banks' current capital ratio,  $CAP_{i,t}$  to its targeted level,  $CAP_{i,t}^*$  according to the following:

$$CAP_{i,t} - CAP_{i,t-1} = \theta(CAP_{i,t}^* - CAP_{i,t-1}) , \quad (1)$$

where  $\theta$  is a positive adjustment parameter,  $i$  indexes banks and  $t$  indexes time. In the long run  $CAP_{i,t}$  converges to the optimal  $CAP_{i,t}^*$ , where  $\theta$  reflects the speed of adjustment. If  $\theta$  equals zero, no adjustment are made, potentially because the costs of doing so outweigh the costs of remaining away from the target. If  $\theta$  equals one, then full adjustment is made within one time period of analysis (one quarter for our analysis). Because we cannot observe the targeted capital ratio, we have to approximate  $CAP_{i,t}^*$  assuming it to be a function of a set of  $N$  explanatory factors:

$$CAP_{i,t}^* = \sum_{n=1}^N \delta_n X_{n,i,t} , \quad (2)$$

where  $X$  is a vector of  $N$  explanatory factors and  $\delta$  is a vector of parameters. Combining (1) and (2) yields the following model of a bank's choice of capital ratio:

$$CAP_{i,t} = (1 - \theta) CAP_{i,t-1} + \sum_{n=1}^N \theta \delta_n X_{n,i,t} . \quad (3)$$

Equation (3) forms the basis of our analysis and our paper's four main research questions:

Question 1: How do banks in the UK respond to regulatory capital requirements set by the FSA?

Question 2: Does this response change depending on characteristics of the bank (size, distance to regulatory minimum, exposure to market discipline) or economic conditions?

Question 3: Are UK bank capital ratios procyclical, i.e. do they rise (fall) during economic downturns (upturns)?

Question 4: How does the quality of capital affect banks' choice of risk-based capital ratios?

Toward addressing these questions, we discuss the choice of variables and the estimated equation below.

## 4.2. Variable definitions

Our dependent variable, the total risk-based capital ratio (CAP), is calculated as the ratio of total regulatory capital (the sum of eligible tier 1, tier 2 and, where applicable, tier 3 capital) to total risk-weighted assets in the banking and trading book. As Table 3 shows, the average total risk-based capital ratio for all banks over the period 1998-2006 was around 25 percent. The statistics also show that this figure is highly dispersed both across banks and over time.

Our choices of explanatory factors are largely based on previous work (described above) on the determinants of bank capitalization. To measure the impact of individual capital requirements on risk-based capital ratios, we use the banking book trigger ratio (TRIGGER).<sup>21</sup> Individual capital requirements (trigger ratios) are typically set every 18-36 months and, as a result, tend to be relatively stable over time. This is borne out in the statistics reported in Table 3, which shows the average trigger to be just under 13 percent, with a standard deviation of around 3 percent overall (across firms). On the basis of regulatory reports alone, we only know if individual capital requirements have changed if we observe a change in the reported trigger ratio from the last submitted report. For a report showing a revised requirement, we have no way of telling at what point during the preceding three months the change occurred. While we treat the change as having occurred at the time of the most recently submitted report, we recognize that a change later (earlier) in the three month period may be associated with a smaller (larger) change in capital in our data.

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<sup>21</sup> The trading book trigger ratio was not used as it only applies to a small number of firms and we wished to present results for a regulatory tool readily available to supervisors for most banks.

As discussed in more depth below, to address the question of whether bank characteristics affect the response rate, we run separate models using sub-samples based on bank size and capital buffer. We construct interaction terms using the TRIGGER ratio and dummy variables denoting the direction of the business cycle (UPTURN or DOWNTURN) to evaluate whether bank reactions vary over the cycle. We address the question of whether banks' capital ratios have been related to economic cycles by including a cyclical variable: annualised, quarterly real GDP growth (GDP). Our final research question, whether the composition of capital has an effect on the overall level of risk-based capital ratios, is addressed by including an explicit measure of the higher-costing regulatory capital (TIER1), the ratio of tier 1 capital to total regulatory capital (prior to deductions).

One important factor considered by Estrella (2004) is the cost for firms of holding capital, although in practice measurement of this cost is difficult. Prior studies (see, for example, Ayuso et al. (2004); Bikker and Metzmakers (2004); Stolz and Wedow (2005); Jokipii and Milne (2008)) employ banks' return on equity (ROE), the ratio of post-tax earnings to book equity, as a proxy of the direct opportunity cost of holding equity capital. Under this cost interpretation, we expect to observe a negative relationship between risk-based capital ratios and the ROE variable.<sup>22</sup> To proxy for the potentially higher costs associated with adjusting equity capital (e.g., direct transaction and indirect signalling costs that could adversely impact share prices), previous studies (see, among others, Alfon et al. (2004); Wong et al. (2005)) have also included lagged values of the capital ratio (LCAP). We note that the capital quality variable (TIER1) may also be a proxy for the cost of capital, since if it is more costly for banks to adjust equity, then we expect that cost-minimizing banks will hold higher total risk-based capital ratios and, therefore, to observe a positive association between risk-based capital ratios and TIER1.

