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Optimal regulation of bank capital and liquidity: how to calibrate new international standards[1]

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Abstract

Raising capital adequacy standards and introducing binding liquidity requirements can have beneficial effects if they reduce the probability of a costly financial crisis, but may also reduce GDP by raising borrowing costs for households and companies. In this paper, we estimate both benefits and costs of raising capital and liquidity, with the benefits being in terms of reduction in the probability of banking crises, while the costs are defined in terms of the economic impact of higher spreads for bank customers. We note that both of these results are contrary to the Modigliani-Miller theorem of irrelevance of the debt-equity choice. The result shows a positive net benefit from regulatory tightening, for a range of 2-6 percentage points increase in capital and liquidity ratios, depending on underlying assumptions.

Executive summary

There is a trade off between using tighter banking regulation to reap the benefits from reducing the incidence of costly financial crises, and the cost imposed by higher regulatory requirements on households and companies via wider bank spreads. The balance between these costs and benefits can be evaluated using data and our understanding of the economy. This study uses NIESR's global macro model NiGEM, with a new sub-model of the UK banking sector, to estimate the net benefit for the UK economy of tightening bank regulation in respect of capital and liquidity ratios. The key findings include:

- Benefits are in terms of reducing the risk of the long run scarring of the economy due to higher risk premia after a crisis, which arises in turn from a lower probability of a banking crisis.
    - We find that a rise in the capital adequacy ratio or a rise in the liquidity ratio significantly reduces the probability of a banking crisis. These changes would have been particularly effective in the UK in the run up to the crisis experienced in 2007 and 2008;
    - House price booms increase the probability of a banking crisis as they are often associated with unsound, albeit secured, lending;
    - We estimate that a 1 point rise in the capital adequacy target would have reduced the probability of a crisis in the UK in 2007 and 2008 by five to six percent.
- If house prices are rising rapidly, it may be prudent to increase capital adequacy and liquidity requirements, to offset the increased risk of a banking crisis.
    - The benefits of tighter regulation depend on the costs of banking crises and these may be very large, cumulating to as much as 80 per cent of GDP;
    - The costs of crises include the recessions that follow and any long run impact on sustainable output. They also include welfare losses from greater economic uncertainty.

- On the other hand, a rise in risk-adjusted capital adequacy or liquidity requirements is a cost to banks, and to offset this cost banks will increase lending margins. Higher firm borrowing costs raise the user cost of capital and have a negative long-run effect on output; higher household borrowing costs affect consumption and welfare but do not affect output in the longer term:
  - We estimate that a 1 percentage point rise in the capital adequacy target reduces output by at most 0.08 per cent in the long-run. The negative effects of a change in regulation tightening capital adequacy in early 2007 would have come through very slowly whilst the benefits may have been immediate;
  - US-based evidence suggests that a rise in the liquid asset ratio target of 1 percentage point reduces output by at most 0.03 per cent in the long-run. The regulatory regime in the UK in the last two decades means it is difficult to identify liquidity effects here;
  - Large changes in capital adequacy will induce substitution between types of borrowing by firms and increase equity issues. This could halve the cost to the economy of increased capital adequacy requirements, but it would also imply additional reductions in the benefits.
- The results show a positive net benefit from regulatory tightening, for a 2-6 percentage point increase in capital and liquidity ratios, depending on the underlying assumptions.
- Banks only exist because asset holders are not indifferent to whether an individual firm issues bonds or equity, and there are limits to the applicability of the Modigliani-Miller theorem to their activities.

Contents

1. Introduction

In the aftermath of the financial crisis that developed between August 2007 and winter 2008, there has been a great deal of discussion regarding the need for changes in the regulation of the financial services sector. This paper investigates the benefits and costs of such changes in regulation. We first survey the literature on the behaviour of banks, focusing in particular on responses to changes in regulatory capital and liquidity targets. We then discuss the impacts of such targets on the probability of a banking crisis emerging. We use a logit analysis on 14 OECD countries to determine the causes of banking crises, and we show that banking crises are more common when liquidity and capital adequacy standards are lower as well as when an economy has experienced an acceleration in real house price growth in recent years. These results suggest that crises would be less common if regulatory standards were tighter and if macro-prudential regulations (specific system-wide responses) were to be used to restrict the scale of housing market bubbles.

Even if we have estimates of the causes of financial crises, we cannot judge the appropriate actions that might be needed to prevent them without some idea of the benefits of tighter policy, or rather the costs of having a crisis. We investigate the costs of previous crises and those associated with the scarring from the current crisis. The last fifteen years have been a period of low and stable inflation, with output and prices not displaying much volatility. The so called '*Great Moderation*' was a period when risk premia were low and continued to fall as many economic agents thought the world had changed permanently. Low risk premia in investment decisions led to capital deepening and stronger growth for a sustained period. However, it is now recognised that risk was being underpriced and risk premia are being re-evaluated. This would imply that, going forward, sustainable output will be permanently lower than we thought it would have been, because the equilibrium capital stock desired in the future will be lower as risk premia are higher. Estimates from NIESR and from the UK Budget suggest that the permanent scar from the crisis could be as high as 5 percent of GDP, although some of this comes from a re-evaluation of capital gains in the financial sector (see Weale 2009) and from changes to migration projections (see Barrell et al 2009). Overall we would judge that the risk premium related scar, which is relevant to the evaluation of welfare costs, would amount to a permanent loss of 3 percent of GDP.

If the regulatory framework affects the probability of having a crisis, it is useful to investigate the potential effects of changing that framework. We have undertaken an empirical analysis of the factors affecting the costs of borrowing from financial institutions for firms and for consumers in the UK. We also investigate the demand for loans. It is possible that changes in bank lending costs induced by regulatory changes could raise the user cost of capital and hence reduce the equilibrium capital stock and the sustainable level of output. The evidence presented suggests that this is possible, but that the effects are not large.

Given we have discussed the causes of crises and firmly locate them within the scope of regulation, and given we have some estimates of the cost of crises, we can compare the benefits of tighter regulation against an estimate of the costs of such regulation, and we turn to this cost benefit analysis in the last section of the paper.

2. Literature survey

Banks and Regulatory Capital and Liquidity

Although there is an extensive theoretical literature on bank capital, a weakness of many of these works, such as Holmstrom and Tirole (1997) and Diamond and Rajan (2000), is that they typically do not focus on incorporation of bank regulations, focusing rather on aspects such as effects of capital availability on refinancing ability, safety of banks and the ability to extract payment from or liquidate borrowers. These give rise to analyses of the determinants of long run desired capital in the absence of regulation. More conceptually relevant is the range of work on the dynamics of bank capital buffers, which protect banks against the need for recapitalisation or sharp adjustments in lending when capital falls below regulatory norms. As such the buffer provides a cushion against shocks, whether in terms of losses or regulatory changes *per se*. See, for example, Milne and Whalley (2001) and Milne (2004). This forms a background to our own empirical work.

Much of the work we discuss focuses on capital adequacy rather than liquidity determination. There has been little work on the determinants of liquid asset holdings, reflecting in part the lack of interest, until recently at least, on the part of regulators. Given the lack of an international agreement, standards have varied more across countries than with capital adequacy rules, and holdings in some countries, such as the UK, dropped to historically low levels in the run up to the recent crisis.

Studies of UK banks' responses to capital regulation

Key background for our empirical research is Ediz et al (1998), which considered the impact of capital requirements on the behaviour of 94 UK banks between 1989 and 1995. The particular focus was on whether banks reacted to declines in capital that led to banks approaching the trigger ratios[3], and what the impact of higher trigger ratios *per se* is. Scatter plots suggested that there was a pattern of nonlinearity, with banks near the trigger adjusting capital in a manner not present at higher levels of capital adequacy. Regression analysis supports this conclusion while controlling for other variables which might influence capital ratios (such as ratios of fee to net interest income and bank deposits over total deposits). They also found that adjustment in capital ratios is mainly undertaken by capital issues and not adjustment in the balance sheet composition.

Alfon et al (2004), looking at UK banks over 1998-2003 and using GMM estimation, again show that capital adequacy is largely influenced by regulatory requirements as opposed to risk management and market discipline considerations. This is despite the fact that banks typically hold levels of capital well above the regulatory minimum; in fact the buffer absorbs part of a rise in capital requirements, but typically less than half of it in the long run. There is a greater response to increases in capital requirements than to decreases. Responses are again greatest when capital holdings are close to the regulatory minimum. Since large firms tend to hold capital close to the lower limit, regulatory policy will tend to affect larger banks more than smaller ones.

[3] Trigger ratios are the standards set for individual banks by UK regulators in excess of Basel minima, below which banks are subject to intensified regulatory scrutiny.

Similar results to Ediz et al (1998) and Alfon et al (2004) on capital adequacy *per se* were found by Francis and Osborne (2009a), using UK bank data from 1998 to 2006 for 168 banks. The results suggest that there is a statistically significant association between banks' risk-based capital ratios and individual capital requirements set by regulators in the UK. They also find that the rate at which banks respond to changing capital requirements depends significantly on the characteristics of the bank as well as the economic cycle. There is a negative association between capital ratios and the economic cycle in general in their results, but not for the largest banks in the UK. They also find a positive association between capital ratios and capital quality, suggesting that regulation has been effective.

On the second topic addressed by Ediz et al (1998), namely adjustment of balance sheets to capital requirements, Francis and Osborne (2009b) investigated using a 1996-2007 dataset. Estimation used system GMM panel allowing long run coefficients to be derived. Their results show not only an impact of capital requirements on desired capital but also that the distance of bank capital from desired ratios is significantly positively associated with banks' loan supply (suggesting that loan supply falls as actual capital falls below targeted levels). Taken together, these results indicate that capital requirements affect credit supply, confirming the linkage found by previous researchers and demonstrating a 'credit view' channel through which prudential regulation affects economic output. A one percentage point rise in capital adequacy requirements reduces risk weighted assets by 2.4% and total assets by 1.4%, with banks substituting from high risk to low risk assets as well as restraining asset growth overall.

Cross-country and other country studies

Some studies have looked across countries at the determinants of bank capital and its relation to regulation. For example Bikker and Metzemakers (2007) looked at a range of OECD countries and found that the capital buffer (over the regulatory minimum) varies negatively with the cycle (i.e. capital is stable while GDP fluctuates). They found that there is no reaction of capital to rapid loan growth or highly risky portfolios, which suggests poor risk management or moral hazard. Jokipii and Milne (2006) again looked at a range of countries and found differing behaviour across countries, with Eastern European country systems showing a co-movement of buffers with the cycle while in the EU-15 there is a negative link. Also, cooperative and smaller banks tend to have buffers that move with the cycle, while other banks' buffers move negatively with the cycle. Note however that the authors do not have data on possible additional capital requirements over regulatory minima, as applies in the UK for example.

Looking at work on the US, mainly on the capital crunch of the early 1990s, much of it suggests that banks adjusted balance sheets by shifting from riskier assets into government bonds at the time that the Basel capital requirements were introduced, rather than raising capital. A number of papers suggest that they became a binding constraint on banks for whom capital raising was costly or impossible due to the recession, see Hall (1993), Haubrich and Wachtel (1993) and Thakor (1996). On the other hand, Berger and Udell (1994) are more sceptical and attribute the fall in loans and shift to securities during that period more to the demand side and to a shift in risk preferences by banks, independent of capital requirements. Hancock et al (1995) with a VAR approach found a short period of adjustment to capital shocks in the US (a maximum of 3 years). That paper again found a balance sheet response (especially loans) and not just a capital adjustment in response to a capital shock, in contrast to the earlier paper by Hancock and Wilcox (1994), who found banks with capital shortfalls tended to shift away from lower risk assets, responding to the unweighted rather than the weighted capital adequacy standard.

Sharpe (1995) in his survey paper finds that there is only weak evidence of the transmission of shortage of capital to bank lending, although this is partly due to the inherent ambiguity of use of macro data to study credit crunch periods, which cannot readily distinguish supply and demand effects, or those of large and small banks. This problem is overcome by work using micro data such as Kashyap and Stein (2000) who find that smaller banks have a larger loan supply response to shocks. Furfine (2001) developed a structural dynamic model of the banking sector to analyse banks' responses to shifts in the environment and found that a rise in risk based capital could explain falls in loan growth and rises in securities, but not the observed rise in the unweighted capital ratio, which Furfine explained with an increase in regulatory monitoring. Berraspide and Rochelle (2008) find links from shortfalls in bank capital to lending during the early stages of the sub-prime crisis for US banks.

Work by Watanabe (2006) for Japan seeks to assess whether capital shocks, as occurred in the tougher regulation in 1997, leads to reallocation of bank lending between riskier and less risky borrowers. He found that Japanese banks tended to shift lending to higher risk companies rather than low risk ones, because of the risk that the latter would drive high risk firms into default, worsening the capital situation. However, this may have limited applicability for other countries, except possibly in the depths of a prolonged recession.

As regards other countries, Stolz et al (2004) looking at German savings banks, found evidence that the coordination of capital and risk adjustments depends on the amount of capital the bank holds in excess of the regulatory minimum (the so-called capital buffer). Banks with low capital buffers try to rebuild an appropriate capital buffer by raising capital and simultaneously lowering risk. In contrast, banks with high capital buffers try to maintain their capital buffer by increasing risk when capital increases. Banks with large capital buffers over regulatory minima benefit from greater robustness to shocks than those without such buffers. Gambacorta and Mistrulli (2004) show that Italian banks that are well-capitalised can better shield lending from monetary policy shocks, since they have better access to non deposit funding, and the credit supply of well capitalised banks is less pro-cyclical.

Price adjustment

A general shortcoming of the existing literature on impacts of capital adequacy on bank behaviour is its focus on quantities of bank assets and not prices. Arguably, a quantity adjustment requires a price adjustment, so long as the latter includes a shadow price of credit rationing. And of course price adjustments affect both the demand for, and supply of, credit. On the other hand, there remains a sizeable literature on determinants of bank margins and spreads that often includes capital adequacy as a determinant. Typically such work applies the Ho and Saunders (1981) model which sees banks as a risk-averse agent that acts as a dealer in the market for provision of loans and deposits. It typically decomposes bank margins into a regulatory component, a market structure component and a risk premium component.