Our base model includes four additional variables (RISK, PROVISIONS, SIZE, and MARKET) as controls for various determinants of bank capital ratios and buffers discussed in previous literature. A key determinant of bank capital management practices identified by Estrella (2004) is the expected cost of failure, which depends on the likelihood of failure. Because the likelihood of failure is dependent on a bank's risk profile, we control for the cost of failure by incorporating an ex-post measure of risk (RISK), calculated as the ratio of risk-weighted assets to total assets.<sup>23</sup> In this calculation, total assets include a measure of the on-balance sheet, notional amount of off-balance sheet assets.<sup>24</sup> In that respect, RISK will typically range from 0 if all assets were zero-weighted to 1 if all were 100% weighted, although there may be rare cases where this ratio exceeds one in when an institutions that have material off-balance sheet activities. The higher RISK is, the higher the expected cost of failure. Finding a negative association between capital ratios and RISK would be consistent with moral hazard behaviour. Indeed, using similarly constructed measures of risk, previous research (e.g., Alfon et al. (2004), Ayuso et al. (2004); Lindquist (2004)), find a negative association and interpret the result in this manner. Alternatively, if capital is slow to adjust to changes in risk weighted assets, we might also expect to observe a negative coefficient on a contemporaneous measure of RISK (since that variable includes risk-weighted assets in the numerator). We examine this possibility by including a lagged measure of RISK (LRISK) in our analysis below.

Since RISK can be seen as a regulatory measure as opposed to a bank's own internal estimate of risk, we also include each bank's total provisions over balance sheet assets (PROVISIONS). This variable

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<sup>22</sup> Jokipii and Milne (2008) also point out in their specification that the ROE variable may reflect revenue and, accordingly, that stronger banks (i.e., those with high ROEs) may be better able to increase capital ratios (e.g., through higher retained earnings). Under that interpretation, we may expect to see a positive association with risk-based capital ratios.

<sup>23</sup> Another measure of risk which is often used is the leverage ratio, defined as core capital over total liabilities. We included this as a regressor in our main model with little change to the coefficients. However, since we consider changing leverage as being one of the most important ways in which banks may respond to changing capital requirements, we do not include this variable in the specifications reported below.

<sup>24</sup> We also calculated this variable using credit equivalent amounts of off-balance sheet assets, with little change to the results.

represents a bank's own view about the quality of its asset portfolio. For that reason, it may be more closely aligned with the bank's own perception of risk: relatively higher (lower) ratios suggest more (less) risk. Again, finding a negative association with capital ratios may be indicative of moral hazard behaviour. Alternatively, a positive association may imply evidence of market discipline.

As discussed above, there are a number of reasons, namely greater portfolio diversification and economies of scale, for why we would expect bank size to affect banks' capital management practices. Previous studies have found significant evidence in support of this effect (see, for example, Alfon et al. (2004); Stolz and Wedow (2005); and Jokipii and Milne (2008)). To control for this effect, we include bank size (SIZE), as proxied by a bank's share of total UK banking assets measured at each reporting date.<sup>25</sup> We expect the association between risk-based capital ratios and SIZE to be negative, since larger firms may achieve greater economies of scale in screening risky borrowers and better diversification of risk across asset classes and geographic locations.

Finally, we control for the degree to which a bank is exposed to market discipline by including a variable measuring subordinated term debt as a proportion of total liabilities (MARKET).<sup>26</sup> There is evidence that subordinated debtholders are effective in imposing such discipline on bank behaviour; see, for example, Covitz et al. (2004). We expect the association between risk-based capital ratios and MARKET to be positive, since banks that rely on such external funding may hold higher capital ratios to mitigate market responses (i.e., disciplinary impacts) on their funding costs and access to capital market activities. For just under half the banks in our sample, this variable is zero.

Table 2 defines the variables used in our base specification (Base Model) as well as the expected association with our dependent variable, the total risk-based capital ratio. Table 3 provides descriptive statistics for the key bank variables used in our regression analysis. As the table shows, there is considerable variation between firms and within firms over time. In all cases, the standard deviation is larger between than within, demonstrating the considerable diversity between firms.

**Table 2: Description of variables used in empirical estimation**

Variable	Description	Expected Sign
CAP	Risk-based capital ratio	
LCAP	Lagged risk-based capital ratio	+
RISK	Ratio of risk weighted assets to the sum of total assets and notional off-balance sheet assets	+/-
LRISK	Lagged RISK	+
PROVISIONS	Ratio of provisions to balance sheet assets	+
ROE	Return on equity	+/-
SIZE	Share of aggregate banking assets	-
TIER1	Proportion of qualifying regulatory capital (before deductions) consisting of Tier 1 capital	+/-
TRIGGER	Individual Capital Requirement set by the FSA	+
MARKET	Ratio of Subordinated Debt to Total Liabilities	+
GDP	Growth in real UK GDP	+/-

<sup>25</sup> As a robustness check, we also ran the main model using the log of total assets as the measure of banks size, as is customary. Although most of the coefficients were similar in this model, we have reservations about using a nominally specified variable over a long time period, since changes may be driven by prices or economic growth as well as relative bank size.

<sup>26</sup> As an extension of this analysis, we plan to use the spread on subordinated debt as a proxy of market discipline.

**Table 3: Descriptive statistics for bank-level regression variables, 1998q4-2006q4**

Variable	Mean	Standard deviation		
		Overall	Between	Within
CAP	25.4	18.4	17.6	7.4
RISK	45.1	21.0	20.2	7.8
PROVISIONS	1.4	5.1	4.6	2.6
SIZE	0.4	1.3	1.2	0.3
TIER1	81.0	16.4	15.1	7.0
ROE	5.5	10.3	7.8	7.8
MARKET	1.3	1.9	1.7	0.9
TRIGGER	12.5	3.6	3.4	1.4
Number of observations	4505			
Number of banks	168			

Source: FSA Banking Supervision Database

#### 4.3. Estimated equation

The estimated version of our base model includes these variables and is therefore:

$$CAP_{i,t} = \beta_0 + \beta_1 LCAP_{i,t} + \beta_2 ROE_{i,t} + \beta_3 RISK_{i,t} + \beta_4 LRISK_{i,t} + \beta_5 PROVISIONS_{i,t} + \beta_6 SIZE_{i,t} \\ + \beta_7 TIER1_{i,t} + \beta_8 TRIGGER_{i,t} + \beta_9 MARKET_{i,t} + \beta_{10} GDP_t + \varepsilon_{i,t}, \quad (4)$$

where  $\varepsilon$  is a potentially serially correlated and heteroscedastic disturbance term. Except for LCAP and LRISK, all of the variables are contemporaneous. This implies that we model the bank's choice of risk-based capital ratio as a function of capital ratios one quarter prior and current attributes. All of the variables defined in (4) are defined in levels. As is common with panel data analysis, (4) can be transformed into first differences to obtain unbiased estimates. We describe our estimation framework in more depth below.

#### 4.4. Sample description and data sources

We compiled two unbalanced panel datasets containing quarterly bank-specific and macroeconomic information. The first panel, which we use for our main analysis, includes 168 banks and spans the period 1998 (fourth quarter) to 2006 (fourth quarter). It contains information on UK (solo-level) banks' risk-based capital ratios, individual capital requirements and other bank-specific and macro-economic variables. The second panel encompasses 147 banks covering the earlier timeframe 1990 (first quarter) to 1995 (fourth quarter) and, with the exception of individual capital requirements, includes similar banking and macroeconomic data.

Data observations are quarterly, resulting in, on average, 27 observations per bank in the first panel and 20 in the second. As is usual with panel studies using accounting data, we removed extreme outlier observations where these were due to reporting errors or extreme events such as takeovers, mergers

or new entrants, or where it was clear that they were not operating a banking business model (identified through discussion with supervisors or comparisons with previous reports or ancillary schedules).<sup>27</sup>

Banking data come primarily from the regulatory returns submitted to the Bank of England by all UK banks on a quarterly basis. These returns include details on banks' assets and liabilities, profits, and capital adequacy. For some large institutions, we supplemented profit and loss data with information from annual reports deposited at Companies House. The returns extend as far back as 1989, but only include firms' individual capital requirements (i.e., those assigned directly by the FSA and Bank of England as legacy supervisor) from 1998 onwards. In addition, a change in reporting requirements in 1996 means that data for that year are unreliable. For these reasons, our empirical analysis employs two distinct estimation periods: one spanning September 1998 to December 2006 for our main analysis and another spanning January 1990 to December 1995 for our supplementary analysis. We obtained data on UK real GDP growth from Thomson Datastream. The OECD's Economic Outlook provided our source of data on the UK GDP gap (deviation of actual GDP from potential GDP as a percentage of potential GDP).

#### **4.5. Estimation framework and discussion of methodology**

We estimate this relationship using three different methodologies. First, we present random effects specifications, to serve as a simple benchmark of other results.<sup>28</sup> We then use two variants of the Generalised Method of Moments (GMM) estimator for dynamic panel data introduced by Arellano and Bond (1991) and developed further in Blundell and Bond (1998).

The GMM method is preferable to a simple random effects specification in many cases, since it overcomes estimation problems associated with the use of lagged dependent variables, namely that lagged dependent variables are correlated with the disturbance term, raising issues about the consistency of coefficient estimates. This method has the added advantage of allowing us to model various bank specific variables as endogenously determined, and in our GMM specifications below we model risk as endogenously determined. The original Arellano-Bond estimator, often known as the 'difference GMM' estimator, uses lags  $t-1$  and deeper of levels of the dependent variable and endogenous variables as instruments for the equation in first differences.

Blundell and Bond address the problem that persistency in instrumented variables leads to weak instruments, which can result in downward-biased estimates of the parameters and a loss in asymptotic efficiency. They develop the 'system GMM' estimator which incorporates lagged differences as instruments for the equation in levels, as well as the original Arellano-Bond instruments. This estimator can yield substantial improvements in efficiency. Since we observe substantial persistency in the primary variables in our analysis,<sup>29</sup> we report additional results using the system GMM method.

One issue which can arise when using the GMM estimators is that a large number of instruments can lead to biased estimates of the coefficients on endogenous variables and an invalid Hansen test statistic (producing a p-value which is unrealistically close to 1). It can also result in the covariance matrix of the moments being singular, so that we are unable to compute the optimal weighting matrix

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<sup>27</sup> Extreme and missing values contributed to large movements in reported capital ratios and model variables in the first panel. Of the total 5341 observations available to us, we dropped 1077 due to reasons cited above, leaving us with 4264 observations in our main estimation dataset.

<sup>28</sup> The choice of random-effects rather than fixed-effects specification was made after consulting Breusch-Pagan and Hausman tests.

<sup>29</sup> We confirmed this by using OLS and fixed effects panel regressions to estimate a range of the coefficients on lagged levels, following Bond (2002). These regressions are not included here but are available upon request.

for the two-step GMM procedure (see Roodman (2007) for a discussion of this issue). This is a particular problem for our analysis since the number of instruments is quadratic in the number of time periods, and we have a relatively large number of time periods (36). Consequently, in the regression below we collapse the instrument matrix so that there are no longer unique instruments for each time period. We follow the advice given by Roodman (2007) and report the instrument count, as well as Hansen test statistics.

We also address the problem that using the relatively efficient two-step GMM procedure produces estimates of standard errors which are severely downward biased in finite samples (Arellano and Bond (1991)). To benefit from the increased efficiency of this procedure, we apply the correction to the standard errors proposed by Windmeijer (2005). We use the orthogonal deviations transform which makes optimal use of the sample in unbalanced panels (Arellano and Bover (1995)). Finally, we incorporate time dummies in GMM specifications, to address the issue of contemporaneous correlation among groups, which can affect the diagnostic tests and robust estimates of the standard errors (Roodman (2006)).