A key article is Demirguc-Kunt and Huizinga (2000), using data on banks in 80 countries over 1988-1995 who found a positive correlation between capitalisation and interest margins. Berger et al (1995) found similar results for the US, Saunders and Shumacher (2000) in an international sample and Valverde and Fernandez (2007) for Europe. This may relate to capital adequacy requirements since the cost of equity capital is seen by banks as higher than of deposits. However, there are other possible explanations not related directly to regulation. For example, a bank with higher franchise value has incentives to be prudent in lending; also well capitalised banks face lower expected bankruptcy costs that reduce the cost of funding.

A weakness of the work which focuses on the ex post interest rate margin is that it encapsulates not only changes in financing conditions for customers but also changes in balance sheet structure and non performing loans. An alternative, which we use in this work, is to estimate ex ante spreads. Gambacorta (2008) is one of the few papers to have taken this approach to date, finding that the spreads of well capitalised banks respond less to a monetary policy shock than those with lesser capital buffers.

Modigliani-Miller and banks

The Modigliani-Miller (MM) theorem (of Franco Modigliani and Merton Miller) forms the basis for modern thinking on firm capital structure. The basic theorem states that, in the absence of taxes, bankruptcy costs, asymmetric information and agency costs, and in an efficient market, the value of a firm is unaffected by how that firm is financed. So it is irrelevant whether debt or equity is issued.

In general, a perfect MM world would have no need for banks since financing would be direct from households to companies. Abstracting from this, in the specific case of banks, under MM a bank's lending and pricing decisions would be independent of its financial structure. As the bank will always be able to find investors willing to finance any profitable lending opportunities, the level of bank capital is irrelevant to lending and its pricing (Van den Heuvel 2002).

It is self evident that the basic conditions do not apply to banks, even abstracting from capital adequacy regulations. The bankruptcy costs for banks are likely to be particularly high owing to the 'fire sale' problem for loans that cannot be sold for fundamental value owing to asymmetric information, and these fire sale costs will be higher for leveraged banks since bankruptcy itself is more likely. There will also be additional administrative and legal costs of bankruptcy (Berger et al 1995). The expected value of these costs are shared amongst equity holders, and they raise the cost of equity finance. However, as more equity is issued relative to debt the cost of equity comes down. Debt costs are likely to fall as well, as bankruptcy risk should be reduced if there is more equity. Hence an equilibrium between debt and equity costs would emerge, giving the optimal balance between them.

There are also ongoing asymmetries of information between investors and the bank again due to the private information banks use and the resultant opacity of the loan portfolio. The private information produced by banks regarding their loan customers creates an asymmetric information problem for banks vis-à-vis financial markets. Bank managers will generally have more information about their own earnings prospects and financial condition than the capital markets. Because of this opacity, the market will draw inferences about a banks' health from the actions of the bank. Managers may signal information to the market through capital issuance decisions and good banks may show their quality via high capital adequacy.

Furthermore the market for issuing new equity is typically highly constrained, particularly at times of financial tension. Because bank managers have significant private information, shareholders may be reluctant to purchase new equity because it may sell at a discount. Even if there is not direct rationing of equity finance, banks may face higher transactions costs in raising funds by issuing equity, notably relative to raising deposits. Banks may consequently hold a buffer of excess capital to allow for new lending opportunities, or to protect against costly unexpected shocks to capital if the financial distress costs from low capital are substantial and the transactions costs of raising new capital quickly are very high.

Agency conflicts between debt and equity holders may also loom large in banks if, as is realistic, shareholders have a moral hazard opportunity to exploit creditors by substituting riskier assets for safer ones when creditors lack information to react, or shareholders have incentives to continue the bank's operations beyond the point at which it should be liquidated in order to maintain at least an option value for their claims. These may again be more acute with low capital. Creditors will demand compensation in the form of higher interest rates on debt for the expected value of expropriations of their claims by shareholders under risk neutrality, again making capital structure relevant. An offsetting aspect may be that debt is a better discipline on managers than equity so higher leverage might increase a firm's value. But it is unclear that changing regulatory requirements could have an impact on management slack.

Many of these points mean banks' market values will fall when a bank holds equity below the level that the market desires (implying in turn a higher cost of debt). Bank owners will seek to optimise between this downward pressure on value from low equity and the benefit it gives in terms of tax deductibility of debt and the higher cost of raising and maintaining equity capital. If banks are induced by regulators to hold more equity than the optimal level they will lose some of the benefits of tax deductibility on debt that they had chosen, and hence regulation will raise banks' costs somewhat as compared to those seen when they hold their desired debt to equity ratio. The higher the level of regulatory equity that is required to be held the larger the increase in costs is likely to be.

Meanwhile, the safety net reduces market capital 'requirements' by insulating banks from potential market discipline, and making the authorities the key 'uninsured creditor'. This may limit the degree to which the price of debt increases with low capital adequacy. It is partly to counter this that the authorities set capital adequacy standards that imply that banks' leverage is constrained by regulation independently of market forces. Regulators also respond to other externalities associated with financial intermediaries on behalf of the rest of society, notably systemic risk, which in turn implies regulatory capital requirements typically exceed the 'economic capital' that markets would themselves enforce. The fact that regulators penalise banks with inadequate capital further impacts on behaviour.

In our own model, for example, the effect of leverage of banks on spreads (etc.) indicates that MM is not fulfilled, as the leverage of the bank is shown to affect its real behaviour. In fact, the effect of increased capital requirements on spreads is broadly in line with the loss of tax deductibility from debt finance.[4]

Crisis Probability Studies

As regards estimates of the benefits of capital adequacy in reducing banking crises, rather little has been seen in the literature to date, but the centrepiece of a usable approach is the multivariate logit approach to financial crises as in Demirguc-Kunt and Detragiache (1998). This relates the likelihood of occurrence or non-occurrence of a banking crisis to a vector of *n* explanatory variables. The probability that the banking dummy takes a value of one (crisis occurs) at a point in time is given by the value of the logistic cumulative distribution evaluated for the data and parameters at that point in time. The advantage of this parametric approach is that it takes into account the interdependencies of explanatory variables which in combination could trigger a crisis.

As noted in Davis and Karim (2008), typical explanatory variables for crises in the existing literature generally do not include capital and liquidity measures although bank cash plus reserves as a proportion of total bank assets have been used to show liquidity risk. It is common to look at rapid real credit growth and increases in private sector credit/GDP during pre-crisis periods, indicating credit risk accumulation. Most studies include GDP growth to capture boom and bust cycles. As many studies are on emerging markets it is common to look at adverse movements in terms of trade and correspondingly currency depreciations. These are intended to capture market risk and also macroeconomic shocks and vulnerability to currency crises, as are measures such as M2 / foreign exchange reserves. Currency crises are often closely linked to banking crises (Kaminsky and Reinhart (1999)). Real interest rates and interest rate volatility are also included as direct indicators of interest rate risk.

Nominal variables are also relevant and high inflation showing policy mismanagement which causes higher nominal interest rates at the expense of lenders is an important variable in many large scale studies. Low fiscal surpluses as a percentage of GDP are presumed to change the probability of crises, and asset prices, such as those of real estate, for proxying market risk are also seen as

[4] Besides the issue of tax loss, there arises the question of what return on equity (ROE) is sought by banks. It has long been seen that UK banks have high ROEs, compared to those in Continental Europe. High returns may be sought for reasons relating to corporate governance and peer comparison. In the UK in particular there has been a tendency for banks to seek high rates of return for some time. Banks felt constrained to seek high ROEs given pressure from institutional shareholders and fear of takeover if returns are too low. It was also of benefit to executives with share options. We assessed the relationship between the loss of tax deductibility on debt and the cost rise based on our equations reported in Section 5 below. A percentage point rise in capital would increase revenues by the weighted average of the effects on consumer and corporate margins multiplied by the proportion of the increased equity that was used to increase lending rather than liquidity. The average impact on margins is around 0.11, and between 1999 and 2007 a one percentage point change in capital was associated with a 0.8 percentage point increase in liquidity. A one percentage point rise in capital given a 28% corporation tax rate and an interest rate of around 8% gives a loss which is similar in its impact on banks' profit and loss to the gain from widening spreads given the proportionate allocation to liquid assets.

important. Financial liberalisation indicators and deposit insurance dummies are also frequently included as they link to bank risk-taking and moral hazard.

To our knowledge, none of the literature has focused on capital adequacy as forerunners of banking crises. Also many of these variables are more relevant to emerging market economies than OECD countries, so many of these measures are not used in our own work below. We can then trace an impact of banking crises on the economy via the user cost of capital (affected by the equity premium and equity price volatility).

3. What causes crises – can we reduce the risks?

Barrell, Davis, Karim and Liadze (2009a) develop a crisis prediction model for OECD economies which ultimately reveals that unweighted capital adequacy (often known as the leverage[5] ratio) and the liquidity ratio alongside real house price growth are the most important determinants of the probability of financial crises in these countries. Moreover, their importance remains invariant to different robustness tests and we report at length on their results. The results have important policy implications for financial regulators and central banks; optimising the liquidity and capital adequacy[6] ratios of banks and suppressing rapid property price growth may well reduce the risk of future OECD crises. The work is summarised in this section as an important building block for the overall project.

This analysis follows Demirguc-Kunt and Detragiache (1998) and uses the multivariate logit technique to relate the probabilities of systemic banking crises to a vector of explanatory variables. The banking crisis dependent variable, a binary banking crisis dummy, is defined in terms of observable stresses to a country's banking system and occurs in around 5 per cent of all time and country observations in that paper. The dataset reported on here includes 14 systemic and non systemic crises in 14 OECD countries. Information concerning systemic banking crises is taken from the IMF Financial Crisis Episodes database which covers the period of 1970-2007.[7] Non-systemic crises are collected from the World Bank database of banking crises over the period of 1974-2002[8] and our sample covers the period 1980-2007[9]: These are as follows with within-sample crisis dates in brackets: Belgium, Canada (1983), Denmark (1987), Finland (1991), France (1994), Germany, Italy (1990), Japan (1991), Netherlands, Norway (1990), Sweden (1991), Spain, UK (1984, 1991, 1995, 2007) and the US (1988, 2007).

The criteria used to determine whether or not there is a crisis are: the proportion of non-performing loans to total banking system assets exceeded 10%; or the public bailout cost exceeded 2% of GDP; or systemic crisis caused large scale bank nationalisation; or extensive bank runs were visible and if not, emergency government intervention was visible. Binary crisis dummies inevitably mean that the start and end dates are ambiguous. It could be a while after the onset of crisis before the crisis criteria are observably met, and the criteria reveal nothing about when the crisis terminates. Since the end-dates are to some extent subjectively chosen there are potential endogeneity problems with estimation: the explanatory variables will be affected by ongoing crises. The timing of the crises is also crude in the sense that for annual dummies, a crisis starting in December 2000 would generate a value of 1 in 2000 and zero in 2001. However we are concerned with

[5] Note this definition of the banking leverage ratio (i.e. capital/unadjusted assets) operates contrary to normal concepts of leverage, in the sense that a higher 'leverage ratio' means lower 'leverage' in an economic sense of debt-to-equity. Accordingly we prefer to use the term 'unweighted capital adequacy' to avoid ambiguity.

[6] Note that although for data reasons we use the unweighted capital adequacy ratio, we expect that risk adjusted capital is also a crisis indicator. Our overall view is that both ratios need to be borne in mind in assessing crisis risk.

[7] See Laeven and Valencia (2007)

[8] See Caprio and Klingebiel (2003)

[9] Choice of the countries is limited by the availability of the data for our time period.

predicting the *switch* between crisis and non-crisis states and accordingly we assume one year crisis duration. For the example given, we accept our dummy takes a value of 1 in 2000 and zero thereafter, although in Barrell, Davis, Karim and Liadze (2009a) we relax this assumption and our results remain robust.

Because of the data exigencies of cross country panel work we use the unweighted capital adequacy (leverage[10]) ratio and not risk-adjusted capital adequacy for the estimation. The unweighted capital adequacy ratio is the ratio of capital and reserves for all banks to the end of year total assets as shown by the balance sheet. The corresponding measure of liquidity is the ratio of the sum of cash and balances with central banks and securities for all banks over the end of year total assets as shown by the balance sheet. Unweighted[11] capital adequacy and liquidity ratios were constructed using data from the OECD income statement and balance sheet database for all countries apart from the UK. Any missing OECD database observations, as well as the data for 2006 and 2007, were obtained from individual Central Banks and the BankScope[12] database. The OECD database does not supply figures for the UK. The unweighted capital adequacy ratio was defined as for other countries and was constructed using Bank of England aggregate data, and UK liquidity ratios were constructed using Financial Services Authority (FSA) data, where liquidity was defined as the ratio of liquid assets[13] over total assets.

As discussed above, Demirguc-Kunt and Detragiache (2005) found that crises were correlated with macroeconomic, banking sector and institutional indicators. Crises occurred in periods of low GDP growth, high interest rates and high inflation, as well as fiscal deficits. On the monetary side, the ratio of broad money to Foreign Exchange reserves and also the credit to the private sector / GDP ratio, as well as lagged credit growth were found to be significant. Institutionally, countries with low GDP per capita are more prone to crises, as are those with deposit insurance. We also include the explanatory variables used by Demirguc-Kunt and Detragiache (2005) and, in order to obtain the final model specification, we used a general to specific approach.

Estimates are shown in Table 1. At each stage, we omitted any variables that were insignificant in the previous stages. In order to capture developments in the economy prior to the crisis and to avoid endogenous effects of crises on the explanatory variables all variables were lagged by one period, apart from real house price growth which has 3 lags, which was decided upon by experimentation. It is probably the case that house price growth is a proxy for other driving factors which is why it has a longer lag than the other variables. It remains in the equation probably because it is an indicator of potential bad lending and hence of the wave of consequent defaults that frequently develop as a consequence of a house price bubble. As expected in the context of the OECD, all of the 'traditional' variables proved insignificant, despite experimentation with different lag lengths.

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[10] See footnote 3.

[11] We use unweighted capital adequacy partly for data reasons, as suitable data on risk adjusted capital adequacy is not available for most of the countries in our sample.

[12] For the liquidity measure, the ratio of liquid assets to total assets for the top 200 banks in a country in question was calculated.

[13] Sum of cash, gold bullion and coin, central government and central bank loans, advances and bills held and central government and central bank investments (i.e. securities).

Table 1: The General to Specific Approach in Logit Estimation for Crises

LIQ(-1)	-0.118 (-3.55)	-0.124 (-3.55)	-0.137 (-3.64)	-0.135 (-3.55)	-0.135 (-3.45)	-0.144 (-3.39)	-0.147 (-3.25)
LEV(-1)	-0.333 (-2.85)	-0.239 (-1.90)	-0.315 (-2.24)	-0.247 (-1.64)	-0.271 (-1.67)	-0.280 (-1.72)	-0.273 (-1.62)
RHPG(-3)	0.113 (2.8)	0.113 (2.87)	0.104 (2.67)	0.100 (2.59)	0.104 (2.67)	0.108 (2.76)	0.110 (2.67)
DCG(-1)	-	-0.099 (-1.82)	-0.10 (-1.97)	-0.10 (-1.86)	-0.10 (-1.99)	-0.13 (-1.98)	-0.13 (-1.98)
RIR(-1)	-	-	0.084 (1.37)	0.085 (1.40)	0.165 (1.41)	0.173 (1.46)	0.166 (1.30)
M2RES(-1)	-	-	-	-0.00 (-1.0)	-0.00 (-1.0)	-0.00 (-1.1)	-0.00 (-1.1)
INFL(-1)	-	-	-	-	-0.13 (-0.8)	-0.14 (-0.8)	-0.13 (-0.7)
YG(-1)	-	-	-	-	-	0.116 (0.65)	0.125 (0.66)
BB(-1)	-	-	-	-	-	-	-0.013 (-0.1)

Note: estimation period 1980-2006; t-statistics in parentheses; LIQ = liquidity ratio, LEV = unweighted capital adequacy ratio, YG = real GDP growth, RPHG = real house price inflation, BB = budget balance to GDP ratio, DCG = domestic credit growth, M2RES = M2 to reserves ratio, RIR = real interest rates, INFL = inflation.

The final logit model can be written, with LEV denoting the unweighted capital adequacy ratio, LIQ denoting liquid assets as a share of total assets and RHPG denoting the rate of change of real house prices, as

$$\log\left[\frac{p(\text{crisis})}{1-p(\text{crisis})}\right] = -0.333\text{LEV(-1)} - 0.118\text{LIQ(-1)} + 0.113\text{RHPG(-3)} \qquad (1)$$

$$(-2.85) \qquad (-3.55) \qquad (2.8)$$

Given these indicators, using data up until 2006 it is possible to say that the probability of a crisis in 2007 was higher than the sample average of 3.2 per cent in a number of countries, including Belgium, France, Italy, Netherlands, Spain and the UK, all of whom had a crisis in 2007 or 2008, and also Norway where there was not a crisis. However, if capital adequacy and liquidity levels had been higher the probability of a crisis happening would have been lower, as we can see from Table 2.

Table 2: Probabilities of the occurrence of a crisis

	Probability of crisis in 2007	Percentage points increase in LIQ and LEV							
		1	2	3	4	5	6	7	8
France	0.066	0.043	0.028	0.018	0.012	0.007	0.005	0.003	0.002
Germany	0.007	0.005	0.003	0.002	0.001	0.001	0.001	0.000	0.000
Italy	0.035	0.023	0.014	0.009	0.006	0.004	0.002	0.002	0.001
Spain	0.056	0.036	0.023	0.015	0.010	0.006	0.004	0.003	0.002
UK	0.217	0.150	0.101	0.067	0.044	0.028	0.018	0.012	0.007
	Probability of crisis in 2007	**Percentage point increase in LIQ**							
		1	2	3	4	5	6	7	8
France	0.066	0.059	0.053	0.047	0.042	0.038	0.034	0.030	0.027
Germany	0.007	0.007	0.006	0.005	0.005	0.004	0.004	0.003	0.003
Italy	0.035	0.031	0.028	0.025	0.022	0.020	0.017	0.016	0.014
Spain	0.056	0.050	0.044	0.040	0.035	0.032	0.028	0.025	0.022
UK	0.217	0.198	0.179	0.163	0.147	0.133	0.120	0.108	0.097
	Probability of crisis in 2007	**Percentage points increase in LEV**							
		1	2	3	4	5	6	7	8
France	0.066	0.048	0.035	0.025	0.018	0.013	0.010	0.007	0.005
Germany	0.007	0.005	0.004	0.003	0.002	0.001	0.001	0.001	0.001
Italy	0.035	0.025	0.018	0.013	0.009	0.007	0.005	0.004	0.003
Spain	0.056	0.041	0.029	0.021	0.015	0.011	0.008	0.006	0.004
UK	0.217	0.166	0.125	0.093	0.068	0.050	0.036	0.026	0.019

Source: based on estimates from Barrell, Davis, Karim and Liadze (2009a) at appropriate lag length

Given levels of capital and liquidity in 2006, it would have been possible to reduce the probability of a crisis noticeably, especially in the UK, by adjusting bank liquidity and capital ratios. Increasing the levels of capital and liquidity by one percentage point would have reduced the probability of a crisis in the UK by more than 6 percentage points, and by smaller amounts in other countries. Increasing regulatory requirements further would have reduced the probability further, but the returns to increased regulatory standards are clearly declining, with the gains falling 5 per cent in the UK for a move from a one point increase to a two point increase, for instance. It is also possible to calculate the effects of increasing capital requirements and liquidity requirements on their own, and it is clear that when they change together they slightly offset each other, as can be seen from Table 3. Changes in capital adequacy alone are at least twice as effective as changes in liquidity alone, especially in the UK. We should note that at the start of the crisis capital and liquidity seemed adequate in the US, reflecting the off balance sheet nature of many of the risks. Securitised assets were either missed, or hidden, because they appeared to be insured.

Barrell, Davis, Karim and Liadze (2009a) undertake a number of sensitivity analyses. They show that dropping each of the systemic crises one at a time does not affect the structure of their results, which are also invariant to dropping both the US and Japan together. The timing of crises is also uncertain, but when they switch to using the Reinhart and Rogoff (2009) timings of US and Japanese crises, results are again invariant. Although the regulatory variables, capital ratios and liquidity ratios are not perfect predictors, even in combination with real house price growth, they do pick up two-thirds of the post estimation period crises.

4. Financial crises and the long run equilibrium of the economy

There have been many banking crises in the OECD in the last 35 years, and Hoggarth and Saporta (2001) identify 17 in Australia, Canada, Denmark, Finland, France, Hong Kong, Italy, Japan, Korea, New Zealand, Norway, Spain, Sweden, the UK and the US. There are several ways to evaluate the losses from a crisis. One common method is to look at output losses in the period up until growth returns to the average of the three years before the crisis. This is not a good approach as the period before the crisis was often an unsustainable boom, and output losses should perhaps be seen in relation to the level of output returning to a sustainable level, which may be after growth has passed through the pre-crisis rate. Our preferred measure is the loss of output as compared to the level projected using a standard filter from the previous ten years of output growth (Hoggarth and Saporta's GAP 2). Over these 17 crises the cumulated level of output losses was around 20 per cent of GDP. Table 3 gives details of selected crises between 1990 and 2002, and in this group the output loss averages 29 per cent of GDP. Mopping up afterward is also costly and in the case of Japan the costs to the taxpayer (and hence to national wealth as more debt was issued) of mopping up the crisis was 14.1 per cent of GDP.

Table 3: Banking crises since 1990 – location, length and cumulated GDP cost

	Dates	Length (years)	Cost (% GDP)
Finland	1991-1993	3	44.9
France	1994-1995	2	0.7
Italy	1990-1995	6	24.6
Japan	1992-1998	7	71.7
Sweden	1991	1	3.8

Source: Hoggarth and Saporta (2001), p.22

It is useful to look at the distinction between transitory and permanent effects of a crisis. Financial crises normally bring on a recession, and the output costs can be large, as we can see from the table above. In the majority of cases output returns to its trend level and there is no permanent scar. Hoggarth and Saporta (2001) suggest that this was the case for Finland, France, Italy and Sweden in this table. However, there may have been a permanent scar on the level of output in Japan, making the crisis and subsequent recession much more costly.

Economists think of output being determined, at least in the long run, by factor inputs and technology and not by demand. It is common to summarise these factors into a production function, and we may write this in Constant Elasticity of Substitution (CES) form as

$$Q_t = \gamma\left(\delta K_t^{-\rho} + (1-\delta)\left(L_t \, e^{techl_t}\right)^{-\rho}\right)^{-1/\rho} \qquad (2)$$

where Q_t is output, K_t is capital input, L_t is labour input and labour augmenting technical progress is denoted $techl_t$. There is some evidence that the elasticity of substitution, $\sigma = 1/(1+\rho)$ is around 0.5 (see Barrell and Pain 1997). The elasticity of output with respect to capital is therefore approximately the output capital ratio multiplied by the factor share, as can be seen from (2) as $\rho = 1$ in this case and $\delta\,\gamma$ is the factor share.

$$\mathrm{d}\log(Q)/\mathrm{d}\log(K) = (Q/K)^{\rho}\delta\gamma^{\rho} \tag{3}$$

We may write the associated cost minimising factor demands as

$$\log(K_t/Q_t) = a_1 + \sigma\log(user_t) \tag{4}$$

$$\log(L_t/Q_t) = a_2 + \sigma\log(rwage_t) + techl_t \tag{5}$$

where $rwage_t$ is the real wage per unit of labour input and $user_t$ is the user cost of capital at t. We calculate the user cost of capital according to a standard Hall-Jorgensen formula.

$$user_t = \frac{pdk_t}{py_t}\left[wacc_t + kdep_t - \Delta\ln\left(\frac{pdk_t}{py_t}\right)^e\right] \bigg/ (1 - ctaxr_t) \tag{6}$$

where pdk_t is an investment deflator, py_t is the GDP deflator, $wacc_t$ is the real cost of finance, $kdep_t$ is the depreciation rate, e denotes expectations and $ctaxr_t$ is the corporate tax rate. The real cost of finance as defined by Brealey and Myers (2000), $wacc_t$, can be written as the weighted average cost of capital.

$$wacc_t = b_{1t}(E_t/P_t) + (1-b_{1t})(c_{1t}(lrr_t + corpw_t) + (1-c_{1t})(lrr_t + iprem_t))\cdot(1-ctaxr_t) \tag{7}$$

This weights together the cost of equity finance which depends on the earning price ratio (E_t/P_t) and cost of debt finance. The weights are given by the share of capital in the economy that is listed on the stock market which we denote b_1. The cost of debt finance follows from the average of bank and corporate bond borrowing costs, where c_{1t} is the share of borrowing that comes from banks. Borrowing costs are adjusted by the corporate tax rate, reflecting the tax deductibility of borrowing. It is calculated as the risk-free long real interest rate (lrr_t), plus a measure of corporate spreads ($iprem_t$) and corporate bank borrowing margins ($corpw_t$). In our analysis below, corporate spreads are calculated as the absolute difference between average corporate bond yields and yields on 10-year government bonds. In general, we can expect bank borrowing costs and bond spreads to move together, because if one source of finance becomes more expensive then firms can substitute into the other. However, we do not see borrowing and equity sources as perfect substitutes, as would be the case in a Modigliani-Miller world for similar reasons to those mentioned in Section 2, not least as such a world precludes the existence of banks, but also due to tax deductibility of debt and bankruptcy costs.

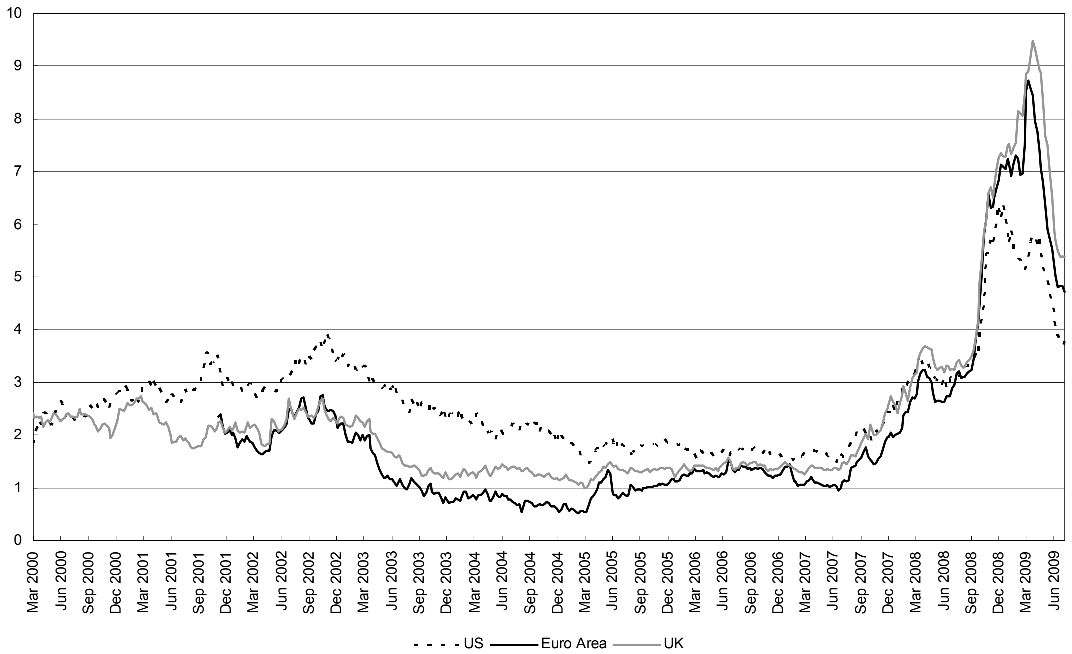
A 10 percent rise in the user cost of capital (from 10 to 11 per cent, say) reduces the equilibrium capital-output ratio by 5 per cent, and as long as labour supply is fixed then equilibrium output will fall by about a quarter of this amount if the elasticity of substitution is around a half, and the capital share is around a quarter (with exact magnitudes depending upon the elasticity of substitution and the elasticity of output with respect to capital). The equilibrium capital stock will therefore fall by around 7 per cent or so.