As described in more depth below, we address these questions by regressing risk-based capital on several explanatory variables. Among others, these include individual bank trigger ratios, a proxy for capital quality and annualized GDP growth. Although we have done our best to address these questions with the data available to us, there are a number of caveats to note. First, analysing the behavioural impacts of capital requirements empirically is challenging, because differences in capital requirements between firms and over time may reflect information also available to the market. Although FSA-determined individual capital ratios are not disclosed to the market and are therefore private information for the regulator and the firm, it is possible that the changes in capital requirements reflect underlying changes in the firm which are also observed by the market. The incremental impact of capital requirements is made even more difficult to measure in light of the influential role that rating agencies (which are party to much of the same information as regulators) play in affecting banks' funding costs (and general market perceptions). It is likely, therefore, that a bank which is close to its regulatory requirements will be under pressure from sources other than the regulator and that such effect may outweigh the capital requirements in influencing banks' choice of how to respond to changing regulation. We address this possibility by controlling for the impact of market discipline by explicitly including a measure of market discipline (i.e., the extent to which banks use subordinated debt to fund their business). We explore the interaction between capital requirements and market discipline to find out if banks that are more exposed to market discipline respond differently to changes in capital requirements.

The second caveat is that our main analysis of the determinants of capital ratios excludes bank behaviours over a full economic cycle. In particular, our estimation period covers a relatively benign economic period, 1998-2006, making it difficult to draw definitive conclusions about whether and how banks behave during more trying conditions. We address this issue by presenting a second set of results which use a dataset from 1990-1995, a period including a sharp recession and a subsequent recovery. However, as noted earlier the models estimated for this period do not include individual capital requirements, since that information is unavailable for this earlier period. Despite this shortcoming, we are able to estimate a model for the period which gives us an interesting additional insight into the relationship between risk-based capital requirements and economic conditions during more unfavourable business cycle conditions.<sup>30</sup>

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<sup>30</sup> We also estimated the later period, 1998-2006, excluding the trigger ratio as an explanatory variable. This step facilitates a better comparison of results from these two periods.



Our final caveat is that our analysis covers only periods prior to the advent of Basel II and the recent upheaval in financial markets. The usefulness of these results is dependent on the assumption that what was true in the past will be true also in the future, at least in terms of the broad relationships between our key variables. In addition, since Basel II moves bank capital regulation further down the path of being sensitive to risk at the firm level, our results may be a useful precursor to analysis of the effects of the new regime, since they indicate how capital levels have been determined under a less risk-sensitive regime.

## **5. Empirical results**

### **5.1. Main results**

In Table 4 below we present the main results for solo banks over the period 1998-2006. These results confirm that capital requirements (TRIGGER) are strongly associated with capital ratios. The relationship is significant at the 1% level in the random effects and system GMM specifications, suggesting (on the basis of the system GMM coefficient) that a 100 basis point increase in capital requirements is associated with a 27 basis point increase in the capital adequacy ratio.<sup>31</sup> The significantly positive association is consistent with previous findings on the effect of regulatory capital requirements (see, for example, Alfon et al. (2004) and Wong et al. (2005)). This result also suggests that banks, on average, react to changing capital requirements by altering actual risk-based capital ratios in the same direction. The relationship is not significant in the difference GMM specification, which could be due to a loss of firm-specific information in the first differencing process.

GDP is negatively related to capital ratios in all three specifications. This relationship is statistically and economically significant in both GMM specifications but only at the 10% level. It is consistent with the findings of previous studies examining the cyclicity of banks' capital management practices in other countries and with policymakers' concerns about short-sightedness in firms' capital management practices, as discussed above.

The quality of capital variable (TIER1) is positively related to capital ratios and statistically significant in all three specifications. This finding is consistent with expectations and suggests that banks that rely to a greater extent on higher-quality (and ostensibly higher-costing) tier 1 capital tend to maintain higher total risk-based capital ratios (everything else constant). It is consistent with the idea that such banks find it more costly to raise capital, and, therefore, to reduce the expected cost of raising new capital, they maintain higher capital. This result may be attributable, in part, to our sample, which includes a large number of small banks with high total capital ratios. Because these banks face constraints in raising lower-quality, tier 2 capital (e.g., subordinated debt), they find it relatively more expensive to raise qualifying regulatory capital in general. These hurdles provide added incentives to maintain higher capital ratios (i.e., as a measure to reduce expected costs of raising additional capital).

When focusing on large banks only (as reported in section 5.2.1 below), however, we also find a positive, although less pronounced, association between total risk-based capital ratios and the proportion of higher-quality capital. This finding is not surprising given that these banks (at least during the period of our study) faced fewer constraints in raising lower-quality (and lower-costing) capital, thereby reducing the marginal benefits (i.e., reduction in expected costs of raising equity capital) of holding higher total risk-based capital ratios. Nevertheless, the positive association between capital ratios and capital quality suggests that the (relatively higher) cost of raising higher-quality capital

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<sup>31</sup> The elasticity is calculated using the capital ratio and trigger evaluated at their sample means.

provides an incentive for larger banks to hold higher capital ratios overall. This finding has implications for evaluating the role of regulatory limits within the definition of capital. Such limits, to the extent that they constrain large banks' use of lower quality capital in meeting regulatory requirements, may actually strengthen incentives for these institutions to effect higher capital ratios (as a way to avoid costly issuance of higher quality capital in general).

The other variables in our base model generally have their expected signs. The contemporaneous (RISK) and lagged (LRISK) measures of risk are statistically significant and negatively and positively associated with capital ratios, respectively. This finding is consistent with the conjecture that banks respond to increases in risk (as proxied by growth in risk-weighted assets) with a lag. No other lags on the RISK variable were found significant in our analysis, further suggesting that, at least under Basel I, UK banks' capital management was relatively responsive to changes in their risk profiles, with capital levels altered within a quarter of the shift in risk.

Our measure of banks' own perceptions of their risk, PROVISIONS, is positively associated with the capital ratio and highly significant at the 1% level. This result is inconsistent with moral hazard behaviour and suggests that banks hold higher capital ratios when they perceive their asset portfolio to be more risky. The positive association may be due to market disciplining effects as banks attempt to mitigate the impact of market reactions (e.g., on their funding costs or access to capital market activities) to unfavourable signals about asset quality.

The size of a bank (SIZE) is highly significant and negative in all three specifications, suggesting that large banks experience economies of scale or are better able to diversify risks. This finding is also consistent with the notion of moral hazard at larger banks. That is, larger banks hold lower capital ratios in the expectation that in the event of difficulties, they will be bailed out. Alternatively, the negative association may reflect the make-up of our sample, which is dominated by a lot of relatively small banks with higher capital ratios.

Interestingly, the extent to which a bank is exposed to market discipline has a significant impact on banks' capital management practices. The coefficient on our proxy for market discipline, MARKET, is positive and statistically significant in all three specifications. This finding suggests that market forces, through their ability to affect banks' funding costs for example, provide banks with incentives to hold higher capital ratios (e.g., to signal financial soundness and dampen adverse affects on funding costs or capital markets activities).

The opportunity cost of capital captured by the return on equity (ROE) is negative in all specifications. This relationship, however, is only statistically significant in the random effects specification, which raises doubt about this factor in explaining capital ratios. Also raising doubt about the role of this variable in affecting banks' choice of risk-based capital ratios is the fact that in all three specifications the coefficients are economically insignificant.

The cost of adjusting capital, captured by the lagged capital ratio, is positive and significant in both GMM specifications.<sup>32</sup> This finding is in line with the idea that the costs of adjusting capital are an important explanation of why banks hold high capital ratios. Banks attempt to minimize these costly adjustments by holding higher capital, hence the higher capital ratios. We also recognize that the positive association between capital ratios and the TIER1 variable, which proxies for capital quality, may also reflect the affect of such adjustment costs.

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<sup>32</sup> This variable is excluded from the random effects model because it raises estimation issues.

**Table 4: Determinants of capital ratios, UK solo banks, 1998q4-2006q4**

	(1) Random effects	(2) Difference GMM	(3) System GMM
L. CAP		0.69 (0.09)***	0.71 (0.06)***
RISK	-0.21 (0.03)***	-0.74 (0.24)***	-0.77 (0.27)***
L. RISK	0.02 (0.03)	0.41 (0.19)**	0.45 (0.18)**
PROVISIONS	0.32 (0.04)***	0.01 (0.06)	0.22 (0.08)***
GDP	-0.09 (0.15)	-5.16 (2.74)*	-5.38 (2.79)*
SIZE	-0.81 (0.31)***	-0.6 (0.31)*	-0.9 (0.44)**
TIER1	0.21 (0.02)***	0.06 (0.03)*	0.12 (0.04)***
ROE	-0.03 (0.01)**	-0.01 (0.02)	0.00 (0.03)
MARKET	2.16 (0.14)***	1.45 (0.52)***	1.22 (0.42)***
TRIGGER	0.89 (0.09)***	0.05 (0.16)	0.55 (0.18)***
Constant	3.87 (2.20)*		19.74 (9.73)**
Observations	4264	4096	4264
Number of groups	168	167	168
Number of instruments		67	70
Arellano-Bond test for AR(1) in first differences (p-value)		0.00	0.00
Arellano-Bond test for AR(2) in first differences (p-value)		0.42	0.37
Hansen test of overidentifying restrictions (p-value)		0.42	0.34
Standard errors in parentheses			
* significant at 10%; ** significant at 5%; *** significant at 1%			
Instruments are exogenous variables plus RISK and CAP at lags 2 to 16			
Time dummies included but not reported			

## **5.2. Bank-feature and economic-condition results**

This section reports further versions of our baseline model that examine whether and how banks' responses to capital requirements differ according to characteristics of the bank or condition of the economy. In Table 5, we examine in more depth the relationship between capital requirements and capital ratios based on sub-samples of the dataset and interaction terms in the system GMM model to analyse whether the relationship is different for large banks (Model 4), for banks with low buffers over capital requirements (Model 5), across different economic conditions (Model 6), and for banks with different exposure to market discipline (Model 7). For comparison, Table 5 reports again the results of our base model (Model 3).

### **5.2.1. Bank Size**

To address the question of whether large banks respond differently to capital requirements compared with small banks, in Model 4 we restrict the sample to large banks (defined as those with greater than 0.1% of a measure of aggregate banking industry assets<sup>33</sup> on average across the reporting period, roughly a third of the sample). The coefficient on the trigger ratio for large banks remains highly significant and is substantially higher than the overall coefficient we found in the main model. Taking into account the difference in mean capital ratios and capital requirements for the two different samples, we calculate that a 100 basis points increase in capital requirements is associated with a 66 basis points increase in capital ratios for large banks, compared to a 27 basis points increase for the whole sample. This result suggests that large banks respond more strongly to capital requirements than small banks. The finding can be explained by the fact that these institutions generally hold lower buffers and, therefore, find the marginal benefits of raising capital ratios (i.e., reduction in the likelihood of breaching regulatory thresholds) are greater.