If the user cost of capital falls in a trend-like way, as it did from the early 1990s to around 2005 (see Barrell, Holland, Liadze and Pomerantz, 2009), then we might see a period of capital deepening. The resulting increase in the capital-output ratio raises the level of output and hence, for a period, the rate of output growth. The *Great Moderation* led to a gradual fall in risk premia, and hence the margin charged on risky investments as compared to risk-free government borrowing, and appeared to have enhanced prospects for growth. Barrell, Holland, Liadze and Pomerantz (2008) suggest that capital deepening contributed about 0.3 per cent to labour productivity growth between 1998 and 2005. Given the turbulence in financial markets, in the medium term we would not expect to see capital deepening generated by a further decline in the user cost of capital, and indeed we would expect to experience a reversal of this process.

There were perhaps two major structural changes in 2007 and 2008 associated with a significant increase in risk premia, as we can see from Figure 1. Barrell and Kirby (2008) argued in early September 2008 that the increase in risk premia we had seen after the start of the crisis in mid-2007 would reduce the level of sustainable output in the UK by 1½-2 percentage points. Their estimate was based on the observed increase of 200 basis points over this period in the BAA spread for corporate bonds over risk-free government bonds. They suggested this would raise risk premia going forward and therefore increase the user cost of capital and hence reduce equilibrium output.

Figure 1: Corporate bond spreads in the UK, the USA and the Euro Area

Spread between BAA corporate and government bonds



Source: Thompson Datastream weekly data

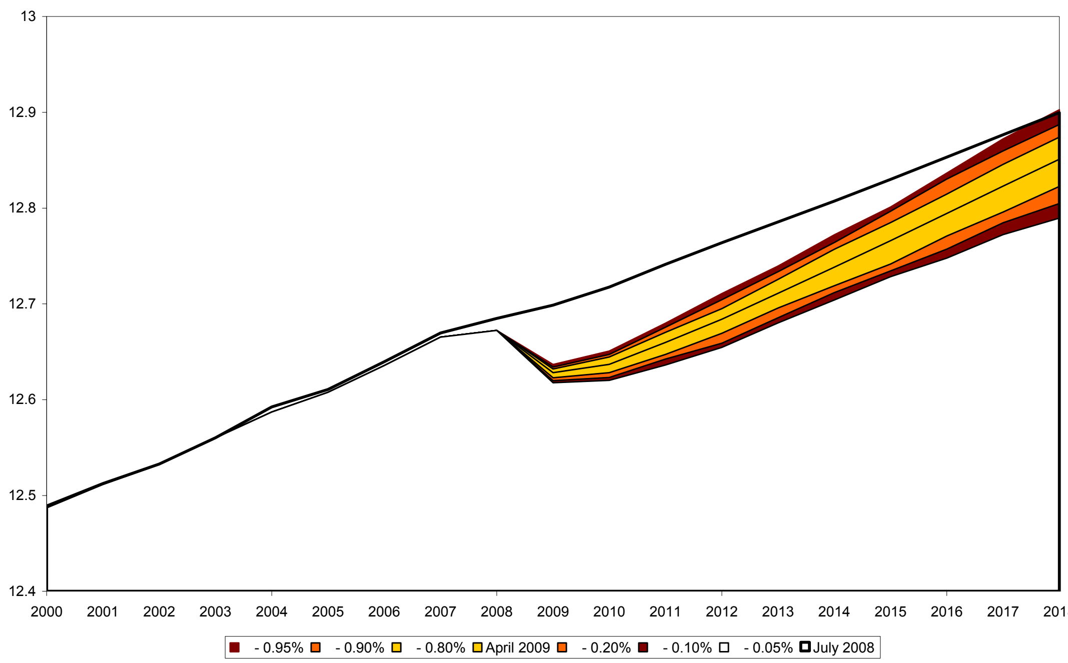
The near-collapse of the UK and other banking sectors in the wake of the failure of Lehman Brothers in mid-September led to a further increase in risk premia well beyond the scenario reported in Barrell and Kirby (2008). Indeed, in Barrell and Kirby (2009) we doubled our estimate of the effect of the financial crisis on trend output via the impact of risk premia. In our April 2009 forecast in the *National Institute Economic Review* we suggested that, in the medium term, output in the UK would settle down around 4 to 5 per cent below our projection published in July 2008, as we can see from figure 2. The UK Financial Statement and Budget Report (2009) produced similar estimates, although they refer to the effect as temporarily reducing trend growth for a period of years[14]. There are potentially three components to this change in trend, and it is important that we distinguish between those induced by changes in risk premia, the impacts on output of changes in patterns of migration and any potential misclassification of incomes that resulted from capital gains in banking. Barrell and Kirby (2009) suggest that the risk premia related changes could be around 3 percent or a little more, whilst migration effects (see Barrell et al 2009) could be as large as three-quarters of a percentage point, with the rest of the longer term effects coming from the re-evaluation of past incomes discussed in Weale (2009). Changes in migration affect output and the size of the population, and can be discounted in a cost-benefit analysis, as can the reclassification of income sources.

As with all projections we are uncertain about this, and we have included on the chart error bounds generated by stochastic simulations on NiGEM. There is a better

[14] See pages 194 to 197 of the FSBR which refer to our scarring estimates for the impact of the crisis on trend GDP in the National Institute Economic Review for January 2009. They also refer to the migration estimates produced by NIESR for the Department of Communities and Local Government.

than 1 in 20 chance that by 2018 output in the UK will have reverted to the level we projected in July 2008, for instance. There is also a 1 in 20 chance it will be 9 per cent below that level. However, knowing where we were at the end of 2007 and where we expect to be by 2018 does not provide any information about the speed of adjustment of the capital stock to its equilibrium and hence on the output gap at present. The collapse of world trade in capital and equipment goods, along with declines in car production and in residential and other construction, suggests to us that the adjustment of capital stock is taking place relatively quickly.

Figure 2: Scarring from the Financial Crisis – projections for UK GDP



Source: Stochastic evaluations around the April 2009 NIER forecast

The maximum estimate of the output costs of the crisis for the UK would be the cumulated and discounted value of the difference between the July 2008 projection and the April 2009 projection after allowing for migration and capital gains effects discussed above. These costs include both the recession and the implications of the crisis for risk premia and hence trend output going forward. The banking crisis we have seen has been a global one, however, and even countries whose financial systems were little involved in the 'bubble' such as Japan have suffered severe recessions in the wake of the crisis. These have been propagated by trade and exchange rate effects from countries that have been badly affected by the collapse of their financial systems. Hence it is unlikely that the UK would have avoided a significant downturn.

Our estimates of scarring effects are a useful starting point for the evaluation of the effects of regulatory policy on the economy, but they must be treated with care. The crisis probability indicators in the previous section do indicate that in 2007 the UK was more likely to experience a crisis than were the other major European economies. If regulation had been tighter, a crisis might have been less likely in the UK, but it probably still would have emerged in the rest of the world. In that event there would still have been effects on risk premia in the UK, even if a crisis had been avoided. Risk was being under-priced everywhere in the OECD during the *Great Moderation*, and it is now being re-priced everywhere. The effects on premia might have been less, and hence the long run effect on the UK would have been mitigated also.

Our estimates of crisis probabilities in the previous section must also be treated as uncertain, as they are summary indicators of the factors that have driven crises in the last few decades. But as with all such models we cannot easily capture recent developments that have destabilised financial markets. In particular, the models cannot capture the effects of recent financial innovations, as these products did not exist when crises have taken place in the past – they are also hard to capture in the data.

These caveats should be born in mind in the next two sections, as they indicate a degree of uncertainty around the work presented there, and especially the cost benefit analysis we undertake in the last section. In order to complete this cost-benefit calculation we need to evaluate the impacts on the economy of any changes in regulation that we might expect to see, and we turn to this issue in the next section.

5. Modelling the banking sector and financial regulation

Our research on the causes of crises in section three above suggest that changes in liquidity and capital adequacy may change the probability of suffering a crisis, and hence change the expected costs of a crisis. It is not wise to assume that increased capital and liquidity requirements are therefore unreservedly beneficial, since they may also have a negative impact on output in both the short and the long run by increasing borrowing costs and raising the user cost of capital. This is likely to happen because any regulation on banking activity must, if it is effective, act as a tax on banks and hence lead to a widening of the spread between borrowing and lending rates. In order to be able to compare the costs and benefits of regulation we have to be able to model their effects on output, and we do this by constructing a model of the banking sector and embedding it in our structural model of the UK, which is part of the global model, NiGEM.

The NiGEM model is described in Appendix 1. It contains elements of demand, including consumption, and a supply side that is driven by technology and the user cost of capital. Financial markets are forward looking, as are factor markets. All of these may be affected by financial regulation. Increasing the spread between borrowing and lending rates for individuals changes their incomes, and can also change their decision making on the timing of consumption, with the possibility of inducing sharp short term reductions. Changing the spread between borrowing and lending rates for firms may change the user cost of capital and hence the equilibrium level of output and capital in the economy in a sustained way. We turn to these markets next, and embed our new work into NiGEM to help us evaluate the costs and benefits of changing financial sector regulation.

Costs of capital adequacy
We model banking activity as a set of supply (or price) and demand curves. Demand depends on levels of income or activity, and on relative prices, whilst supply, or price, depends upon the costs of providing assets and on the risks associated with those assets. The banking sector in our model has four assets – secured loans to individuals for mortgages (*morth*) with a borrowing cost (*rmorth*), unsecured loans to individuals for consumer credit (*cc*) with a higher borrowing cost or rate of return (*ccrate*), loans to corporates (*corpl*) with a rate of return or cost of borrowing (*lrr+corpw*) where *lrr* is the risk free long rate and *corpw* is the mark up applied by banks, and there are liquid assets (*lar*). The categories subsume, along with deposits and risk weighted capital adequacy itself (*levrr*), all on-balance sheet activity within the UK.

We note that there are periods where off balance sheet activity increases, with loans being made by shadow banks. These activities may be more common when there is more regulatory control. However, this would only matter if we were relying in our modelling on a significant role for quantities of loans rather than the cost of loans. A change in regulation will induce an increase in costs and an increase in off balance sheet activity, all else equal, but the cost of off- and on-balance-sheet borrowing will settle to be equal at the margin, and hence it is likely that our approach to modelling the impacts of regulation on prices finesses the problem of the shadow market.

Banks issue equities and bonds and take deposits and charge for loans as a mark up over costs. Each part of the loans portfolio can be described as a market. Each has a long run demand curve for quantities and a long run price (or supply) relationship. They all include standard determinants to avoid omitted variables bias. We may write them as follows.

Secured consumer loans market
The volume of mortgages depends upon real disposable incomes (*rpdi*), real house prices (*rph*) and the real cost of borrowing (*rmort*).

$$morth = \mathrm{f}(rpdi, rph, rmort) \tag{8}$$

The cost of mortgages depends on the bank rate (*int*) and a markup (*lendw*).

$$rmort = int + lendw \tag{9}$$

The mark up of the mortgage rate over the bank rate depends on regulation and risk, and these are captured by the risk adjusted capital adequacy ratio (*levrr*), real net personal sector financial wealth as a ratio of personal incomes (*rnwpi*) and mortgage arrears (*arr*) as well as on a number of other risk related factors discussed below.

$$lendw = \mathrm{g}(levrr, rnwpi, arr) \tag{10}$$

Unsecured consumer loans market
The volume of unsecured loans (*cc*) depends on real personal disposable income and on the cost of consumer credit borrowing (*ccrate*) which, in turn, depends on the Central Bank intervention rate (*int*) and the normal margin between borrowing and lending rates, and on any specific risk factors for consumer credit (*rpcc*).

$$cc = \mathrm{f}(rpdi, ccrate) \tag{11}$$

$$ccrate = \mathrm{g}(int, lendw, rpcc) \tag{12}$$

Corporate loans
The volume of corporate borrowing depends on the profits of the corporate sector (*gprc*) and on the cost of borrowing, which is the sum of the risk free long rate (*lrr*) and the mark up above this that banks charge corporates (*corpw*).

$$corpl = \mathrm{h}(gprc(lrr + corpw)) \tag{13}$$

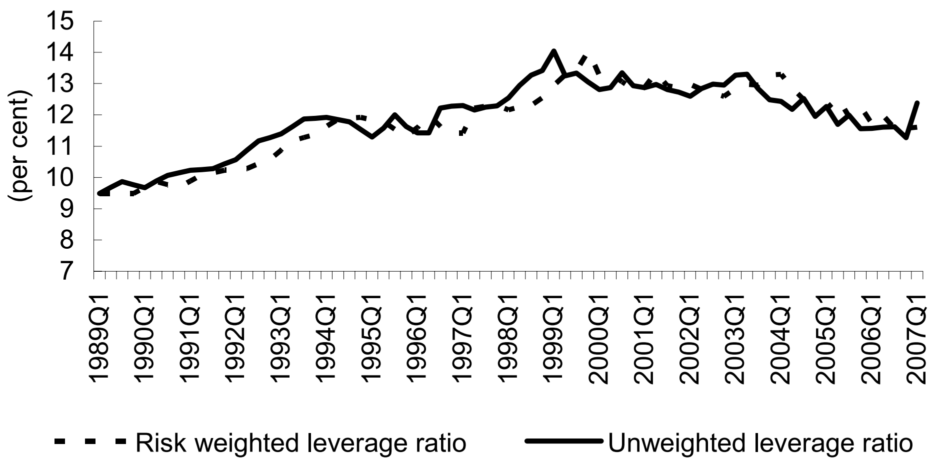
The spread between corporate borrowing and lending rates, *corpw*, depends on the policy environment and, in this model, especially on the risk adjusted capital adequacy ratio, *levrr*. It also displays a non-linear effect from the difference between actual and target risk weighted capital, with the latter being given by trigger ratios aggregated across banks. We calculate the difference, which we might call the headroom available to banks for normal operating purposes, and we use the inverse of this (*invhead*) to pick up non-linear effects of shortages of capital on the lending behaviour of banks. We also include a measure of the output gap, which is the ratio of actual output (*y*) to capacity output (*ycap*) to pick up cyclical elements, and we include the corporate insolvency rate (*insolr*) as a measure of the risks involved in lending, as well as on a number of other risk related factors discussed below.

$$corpw = j(levrr, invhead, y/ycap, insolr) \quad (13)$$

The markets for secured and unsecured consumer lending are part of the consumption and saving decisions in the economy. If consumer borrowing costs change and hence consumption changes as a share of income, then the savings rate changes. In a small open economy with perfect capital mobility, after an adjustment period, this is reflected in the current account and in foreign assets and incomes from abroad, as the saving rate does not affect the production potential of the economy[15].