Also worthy of note is the finding that GDP is not significantly related to capital ratios for these banks. Since these banks together account for around 95-97% of total assets within our sample, this suggests that the correlation with GDP growth observed in the base Model 3 may be driven by small banks with little systemic importance. Importantly, this finding is not consistent with the idea that large banks' capital management practices are short-sighted and, therefore, procyclical. Since these institutions supply the bulk of the credit feeding the UK economy, this finding may dampen concerns that banks' capital management practices may deepen or prolong business cycles.

There are, however, a couple of reasons that make this interpretation less than definitive. First, the estimation was for a period that excluded a full economic cycle, thus making it difficult to draw conclusions about large banks' capital management practices over a full business cycle. We explore this issue below in more depth by using a set of data drawn from a period that includes a notable economic downturn. Second, the accounting and regulatory capital treatment of securitization activities, which grew dramatically during the period of our study, may, in part, explain the lack of association. Because the lending underlying much of the securitization activity during that period did not remain on balance sheet and garnered very little or no capital charge, capital ratios may have been artificially inflated -- especially during the heart of the recent boom. Had the underlying assets been on balance sheet and a corresponding capital charge levied, our results may have been different.<sup>34</sup>

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<sup>33</sup> We use Bank of England data on UK resident banks' total assets. We do this to identify assets at the highest level of consolidation over time, a task which is not possible with historical data held by the FSA.

<sup>34</sup> This issue is difficult to assess empirically given the lack of bank-level data on securitization activity available from regulatory returns.

### **5.2.2. Size of capital buffer**

To examine whether the response to regulatory capital requirements varies according to the size of capital buffers, in Model 5 we restrict the sample to banks with low buffers.<sup>35</sup> Approximately half the sample had low buffers. Results for these banks are different from the base model in several notable ways. First, except for the lagged capital ratio and the trigger ratio, no other variables are significant. This may be interpreted as indicating that banks with low buffers simply set capital requirements to equal required levels plus a buffer against a breach, which implies that in the absence of regulation these banks may have set capital ratios below required levels.<sup>36</sup> Calculating elasticities for this group shows that a 100 basis points increase in capital requirements is associated with a 52 basis points increase in capital ratios for banks with low buffers. Relative to the results for the full sample (where the elasticity approximated 33 basis points), this finding suggests that the responsiveness of low buffer banks to changes in capital requirements is more pronounced than banks with higher buffers.

### **5.2.3. Economic conditions**

To evaluate whether and how the state of the economy affects banks' reactions to capital requirements, we interact the trigger with a dummy variable which captures economic conditions (Model 6). The dummy variable UPTURN takes on a value of 1 if the GDP gap is positive and 0 otherwise. Similarly, the dummy variable DOWNTURN takes on a value of 1 if the GDP gap is negative and 0 otherwise. The relationship is slightly stronger in an upturn than in a downturn, although the magnitude is very similar. This suggests that changing capital requirements during an upturn will have a moderately more pronounced effect on capital ratios than during a downturn. Raising requirements during an upturn, for example, results in a slightly higher increase in capital ratios versus that during a downturn. This finding is not unreasonable as banks may generally find it less costly to raise capital during an upturn, so that maintaining targeted capital buffers or ratios may also be less costly to effect.

### **5.2.4. Market discipline**

Finally, we examine whether the relationship between capital requirements and capital ratios varies according to the degree of market discipline to which a bank is exposed (Model 7). We do this by including an interaction term calculated as the product of the trigger ratio (TRIGGER) and our market discipline variable (MARKET). This interaction term is negatively related to capital ratios, suggesting that the relationship between capital requirements and capital ratios is less pronounced (although still positive and economically and statistically significant) for banks exposed to market discipline. This finding is consistent with the hypothesis that banks that are more exposed to market discipline have a greater incentive to modify capital ratios in response to the market's review and perception of their overall risk profile. If banks did not, this could impact external credit ratings, having detrimental knock on effects, for example, on their funding costs or access to certain capital markets activities. For these banks, then, it is likely that a change in risk will be reflected in capital levels more quickly and to a greater extent than in banks less exposed to market discipline. Since regulatory capital requirements are reviewed only every 18-36 months, one explanation for the difference in response rates is that banks exposed to market discipline adjust their capital ratios more frequently over time due to more continuous market pressures.

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<sup>35</sup> These banks had average buffers over our sample period of less than 50 percent, where the buffer percentage was calculated as  $100 \times ((CAP/TRIGGER) - 1)$ .

<sup>36</sup> This argument is supported by the results for high buffer firms (not reported) which show coefficients with similar magnitude and significance as in the main model.

**Table 5: Determinants of capital ratios, UK solo banks, 1998q4-2006q4**

	(3) Base model	(4) Large firms only	(5) Low buffer firms only	(6) Economic conditions	(7) Market discipline
L. CAP	0.71 (0.06)***	0.64 (0.13)***	0.54 (0.07)***	0.70 (0.06)***	0.70 (0.06)***
RISK	-0.77 (0.27)***	-0.48 (0.25)**	0.05 (0.05)	-0.77 (0.27)***	-0.72 (0.27)***
L. RISK	0.45 (0.18)**	0.31 (0.19)	-0.03 (0.04)	0.45 (0.18)**	0.41 (0.17)**
PROVISIONS	0.22 (0.08)***	0.21 (0.11)*	0.03 (0.02)	0.23 (0.08)***	0.20 (0.08)***
GDP	-5.38 (2.79)*	-0.05 (2.32)	0.47 (0.92)	-5.4 (2.80)*	-5.22 (2.72)*
SIZE	-0.90 (0.44)**		0.06 (0.05)	-0.91 (0.44)**	-0.89 (0.46)*
TIER1	0.12 (0.04)***	0.07 (0.04)*	0.00 (0.01)	0.12 (0.04)***	0.11 (0.04)***
ROE	0.00 (0.03)	-0.04 (0.03)	0.00 (0.01)	0.00 (0.03)	0.00 (0.02)
MARKET	1.22 (0.42)***	1.27 (0.77)*	0.04 (0.07)	1.23 (0.42)***	2.97 (1.12)***
TRIGGER	0.55 (0.18)***	1.08 (0.50)**	0.67 (0.10)***		0.77 (0.22)***
TRIGGERupturn				0.57 (0.18)***	
TRIGGERdownturn				0.54 (0.19)***	
TRIGGERxMARKET					-0.14 (0.06)**
Constant	19.74 (9.73)**	-4.95 (7.76)	-3.21 (3.09)	19.92 (9.75)**	16.41 (9.35)*
Observations	4264	1433	2203	4264	4264
Number of groups	168	53	81	168	168
Number of instruments	70	53	60	71	71
Arellano-Bond test for AR(1) in first differences (p-value)	0.00	0.03	0.00	0.00	0.00
Arellano-Bond test for AR(2) in first differences (p-value)	0.37	0.89	0.12	0.36	0.44
Hansen test of overidentifying restrictions (p-value)	0.34	0.20	0.48	0.33	0.33

Standard errors in parentheses

\* significant at 10%; \*\* significant at 5%; \*\*\* significant at 1%

Instruments are exogenous variables plus RISK and CAP at lags 2 to 15, except in regression (4) where 7 are used, and (5) where 10 are used.

Time dummies included but not reported

### 5.3. Economic downturn results

Finally, in Table 6 we present the results using our earlier dataset, which covers the period from 1990 (first quarter) to 1995 (fourth quarter) and includes a notable recessionary period in the UK. As mentioned earlier, this dataset excludes the trigger ratio since this variable was only available in later years. Perhaps because of this exclusion (or possibly due to inconsistent reporting in the earlier Basel I reporting system), the models do not perform so well as those we apply to later periods.<sup>37</sup> Most of the variables have the same sign as those based on the later dataset, although they often lack statistical significance. In addition, the Arellano-Bond test for second order autocorrelation in errors indicates that the key assumption involving the GMM instruments (i.e. no auto-correlation of this sort) may not be justified.

Despite these limitations, we regard this analysis as useful because, unlike the analysis above, it uses data from a period in which there were sharp movements in GDP, including a recession and a subsequent recovery. We might expect the relationship between capital ratios and GDP to be more pronounced during a period of large changes in economic conditions. However, in our analysis of this period, the GDP variable is *positively* associated with capital ratios, but only statistically significant (at the 1% level) in the random effects specification. During that time period, UK bank capital ratios, on average, increased as real economic activity improved and fell as it worsened. This finding contrasts with the negative (but only moderately statistically significant) relationship observed in the more benign 1998-2006 period. It also echoes our analysis of aggregate industry figures reported in section 2.2 above, which found that capital ratios appeared to move in concert with GDP growth during the early 1990s and, therefore, that UK banks' capital management practices did not exhibit procyclical traits.

The positive association for this earlier period may be explained, in part, by the introduction of Basel I. Previous studies found that the implementation of Basel I was associated with increases in the capitalisation of banks around the world (see Jackson et al. (1999)) and coincided with an economic recovery in the UK from 1991 to 1994. One interpretation of this finding is that regulatory pressure can bring about increases in capital levels in banks despite the countervailing influence of the economic cycle.

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<sup>37</sup> To get a handle on how much of the difference is due to the omission of the trigger, we estimated the base model (Model 3) without the trigger. The results (not reported here) were similar to those for the base model and, therefore, suggest that the omission of the trigger is not driving the results for the earlier period.

**Table 6: Determinants of capital ratios, UK solo banks, 1990q1-1995q4**

	(1) Random effects	(2) Difference GMM	(3) System GMM
L. CAP		0.45 (0.09)***	0.67 (0.07)***
RISK	-0.16 (0.02)***	-0.06 (0.14)	-0.31 (0.18)*
L. RISK	-0.04 (0.02)	-0.06 (0.09)	0.08 (0.09)
PROVISIONS	-0.03 (0.03)	0.07 (0.42)	0.28 (0.11)**
GDP	0.37 (0.07)***	1.62 (1.66)	0.92 (0.94)
SIZE	-6.36 (1.06)***	-4.83 (2.51)*	-1.96 (0.87)**
TIER1	0.06 (0.02)***	-0.05 (0.04)	0.17 (0.06)***
ROE	-0.01 (0.01)	-0.2 (0.13)	0.01 (0.02)
MARKET	0.41 (0.11)***	0.03 (0.28)	0.94 (0.31)***
Constant	33.16 (2.26)***		1.19 (5.91)
Observations	2953	2797	2944
Number of groups	147	147	147
Number of instruments		69	74
Arellano-Bond test for AR(1) in first differences (p-value)		0.00	0.00
Arellano-Bond test for AR(2) in first differences (p-value)		0.40	0.09
Hansen test of overidentifying restrictions (p-value)		0.27	0.225

Standard errors in parentheses

\* significant at 10%; \*\* significant at 5%; \*\*\* significant at 1%

Instruments are exogenous variables plus RISK and CAP at lags 2 and deeper

Time dummies included but not reported

## 6. Considerations for Policymaking and Future Research

Our main results indicate that banks increase (decrease) risk-based capital ratios in response to higher (lower) capital requirements. From a policy point of view, this result shows the likely marginal impact of changes to capital requirements introduced by supervisors, suggesting that this is a potentially valid tool for supervision where the objective is to raise firms' solvency levels. It also implies that even if they hold excess capital above regulatory minimums, banks face capital compliance costs when faced with higher capital requirements as they attempt to manage the buffers in response.