The market for corporate borrowing is more closely involved in the determination of the level of output, which depends upon the supply of labour, the level of technical progress and the stock of capital, as discussed above and shown in equation (2). The stock of capital depends in turn on the user cost of capital, and firms ability to borrow from banks (or from shadow banks), in the equity market and through issuing bonds. At the margin, the cost of each form of borrowing will be the same. Hence a rise in the cost of borrowing from banks will induce a substitution away from that form of borrowing, and this will drive up the marginal cost of borrowing elsewhere. A higher cost of capital will result, and equilibrium output will be affected.

Figure 3: Capital Adequacy ratios for UK banks



Source: FSA, BankScope and Bank of England Financial statistics

As noted above, in our work on banking crises, for data reasons we utilised data on the unweighted capital adequacy ratio, whilst in this section we use a risk-weighted indicator in use by the regulator. In our investigation of the model and the data in each of the spread equations we looked for an effect from both book capital adequacy and risk weighted capital adequacy, and both were possibly significant on their own. As the current regulatory regime focuses on risk weighted assets these latter equations are used in our analysis, but this choice will have almost no impact

[15] It is of course possible that changes in foreign indebtedness could change the risk premium on UK borrowing and hence impact back onto real output. However, this is only likely to be significant for countries with persistent deficits or surpluses on the scale seen for Japan, Spain and perhaps the US over the past decade, and for the sake of brevity we do not deal with it here.

on our results, as the two measures are strongly related. Figure 3 plots the weighted and unweighted capital ratios for the UK, and they have a correlation coefficient of 0.92. If we regress the weighted capital ratio on a constant and an unweighted capital ratio for the UK the coefficient on unweighted capital is 1.0007 with a standard error of 19.6 and hence there is no problem in linking our results in this section with those in the section above on the causes of crises.

The FSA (previously Bank of England) trigger ratios[16] for banks vary between banks and we use an average measure. An excess over the trigger ratio is considered to be held for normal precautionary purposes. As noted in the research quoted in Section 2, if banks move below their normal precautionary level of excess capital, they appear to respond by increasing the cost of borrowing for firms and persons in order to reduce the scale of their book with a view to restoring the excess of their capital ratio above the trigger ratio.

Both increasing margins and reducing lending will move banks back toward their desired capital ratio. If the capital adequacy target ratio (*levrrt*) rises then risk weighted capital adequacy (*levrr)* will increase and so will the cost of corporate and personal sector borrowing. There has been a 'normal' excess above the required minimum level of capital adequacy which has averaged 3 percentage points in this sample. As the difference between the actual and the target ratio, or headroom (*head*), available to the banking system shrinks we might expect banks to push up their borrowing charges. As headroom goes to zero we would expect there to be significant non-linear increases in borrowing costs. In order to capture this we included both headroom and its inverse (*invhead*) in all our margin equations, and we retain either variable when they are significant.

Modelling Spreads for Consumers and Companies

The equation we have estimated for the household sector margin (mortgage rate less savings rate, *lendw*) is estimated in error correction form because all variables included in it are integrated I(1), as we can see from Appendix 2, which also shows that the long run of the relationship cointegrates. The wedge between borrowing and lending rates faced by consumers approaches equilibrium relatively quickly with a feedback coefficient of 0.45. The consumer spread depends upon personal sector mortgage arrears (*arr*), which is plotted in Figure 4, the ratio of net personal wealth to personal income (*nwpi*) and the (risk adjusted) capital adequacy ratio of the banking system (*levrr*). Both the level of arrears and the net financial wealth of the personal sector relative to its income may be seen as indicators of risk, with the former increasing it and the latter reducing it, much as is suggested by the signs of their coefficients in the equation. We tested for but found no role for liquidity in this equation, reflecting its absence from the regulatory regime over the estimation period. No separate role for headroom or its inverse was found in this equation. This may reflect the fact that the average mortgage rate (which we use here as this is the rate that also feeds into personal net interest incomes) does not change very rapidly when interest rates change. The personal sector markup, *lendw* feeds into both the mortgage borrowing rate and a credit card borrowing rate.

[16] See footnote 3

$$lendw = lendw(-1) - 0.000128 - 0.446002 \times (lendw(-1) + 0.024201$$

(-0.87) -(4.41) (5.83)

$$- 0.063713 \times levrr(-3)$$

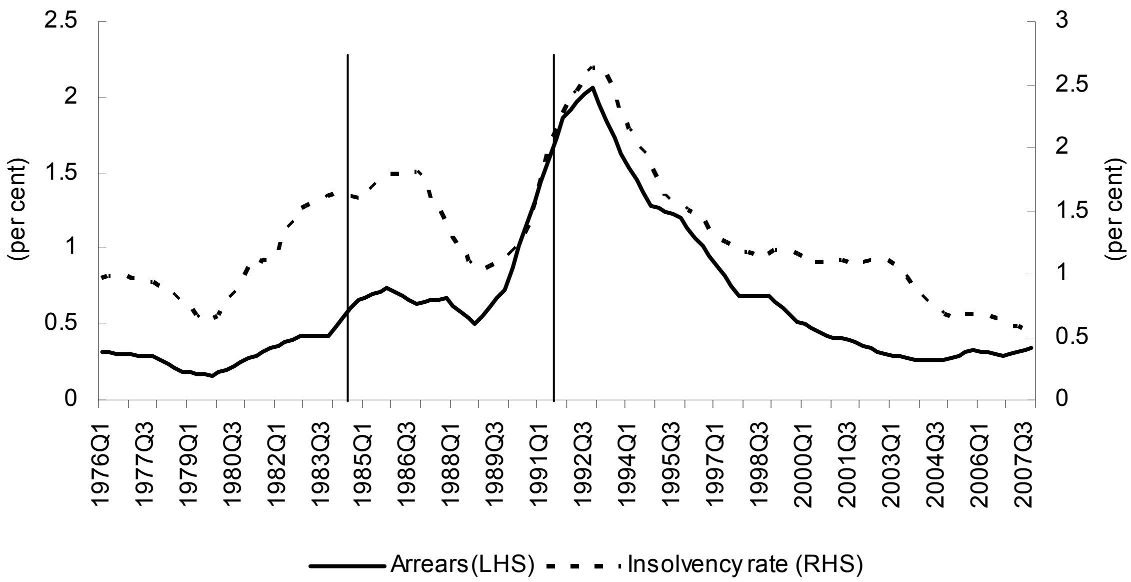
(2.84)

$$- 0.006035 \times arr(-4) + 0.003159 \times nwpi(-1)) \qquad (14)$$

(8.75) (-7.28)

Sample: 1990Q3–2008Q2;
Some quarterly dummies are included

Figure 4: Household Sector Arrears and Corporate Sector Insolvencies



The equation for the corporate borrowing wedge (*corpw*) is estimated in level terms, as the dependant variable appears to be stationary, at least at the 10 per cent level of significance. As the obvious independent variables are all I(1), while *corpw* is I(0), as we can see from Appendix 2, in order to explain the dependent variable we need to find a combination of the driving variables that is itself I(0). The variables included do exhibit a cointegrating relationship when we evaluate this with Johansen's Cointegration test. These test results indicate the presence of a single cointegrating relationship. Residuals in the corporate lending equation are also tested for stationarity and non-stationarity is rejected with a ten per cent confidence level.

$$corpw = -0.196809 + 0.131227 \times (\log(y) - \log(ycap)) \times 100$$

(-0.46) (4.69)

$$+ 0.841752 \times invhead(-1) + 0.522302 \times insolr + 0.194533 \times levrr \qquad (15)$$

(5.32) (5.72) (5.60)

Sample: 1989Q2–2007Q4; Adjusted R-squared 0.64;
Some quarterly dummies are included

The corporate sector margin (corporate lending rate less deposit rate, *corpw*) again depends upon a number of risk-based factors, with a strong role for the output gap (*y/ycap*) and the business sector insolvency rate (*insolr*) shown in Figure 4, as well as the inverse of headroom (*invhead*) and the risk adjusted capital adequacy ratio (*levrr*). For this equation this series was extended back to 1986 using data on sterling and foreign currency bank equity capital as a proportion of lending in these currencies. We also investigated the impact of other indicators of risk, but neither equity price volatility nor interest rate volatility were found to be significant.

We found no role for liquidity in this mark-up equation, reflecting its absence from the regulatory regime over this period. All variables in the equation have a positive sign, i.e. an increase in any of them raises the cost of borrowing for companies and affects their borrowing ability and level. A decrease in headroom and a consequent tightening in bank finance, may lead to firms seeking alternative sources of finance, such as an increase in their bond issuance and reliance on equity markets. Companies may also turn to the shadow market. But in each case we would expect the cost of borrowing in terms of debt to be the same at the margin as bank borrowing (*corpw*).

In order to test this proposition we need to link the corporate bond markup (*iprem*) to the corporate borrowing margin in the banking sector. The user cost of capital is the tax adjusted, market weighted average of the cost of equity finance and the cost of borrowing, from banks or by issuing bonds. It therefore depends upon a mark up over the risk free borrowing rate facing the public sector, and this mark up will be similar in bank and bond markets if firms can easily move between the two. A simple regression of the credit risk premium on BAA-rated bonds on the corporate spread within banks supports our suggestion and indicates a one-to-one relationship between the BAA spread and the bank borrowing rate, as we can see below. Over this data period both *iprem* and *corpw* are stationary as we can see from Appendix 2, and the regression residuals are also stationary.

$$iprem = -1.218458 + 1.001903 \times corpw \tag{16}$$
$$\qquad (-7.40) \qquad (18.85)$$

Sample: 1999 M01–2007 M09
Break dummy is included 2004 M01

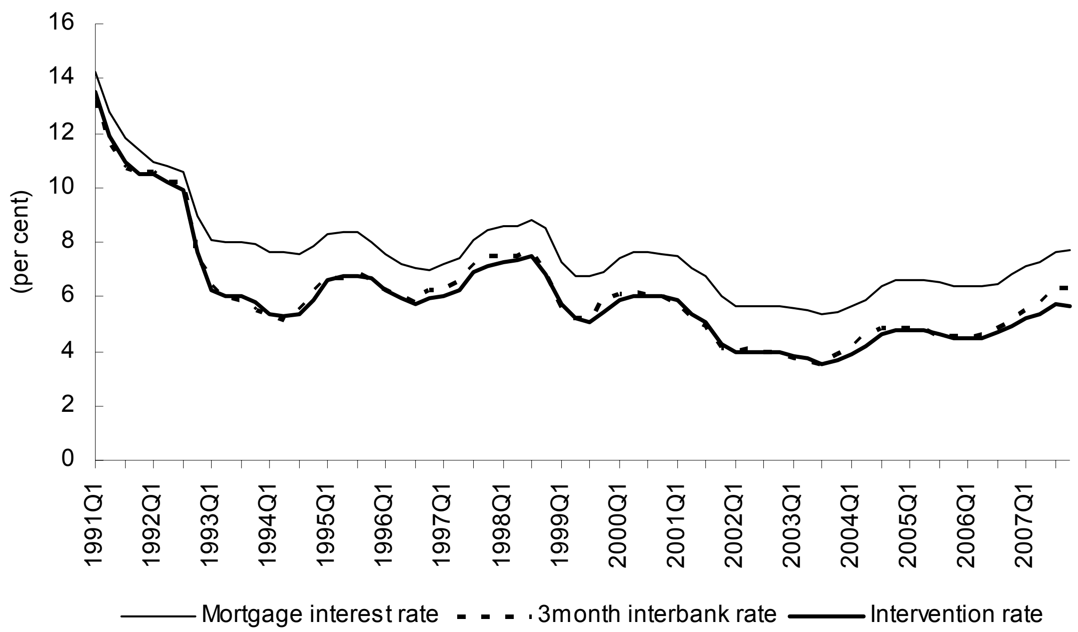
The underlying data for both investment premium and corporate wedge variables is taken in monthly terms to maximise the number of observations. As the monthly data reveals a break in both series in the first month of 2004, which in turn affects stationary test results, we ran unit root tests with break dummies included. Stationarity test results with and without break dummies included can be seen in Appendix 2, Table A.2.3.[17] We estimate the equation up to the point in 2007 when

[17] In order to investigate an order of integration of *iprem* and *corpw* we construct an ADF equation by differencing them and regressing them on a constant, a lagged value of the variable and four lags of the difference. We estimated the equations with and without the break dummy and checked for the significance of a lagged level variable. We concluded that we have I(0) variables with a common break point.

the developments of the financial crises started to show up in the data, so the relationship is not affected by recent volatility in both series. As is illustrated in Appendix 2, inclusion of dummies in both cases allow us to reject the presence of a unit root, so we treat the monthly data on *iprem* and *corpw* as representing stationary variables.