It is important to note, however, that banks may, in this situation, elect to change not only the numerator (i.e., capital), but also the denominator (i.e., risk-weighted assets) in response to changes in capital requirements. These options have important implications for the macro economy more broadly, especially if banks focus on changing their asset portfolios, inducing a change in the volume and risk composition of assets. This alternative may result in a withdrawal of credit as banks seek to reduce their lending, which implies that changes in capital requirements may have important macroeconomic consequences. More research on the impact of capital requirements on bank lending is needed.

We find some evidence of a negative relationship between capital ratios and the economic cycle over recent years, consistent with previous literature. The results are of relevance in the context of the proposals for policy intervention to counteract the potential procyclicality of capital requirements under Basel II, such as dynamic provisioning. At the same time, however, we did not find evidence that capital management practices were procyclical during 1990-1995, a period characterized by more pronounced swings in economic conditions. Moreover, when looking only at large banks, we did not find evidence to support the idea that these banks are short-sighted in their capital management practices. There are, however, important aspects of the recent banking boom, most notably securitization activity and the underlying accounting and regulatory capital treatments, that may have contributed to this finding and that warrant further work before definitive conclusions can be drawn. In addition, the extent to which this behaviour may have been due to regulation, e.g., the possibly less procyclical nature of the Basel I regime or perhaps the FSA's long-standing approach to imposing (Pillar 2-style) capital add-ons, will be important to assess as part of any future work evaluating the need for specific measures to deal with procyclicality going forward.

## **7. Conclusions**

This paper focuses on examining the relationship between UK bank risk-based capital ratios and individual capital requirements set by the FSA (and Bank of England as legacy supervisor). The need to account for a number of other variables that explain the determinants of bank capitalization in prior studies makes this paper useful for understanding the drivers of capital ratios in the UK more generally. We also take the opportunity to incorporate other variables not included in previous studies but useful for examining policymakers' recent interests in procyclicality and the definition of regulatory capital.

We build an unbalanced panel of 168 banks using quarterly data from regulatory returns and public financial statements between 1998 and 2006, supplemented with macroeconomic data for this period. Controlling for a variety of determinants of capital ratios (suggested by the literature), we analyze the remaining impact of the FSA's individual capital requirements. We also use this analysis to tease out the potential impacts of variables capturing the business cycle and capital quality. Understanding the impact of each of these factors on banks' capital management practices is of interest to recent policy debates about procyclicality and the definition of regulatory capital.

We find a significant positive association between the risk-based capital ratios and capital requirements, suggesting that UK banks increase (decrease) ratios in response to higher (lower) capital requirements. This association appears to be more pronounced at larger banks, banks with lower capital cushions and banks that are less exposed to market discipline. In addition, this relationship is a bit stronger during more favourable economic conditions and indicates that, on average, banks raise capital ratios more in response to higher capital requirements in this climate. This finding is not surprising given that it may be easier (less costly) to raise capital and adjust balance sheet makeup during such conditions.

Also in respect to economic conditions, we find a negative association between capital ratios and the rate of GDP growth for all banks in the UK. This finding complements those of previous researchers examining the relationship between bank capitalization and the business cycle (Ayuso et al. (2004); Lindquist (2004); Stolz and Wedow (2005); Jokipii and Milne (2008) for banks in Spain, Norway, Germany and Europe, respectively). The negative co-movement lends some further credence to policymakers' concerns about procyclicality and some evidence supporting regulatory intervention.

This evidence on procyclical bank practices, however, is far from clear for a couple of reasons. First, when looking only at large banks, we find no statistical association between risk-based capital ratios and economic conditions. This finding is not consistent with the idea that these banks are short-sighted in their capital management practices or that large bank capital management practices may accentuate economic cycles. Second, our results were obtained for a period (1998-2006), which excludes a significant economic downturn in the UK. This exclusion makes it challenging to draw definitive conclusions about capital management practices during more trying economic times. As a step towards addressing that issue, we extended our analysis to a period in the early 1990's that included a notable economic recession and found a positive (although statistically insignificant in the more robust GMM specifications) association between bank capitalization and GDP growth. While some of this countercyclical behaviour can be attributed to the introduction of Basel I during this period (see Jackson et al. (1999)), the result nevertheless suggests that further work in this area is warranted.

On the issue of capital quality, we find a significant positive association between total risk-based capital ratios and the proportion of tier 1 regulatory capital. This finding suggests that banks that rely to a greater extent on higher-quality, tier 1 capital tend to maintain higher total risk-based capital ratios on average. Since this type of capital is generally more costly, this finding is not necessarily surprising as optimizing banks, in their capital management practices, consider the relatively higher adjustment costs associated with this type of capital. The implication here is that by requiring banks to maintain a higher proportion of better quality (tier 1) capital, this mandate may also raise the profile of capital adjustment costs in banks' capital management practices and, therefore, the motivation for cost-minimizing banks to maintain higher risk-based capital ratios overall.

We also find a significant positive association between banks' capital ratios and exposures to market discipline. In particular, our results indicate that capital ratios at banks that rely on subordinated debt to support their business tend to maintain higher capital ratios (everything else constant). We interpret this result as suggesting that banks mitigate expected market reactions (e.g., on their funding costs or access to certain capital markets activities) to their business activities by holding higher capital ratios. It is interesting to note also that we find that the response to changing capital requirements is moderately less pronounced at banks exposed to this type of market discipline. This finding provides further evidence that market forces play important roles in UK banks' capital management practices and supports ongoing efforts to improve and harness market discipline (e.g., in the Pillar 3 process under Basel II) in bank supervision.

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