Secured lending to consumers
The margin on secured lending has to feed into the secured lending equation through its impact on the mortgage rate (*rmort*) which is estimated over a short period as it uses a series for average rates for the stock of mortgages and not a marginal or new borrowing rate. In the long run the mortgage rate rises with the spread and responds one for one to intervention rates, and both are plotted in Figure 5 below along with the three-month interbank rate[18].

Figure 5: Interest rates



In the short term there is some noticeable lag in the effects of intervention rates in part because some of the stock of debt is at fixed rates, but generally only for a short period. The equation is dynamically homogenous to changes in the intervention rate (coefficients on change terms add to one) and hence only the level of the rate affects the long run costs of mortgages. The equation is estimated in error correction form as the variables in it are all I(1), as we can see from Appendix 2, and the long run of the relationship cointegrates. No specific risk factors entered this equation when they were investigated, and hence risk has its impact through the arrears variable in *lendw*.

[18] There may also recently have been a separate role for the three-month interbank rate as credit markets became disrupted, but this is difficult to pick up in this context.

$$rmort = rmort(-1) + (lendw - lendw(-1)) - \underset{(1.3)}{0.03115}$$
$$- \underset{(2.2)}{0.130142} \times (rmort(-1) - (int(-1) + lendw(-1)))$$
$$+ \underset{(35.9)}{0.826449} \times (int - int(-1)) + (1 - 0.826449) \times (int(-4) - int(-5)) \quad (17)$$

Sample: 1999Q1–2008Q3; Adjusted R-squared 0.854

The market for the quantity of mortgage lending (*morth*) must include a demand relationship as well as a price equation. The impact of bank capital on this market depends both on the coefficient on *levrr* in the price equation and also on the coefficient on price in the demand equation. All the variables in the equation for *morth* are I(1) as we can see from Appendix 2, and they form a cointegrating set in the long run, as we can see from Table A.2.2 in Appendix 2. Hence the real stock of mortgages (*morth)*, which is deflated by consumer prices (*ced*) slowly adjusts to an equilibrium relationship with real post tax incomes (*rpdi*) with a long run demand elasticity marginally above one. The level of borrowing and its dynamics are influenced by both the level and rate of change of real house prices (*ph/ced*). The real mortgage rate (*rrmort*) has a significant and negative impact on mortgage borrowing. Hence a rise in capital adequacy, or an increase in liquidity requirements, will raise mortgage rates and negatively affect borrowing.

$$\log(morth) = \log(ced) + \log(morth(-1)/ced(-1)) - \underset{(-2.64)}{0.517579}$$
$$- \underset{(-5.74)}{0.128142} \times \log(morth(-1)/ced(-1)) + \underset{(13.05)}{1.058124} \times \log(rpdi(-2))$$
$$+ \underset{(6.09)}{0.256205} \times \log(ph(-4)/ced(-4)) - \underset{(2.8)}{0.006708} \times rrmort(-2)$$
$$+ \underset{(3.0)}{0.175239} \times \log(ph(-2)/ced(-2)/(ph(-3)/ced(-3))) \quad (18)$$

Sample: 1986Q1–2008Q2; Adjusted R-squared 0.51;
Seasonal dummies included in estimation

Unsecured lending to consumers

Total personal sector borrowing includes consumer credit (*cc*) and this, in turn, depends upon the rate of interest on consumer credit (*ccrate*). In our modeling, the credit card interest rate rises in line with the intervention rate (*int*) and the lending margin for consumers *lendw*, although it is, as might be expected, noticeably higher than the mortgage spread would suggest. The variables are all I(1) and they form a cointegrating set in the long run as we can see from Appendix 2. There is significant inertia in this relationship. There appears to be no separate role for risk factors in this equation, perhaps because they are all strongly correlated with mortgage arrears, which does influence the credit card borrowing rate through *lendw*.

$$
\begin{aligned}
ccrate = ccrate(-1) + \underset{(1.74)}{0.4573} \\
- \underset{(1.98)}{0.04492} \times (ccrate(-1) - (int(-1) + lendw(-1))) \\
+ \underset{(2.50)}{0.30235} \times (int - int(-1)) \\
+ \underset{(3.08)}{0.3486} \times (ccrate(-1) - ccrate(-2)) \qquad (19)
\end{aligned}
$$

Sample: 1995Q3–2008Q3; Adjusted R-squared 0.394

The volume of consumer credit lending, *cc*, is very inertial in relation to income (*rpdi*) with a feedback from the equilibrium of 0.035 suggesting it takes six years to adjust to a new stock equilibrium. The stock is very sensitive to the real cost of consumer credit borrowing (*rccrate*) with a long run semi-elasticity of -0.2 (i.e. -0.0075/0.035). The variables are I(1) and the long run of the relationship cointegrates.

$$
\begin{aligned}
\log(cc) = \log(cc(-1)) + \log(ced/ced(-1)) \\
+ \underset{(0.16)}{0.00055} - \underset{(2.7)}{0.0350} \times \log(cc(-1)) \\
+ 0.0350 \times \log(rpdi(-1)) \\
- \underset{(5.04)}{0.0075} \times rccrate \qquad (20)
\end{aligned}
$$

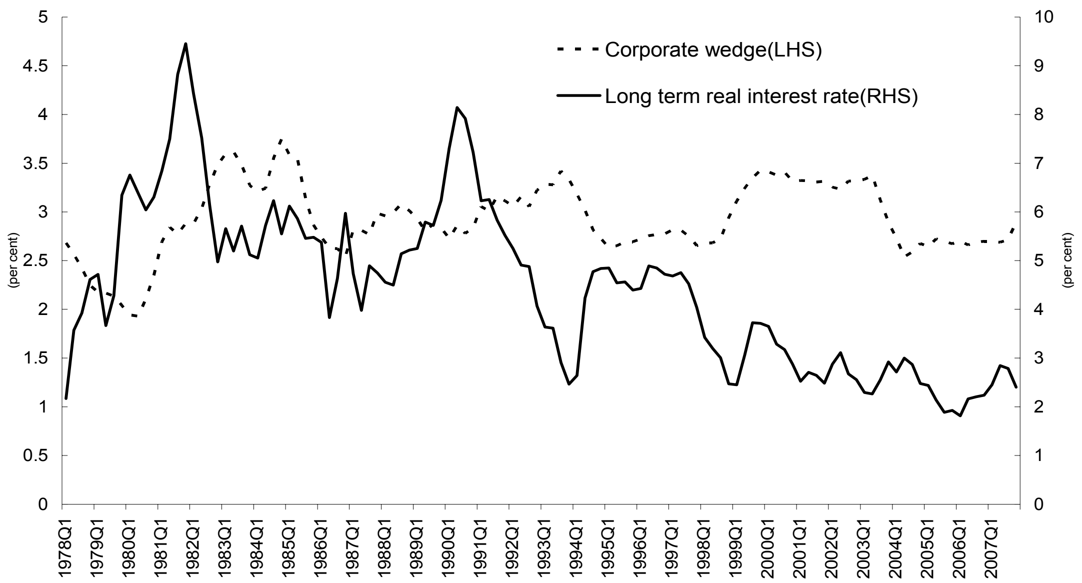
Sample: 1994Q1–2008Q2; Adjusted R-squared 0.625

Corporate sector borrowing

We have modelled the demand for corporate borrowing in a similar way to consumer borrowing, treating it as a demand curve from firms. Real corporate borrowing (*corpl/ced*) error-corrects on real UK corporate profits from the non-oil sector (*gprc*). It is influenced by corporate borrowing costs (*lrr+corpw*) which are a mark up over the risk free interest rate (*lrr*), both components of which are plotted in Figure 6 below. The long run semi-elasticity of demand with respect to real borrowing costs is 0.2, much as in our consumer credit demand equations. Both are more sensitive to these costs than is secured consumer borrowing, partly because issuing equities is a normally available alternative for firms, unlike for the consumer, albeit also because corporations are more leveraged and their expenditure is typically more volatile.

The variables in the equation are all I(1), as we can see from Appendix 2. Although this may not be the case for *corpw* on its own, the overall cost of borrowing which includes the long real rate is I(1) and the long run of the relationship does cointegrate as we can also see from Appendix 2. The equation below also has dynamics of adjustment to the equilibrium that are relatively slow, correcting only 5 per cent of any discrepancy between actual and equilibrium within any quarter.

Figure 6: Corporate borrowing costs



$$\log(corpl) = \log(ced) + \log(corpl(-1)/ced(-1)) + \underset{(4.99)}{0.20399}$$

$$- \underset{(4.24)}{0.04825} \times \log(corpl(-1)/ced(-1))$$

$$+ 0.04825 \times \log(gprc(-1)/ced(-1))$$

$$- \underset{(4.64)}{0.01045} \times (lrr + corpw)$$

$$+ \underset{(4.57)}{0.39380} \times \log(corpl(-4)/ced(-4)/(corpl(-5)/ced(-5))) \qquad (21)$$

Sample: 1988Q2–2008Q2; Adjusted R-squared 0.464
Income elasticity restricted to 1

Liquidity Effects

There is no evidence in any of our UK equations for liquidity effects, although the variable was systematically investigated. As is discussed in Appendix 3, Barrell, Davis, Karim and Liadze (2009b) demonstrate that liquidity effects are present in the mark up of corporate borrowing costs over risk free rates in the US, but the regulatory regime in the UK meant that they played no role. In the US the effect of an increase in liquid assets on bank lending charges was almost half of the size of the effect of a change in capital adequacy levels. This difference reflects their balance sheet positions, as liquid assets achieve some return, albeit lower than illiquid assets, and it is this difference that is the cost of holding them. The cost of holding capital assets is not offset in the same way. In our evaluations below we use these results to calibrate an effect of changes in liquid assets ratios in the UK.

Capital Adequacy

In order to evaluate the impacts of capital (and liquidity) requirements we have to have a complete banking sector balance sheet for assets and we have to model the adjustment of bank capital adequacy either through the adjustment of lending or through the accumulation of additional capital. The unweighted balance sheet (*bbal*) is only one of the definitions that are relevant for the analysis of the impacts of regulation on the UK. It includes our three categories of lending along with liquid assets (*brla*), and it may be written as

$$bbal = corpl + morth + cc + brla \qquad (22)$$

The equilibrium of the balance sheet structure depends upon the impact of factors on the price charged and on the factors that affect the demand equations that in turn depend on prices. If all impacts of, say, *levrr* were the same in all price equations and all elasticities of demand in our quantity equations were the same then a change in *levrr* would leave the proportionate structure of the portfolio unchanged. These price and cost effects are not equal. In order to analyse the portfolio adjustment process in response to a shock we also have to take the risk weighted balance sheet, *bbalwa*, where coefficients are the risk weights from Basel 1, which prevailed for the estimation sample, and can be seen as broadly in line with Basel 2 weights for simulations.

$$bbalwa = corpl + 0.5 \times morth + cc + 0.1 \times brla \qquad (23)$$

If the authorities were to increase the amount of regulatory capital required to be held by banks then it would raise costs and change the scale and structure of the balance sheet. If *levrrt* (and hence *levrr*) were to be raised by one percentage point then our modelling of costs and of the demand for loans etc. would suggest that the size of the bank's balance sheet (*bbal*) would fall by 1.2 per cent. However, the elasticities differ across risk categories, and hence the scale of risk weighted assets falls by 1.6 per cent as banks shift into less risky assets as a result of the increase in costs that follows on from the rise in regulatory capital requirements. This is consistent with the differences observed in Francis and Osborne (2009b) highlighted above.

If there is a shock to any of the assets of the banking system then *levrr* will change, and banks will be obliged to adjust either their capital or their asset structure. Capital can either be raised by rights issues or by absorbing some of the gross operating surplus of the system. The first line in (24) gives the speed of adjustment for bank capital. As *levrr* is the risk-weighted ratio of capital to assets, or *bcap* divided by risk-weighted assets, *brwa*, we can calibrate the adjustment of *bcap* in line with the speeds of adjustment discussed in Osborne (2008). We multiply the shortfall indicator in the first line by 1.5 to achieve this. If *levrr* is below its normal level,[19] given the desired level of headroom, *b*, some of it will be used to rebuild bank capital and increase headroom, and operating margins on consumer lending will be increased. The gross operating surplus of the banking system is the gross margin on the three types of lending multiplied by the total value of the stock of the particular category of lending, and this is the second line in the expression below.

$$bcap = bcap(-1) + ((1-(levrr(-1)/levrrt(-1)+b))) \times 1.5 \times \\ ((lendw(-1)/400) \times (morth(-1)+cc(-1)) + (corpw(-1)/400) \times corpl(-1)) \qquad (24)$$

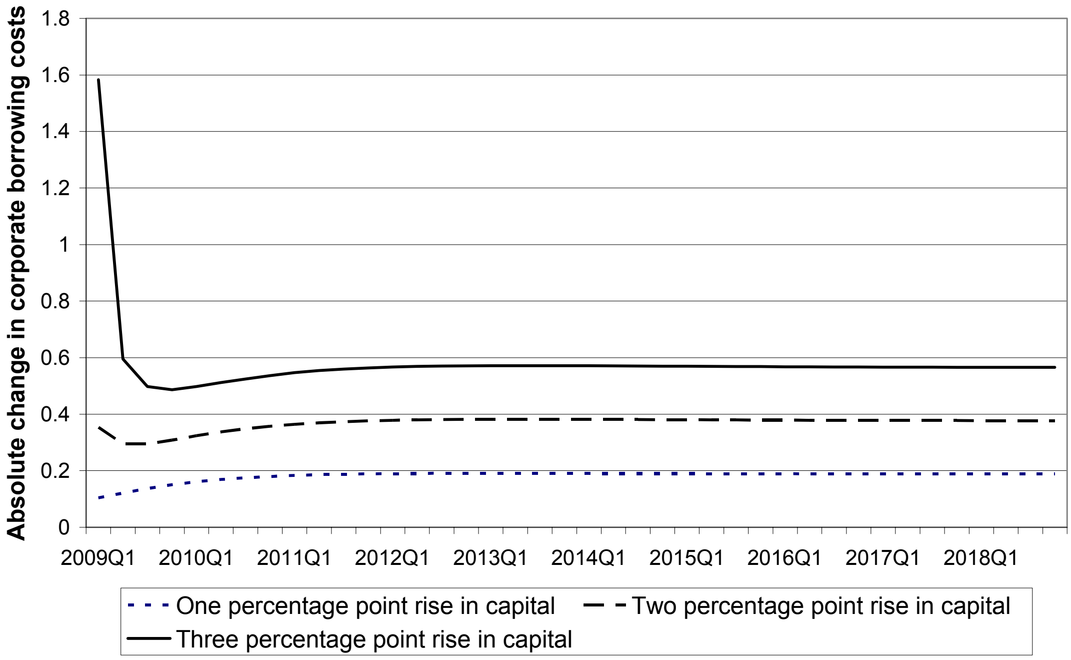
Changes in the speed of adjustment in this equation change the short run, but not the long run, effects of changes in capital adequacy targets.

Bank Regulation in NiGEM

We can utilise these equations in our global macro model NiGEM to evaluate the costs of increased bank regulation. NiGEM, which is described in Appendix 1, is a large scale, global structural model with forward-looking exchange, financial and labour markets. Inflation is determined by a monetary policy rule. The production function is of the form shown in equation (2) above, and labour inputs, factor prices, technical progress and the parameters of the production function determine the level of output in the medium term. Investment decisions run off the cost of capital and there is no evidence for quantity or credit rationing effects in the model. Investment decisions look four years forward and follow from the production function and the cost of capital, whilst the rest of demand is driven by consumption, trade and government behaviour.

[19] Normally *levrr* / (*levrrt* + *b*) would be approximately 1.0, and over our sample period *b* has averaged around 3.0. If banks hold their desired headroom capital then none of the operating surplus will be used to augment it.

Figure 7: Impacts of increases in capital and liquidity targets on corporate bank borrowing margins in the UK (NiGEM simulations)

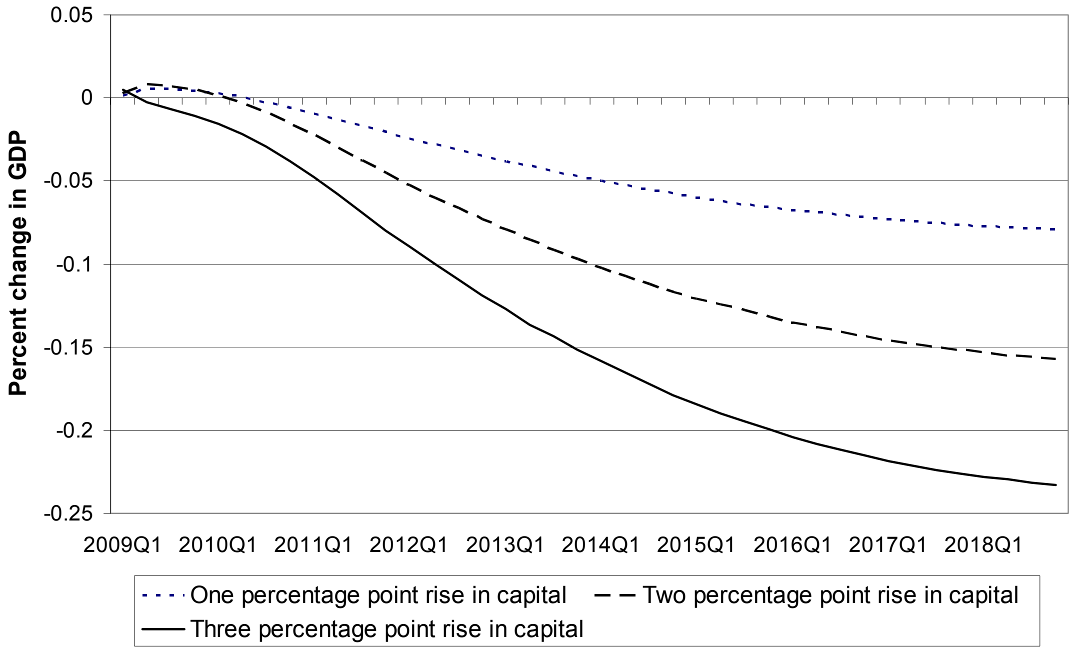


Although changes in borrowing costs may change consumer behaviour, this will be reflected in the current account rather than in the level of output, at least in small open economies. The consumption equations are discussed in Barrell and Weale (2009) and are derived from Barrell and Davis (2007), and they have a role for the level and changes in real housing and financial wealth as well as for income, and they have an inter-temporal elasticity of consumption of around one half. There is no evidence in these equations for a role for bank borrowing on its own, although such borrowing does seem to move in line with real housing wealth, which is included.

Bank borrowing costs, and their follow-on effects on corporate bond costs, affect the user cost of capital on the model, and hence also affect the level of investment and in the long run the equilibrium capital stock. We undertake three experiments, raising the capital adequacy target ratio by 1 percentage point, then by two percentage points and finally by three percentage points. Banks build up the increased assets they need by raising their charges and increasing their retentions from their profit margins. The effects on bank's corporate margins are plotted in Figure 7. Whereas it is clear that they are not large, nevertheless the three point rise in capital requirements takes banks close to their regulatory target and hence causes them to raise spreads significantly which has the effect of rationing lending and enabling extra retentions to be accumulated.

As banks move closer to the regulatory target, bank borrowing costs would rise even more significantly, and the output effects would rise noticeably. In a banking crisis capital is eroded by losses, and banks move extremely close to their regulatory target, and hence start putting up borrowing costs and rationing credit to ensure they stay within target. These actions would generate a sharp recession. They are not the main focus of this paper. These changes in the user cost impact on the level of the capital stock in equilibrium and hence on the equilibrium level of output, as we can see from figure 8. A one percentage point rise in the target level of the capital adequacy ratio and in the liquidity ratio will reduce equilibrium output by around 0.08 per cent in the UK. As we can see, the effects are approximately linear as we increase the target for capital and liquidity.

Figure 8: Impacts of increases in capital and liquidity targets on output in the UK



Source: NiGEM simulations

Changing regulation can take several forms, and the authorities may insist that target and actual capital both change together, and they may also separately (or jointly) require increases in liquid assets as a ratio of total assets. It is harder for us to simulate a rise in required liquid assets than an increase in target capital, as we found no evidence for liquidity effects in the UK *corpw* and *lendw* equations. This reflects the absence of binding regulatory requirements during our estimation period. However, as noted above, Barrell, Davis, Karim and Liadze (2009) have undertaken a cross country analysis of the effects of capital adequacy and liquidity requirements, and their equation for *corpw* in the US is reported in Appendix 3. They find a clear role for liquidity effects with a coefficient of around half the size of the capital adequacy effect, which is in turn very similar in size to that in the UK *corpw* equation above. We may use this scaling factor to undertake some simple evaluations of the impacts of raising liquidity requirement in the UK.

Our estimates of the effects on GDP of changes in capital and liquidity targets in this section and the next should perhaps be seen as upper bounds, because we assume that relative quantities will not change, and that price relativities will stay the same. In our dataset, the cost of bank and bond borrowing move together, and we assume that this relationship would be maintained. However, for large changes in bank regulatory capital this may not be the case, as the change in bank costs reduces bank lending, and the supply of bond finance may not alter as much. This would suggest that borrowing costs from banks would rise more than borrowing costs using bonds, and hence the user cost of capital will rise by less than we might suggest.

In addition, if borrowing costs rise significantly then there should be a shift out of borrowing into issuing equities, and hence the user cost of capital will not rise by as much as it would if there were no substitution.

If prices do not rise together in response to large changes in capital adequacy targets, and if substitution into equities does take place, the effects on output would be smaller than we suggest. As about half of UK investment is equity financed, a one percentage point rise in bank lending costs would, all else equal, raise the user cost by around half a percentage point. If this one point rise were to be reflected in a half point rise in bond borrowing costs, and if it induced a substitution of about 15 percent of total financing out of borrowing into equities then the user cost of capital would rise by half that suggested. Hence the output effects would be half the size, and this would change our cost benefit calculations noticeably.

6. A simple cost benefit analysis of tighter regulation

Changing capital and liquidity ratios changes the probability of financial crises, and crises have clear costs for the economy when they are on the scale of that we have seen in the last two years. Hence we can calculate the expected gross gain from increasing capital and liquidity standards, and we can compare it to the gross costs in terms of output. If we were to take the net present value of all costs and benefits from tighter regulation we would have to take account of the costs incurred during a post crisis recession. This would require us to analyse the effects of changes in capital and liquidity on all bank costs and hence on the path of consumption and investment over the short term. The short term costs of a crisis may be significant, and they are likely to be negative and could outweigh any other costs.

The flow costs of the crisis may be written as the difference between what output would have been at time t (yp_t) if there had been no crisis less the output seen after the crisis (yc_t). If this is multiplied by the change in the probability of the crisis occurring that would flow from a policy action such as tightening capital adequacy before the crisis, then the gross benefit at time t from a tightening of regulations of scale j (b_{jt}) may be written as

$$b_{jt} = \text{dprob}_j \times (yp_t - yc_t) \tag{25}$$

The probabilities can be taken from Table 2 above, whilst the trajectories for output can be taken from the data underlying Figure 2 above. As is also discussed, these probabilities may be seen as rather high estimates of the probability of preventing the loss of output we expect, even if they are reasonable estimates of the probability that improved policy would prevent crises. There are two aspects we should take account of. Firstly the recession around any long run trend may not have been preventable by policy in the UK, as it has been driven in part by a collapse in world trade induced by crises in other countries. Secondly, the rise in risk premia we have seen in the last two years has been seen in most OECD countries as risk was being under priced. Our cost and benefit calculations should look at both these caveats.

There are many uncertainties about the scale of the impact of the crisis on sustainable output, as is clear from the probability bounds around the projection in Figure 2. Barrell and Kirby (2009) suggest that of the 5 percent scar on the level of output, around two percent is accounted for by factors that we should not include in our costs. Up to three-quarters of a percent might come from changes in patterns of migration and their effects on the working population, as is discussed in Barrell et al (2009). If the population shrinks then both output and consumption should decline in similar proportions so welfare per person should not be (much) affected. Hence we should not include this loss of output as a cost in our calculations.

Lower value added in the financial services sector is also a contribution to lower GDP in future. Weale (2009) suggests that somewhere between one and two percentage points of the apparent loss in output could come from the treatment of value added in the financial sector. Capital gains were being recorded as a source of income and hence paid out as part of GDP, but the matching losses were not subsequently included in income. Going forward we can expect many fewer opportunities for the financial services industry to turn such gains into recorded income, and hence the trajectory for GDP will be lower. This results from a misclassification of income, not a loss of output, and hence is not reflected in lower welfare. As a consequence we should not include this loss in our costs of the crisis.

If we are to undertake a full cost benefit analysis we need to evaluate the costs of policy actions, which could have been taken at the start of 2007, for instance, which we may call c_{jt}. Table 4 gives estimates of the effects of raising capital adequacy standard and liquidity requirements on corporate bank borrowing costs and on the user cost of capital using simulations from NiGEM including the banking sector model above. We have assumed that the new targets for capital ratios or liquidity standards are immediately achieved, and hence capital ratio targets are achieved either by a rights issue or by an injection of capital by the state.

Table 4: Impacts on borrowing costs of increases in regulatory constraints

	Changes in Capital and liquidity Requirements			
	Corporate borrowing costs (absolute change)			
Year	**One percentage point increase**	**Two Percentage point increase**	**Three percentage point increase**	**Four percentage point increase**
1	0.29	0.59	0.88	1.17
2	0.29	0.58	0.87	1.17
5	0.29	0.58	0.87	1.16
10	0.29	0.58	0.87	1.16
	User cost of capital (percent change)			
1	0.63	1.26	1.88	2.50
2	0.77	1.54	2.28	3.02
5	0.85	1.70	2.52	3.33
10	0.85	1.70	2.50	3.30
	Changes in Liquidity Requirements			
	Corporate borrowing costs (absolute change)			
1	0.10	0.19	0.29	0.39
2	0.10	0.20	0.30	0.40
5	0.11	0.22	0.33	0.43
10	0.11	0.23	0.34	0.45
	User cost of capital (percent change)			
1	0.21	0.42	0.63	0.84
2	0.27	0.53	0.79	1.05
5	0.32	0.64	0.93	1.23
10	0.33	0.67	0.97	1.27

The effects on output of the rise in the user cost of capital come through relatively slowly, as can be seen from Figures 9 and 10. The first figure plots the effects of raising capital and liquidity standards together, much as would be suggested by our logit analysis above, whilst the second chart plots the smaller output effects of raising capital adequacy standards in the UK on their own. We do not report on the impacts of raising liquidity, in part because of the lack of liquidity regulation in the UK over the past decade. The liquidity impacts we use in Figure 9 come from a relationship calibrated from US data whilst our results on the impacts of capital adequacy alone come from our modelling of the current UK banking market. In the long run a one percentage point increase in capital and liquidity adequacy requirements raises the user cost of capital by 0.85 percent and hence reduces sustainable output in the UK by 0.12 percent. About a third of this comes from our assumption that the effects of liquidity regulation on bank lending margins in the UK would be similar to that in the US. If we were to raise capital adequacy provisions alone then the effects then output would be reduced by the amounts plotted in Figure 10.

Figure 9: Output effects of increases in regulatory capital and liquidity

Percentage points increase

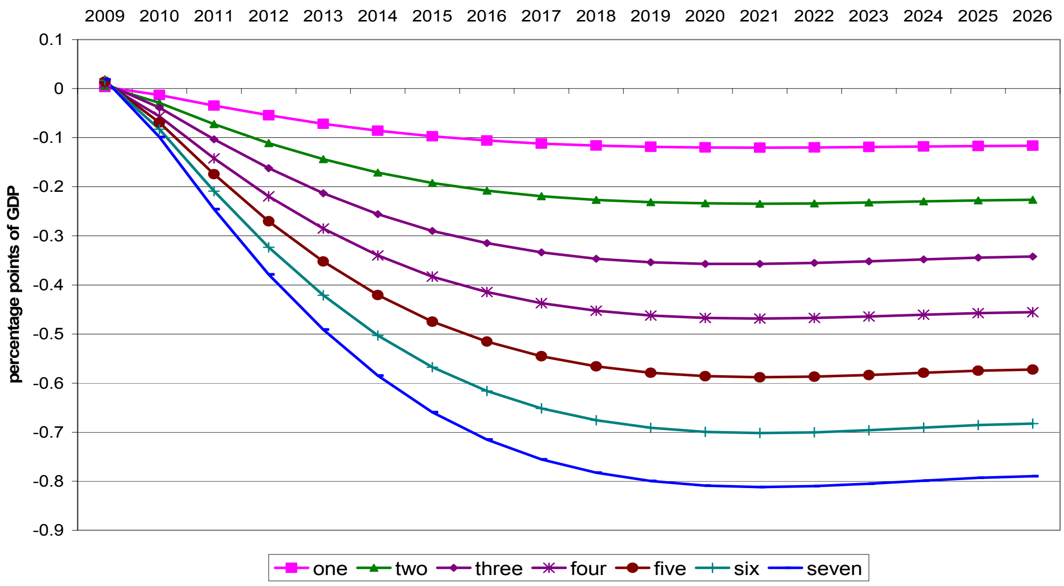
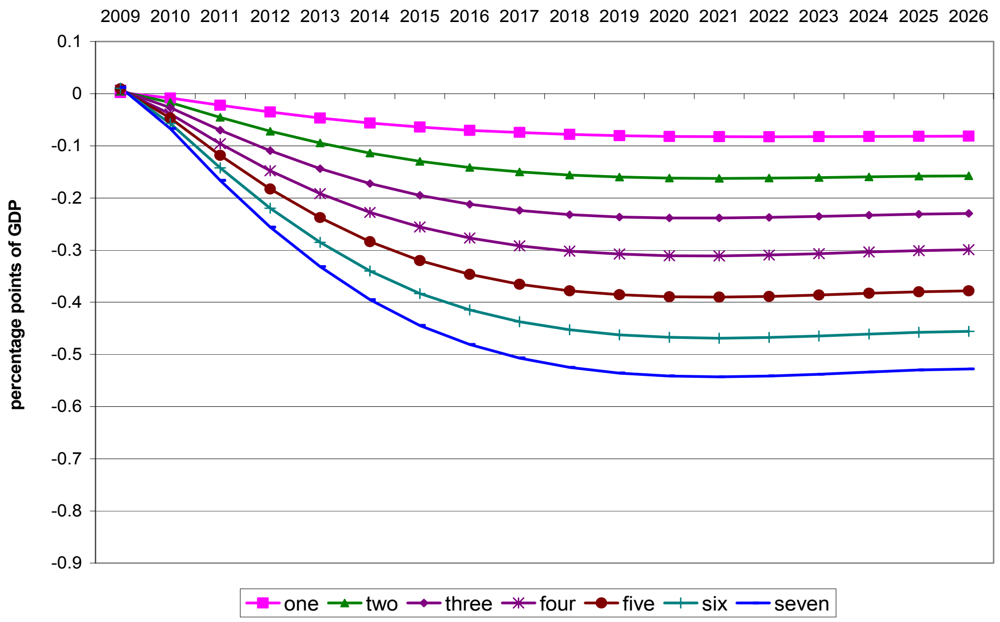


Figure 10: Output effects of increases in regulatory capital

Percentage points increase



Our cost benefit calculations take the net present discounted value of the difference between b_{jt} and c_{jt} using a real discount factor (rr) of three percent. We write this as

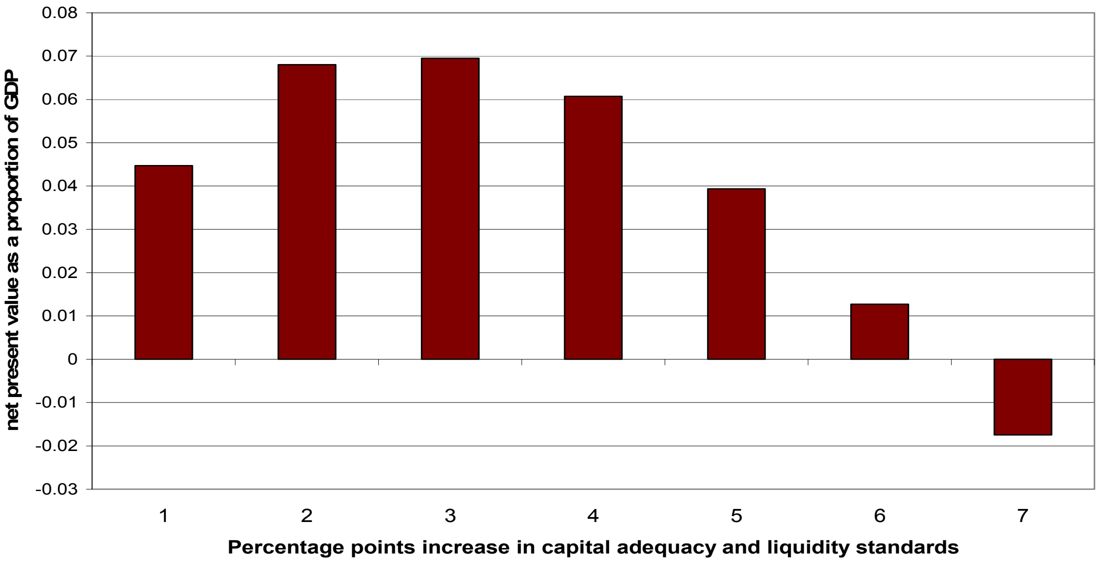
$$NPV_j = \sum_{t=1} (b_{jt} - c_{jt}) / (1 + rr)^t \qquad (26)$$

We undertake this analysis by raising capital and liquidity requirements by one, two, three, four, five, six and seven percentage points, and as we can see from Table 4 the increases in costs are approximately linear. However, as is clear from Table 2, the reduction in the probability of a crisis is not linear, and as the regulatory requirements are increased the gain for each incremental tightening declines, although it is always positive.

Figure 11 plots the net gain from tighter regulation for the UK using all our base case assumptions. Trend output is assumed to be reduced by three percent in the long run, and where output falls more than this the costs are included in our calculations. The cost benefit analysis suggest that the gains from tighter regulation in the UK would have been positive for up to six percentage points increase in capital and liquidity standards. The gains are at their largest for a three percentage point increase, where they would come to a cumulated 7 percent of 2009 GDP.

Figure 11: A cost benefit analysis of increased capital and liquidity standards

Cumulated gains as a proportion of GDP



There are a number of factors that affect the 'optimal' increase in capital and liquidity, and Table 5 details some alternative scenarios and the first row replicates the numbers in Figure 11. The second row assumes that the recession could not have been halted by policy, but the 3 percent scar could have been. In that case, an increase in capital adequacy and liquidity requirements of up to only 2 percentage points would have been beneficial. We have also argued that our estimate of costs must be seen as an upper bound, and that they could be half the level we estimate, especially for larger changes in capital and liquidity requirements, as a result of firms reducing their reliance on banks because of increased borrowing costs and hence issuing more bonds and equities than they otherwise would have done. It may also be the case that policy changes could then be less effective in bearing down on asset price bubbles and thereby reducing the probability of crisis, so the benefits would be lower, although it is difficult to estimate how large this reduction in benefits may be. In any case, as benefits increase at a declining rate but costs rise roughly linearly in the range considered, any reduction in both benefits and costs could lead to different outcomes in terms of the policy change that produces the highest expected net benefits and the largest policy change from which net benefits are expected to be derived. To assess this, the third row of table five adjusts the base case by halving the original reduction in the probability of crisis and subtracting only half of the original estimate of costs. The ranking of policy changes remains the same, indicating that in this sense our results are relatively robust. We could also repeat the table with different discount rates, as we see a three percent rate as a minimum, with higher rates strengthening the case for increased capital adequacy as a higher discount rate puts a lower benefit on the long run costs of increased regulation as well as on the scar effect, and puts more weight on to the shorter run effects.

Table 5: The cumulated effects on output of raising regulatory standards.

New present value of policy as a proportion of 2009 GDP

Capital adequacy and liquidity increased **Percentage**	**1 point**	**2 points**	**3 points**	**4 points**	**5 points**	**6 points**	**7 points**
Base assumptions	0.045	0.068	0.070	0.061	0.039	0.013	*-0.017*
Long run effects alone	0.010	0.009	*-0.007*	*-0.028*	*-0.057*	*-0.088*	*-0.122*
Base except half probs and costs	0.022	0.034	0.035	0.030	0.020	0.006	*-0.009*
Capital adequacy increased							
Base assumptions	0.038	0.063	0.077	0.083	0.080	0.070	0.057
Long run effects alone	0.011	0.016	0.014	0.007	*-0.006*	*-0.022*	*-0.040*
Liquidity increased							
Base assumptions	0.008	0.012	0.017	0.017	0.021	0.018	0.017
Long run effects alone	*-0.002*	*-0.007*	*-0.010*	*-0.019*	*-0.022*	*-0.031*	*-0.039*

Base case. Crisis scarring 3 percent in the long run, all cycle caused by the financial crisis, social discount factor 3%

It is also possible to evaluate the effects of raising capital adequacy and liquidity requirements separately. As we can see from the first row of the capital adequacy experiments, there always seem to be net benefits, although they are declining from a peak of a 4 percentage point increase. If we limit the benefits to the long run effects only, and allocate the cycle to other effects then there would still be gains to be had from raising capital adequacy by 4 percentage points. As liquidity levels were so low in the UK, it is not clear what impact that changes in these alone might have, but two rows for increased liquidity in Table 5 suggest the impact of raising these on their gains would not be large. However, the average effect of liquidity on crisis probability from our logit regression may not fully capture the gains from increased liquidity in the UK, as the effect reflects the average of past crises, whereas the 2007 to 2008 crisis was much more a liquidity crisis than those in our data set, especially in the UK, as Shin (2009) argues.

7. Conclusions

Our research on the determinants of banking crisis suggests that raising capital adequacy standards and introducing binding liquidity requirements can have beneficial effects if they reduce the probability of a costly financial crisis. This should not mean that regulation can be tightened with impunity as any banking regulation that is effective can be described and analysed as a tax on bank activity. Hence regulations may reduce output through their impacts on borrowing costs for households and companies. There is clear evidence for the UK that capital adequacy standards impact on the margin between borrowing and lending rates for both consumers and firms. Increased consumer borrowing margins reduce personal incomes and change consumption decisions. Increased corporate borrowing costs impact on the user cost of capital and hence on equilibrium or sustainable output. Our analysis suggest that markets for corporate borrowing work, in that increases in bank borrowing costs spill over to the corporate bond market, and an equilibrium balance of sources of funds is obtained after any change in regulation. Our estimates of the impacts on costs can be seen as an upper bound as the structure of portfolios and of relative prices may change if regulations significantly increase capital and liquidity requirements.

We also note that when capital adequacy standards are tightened by one percentage point, banks contract their balance sheets by 1.2 per cent and also reduce the riskiness of their portfolio, with their risk weighted assets falling by 1.6 per cent, consistent with Francis and Osborne (2009b). It is clear that regulation changes the structure of bank portfolios, and these results are contrary to the Modigliani Miller theorem of irrelevance of the debt equity choice[20].

We have estimated and compared the benefits and costs of raising capital and liquidity requirements, with the benefits being in terms of reduction in the probability of banking crises, while the costs are defined in terms of the economic impact of higher spreads for bank customers. There is of course a significant amount of uncertainty around our results, and we have presented variants to our main cost benefit analysis to take account of this uncertainty. Our results show a positive net benefit from regulatory tightening, with a 2 to 6 percentage point increase in capital and liquidity ratios increasing welfare, depending upon assumptions.

[20] The coefficients in our banking sector cost equations are broadly consistent with the impact of tax deductibility of bond interest payments on costs given the choice between extra lending and extra liquidity when capital is increased.

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Appendix 1: The Structure and Use of the NiGEM Model

For a macroeconometric model to be useful for policy analyses, particular attention must be paid to its long-term equilibrium properties. At the same time, we need to ensure that short-term dynamic properties and underlying estimated properties are consistent with data and well-determined. As far as possible, the same long run theoretical structure of NiGEM has been adopted for each of the major industrial countries, except where clear institutional or other factors prevent this. As a result, variations in the properties of each country model reflect genuine differences in data ratios and estimated parameters, rather than different theoretical approaches. The model has been in use at the National Institute since 1987, but it has developed and changed over that time. Some of its development was initially financed by the ESRC, but since 1995 it has been funded by its user community of public sector policy institutions. These currently include the Bank of England, the ECB, the IMF, the Bank of France, the Bank of Italy and the Bundesbank as well as most other central banks in Europe along with research institutes and finance ministries throughout Europe and elsewhere.

Each quarter since 1987 the model group has produced a forecast baseline that has been published in the Institute *Review* and used by the subscribers as a starting point for their own forecasts. The forecast is currently constructed and used out to beyond 2031 each quarter, although the projection beyond 2015 is a stylized use of the long run properties of the model. Since 1998, the model has also been used by the EFN Euroframe group to produce forecasts for the European Commission. Forecasts are produced based on assumptions and they do not always use forward looking behaviour. In policy analyses the model can be switched between forward looking, rational expectations mode and adaptive learning for consumers, firms, labour and financial markets. Policy environments are very flexible, allowing a number of monetary and fiscal policy responses. The model has been extensively used in projects for the European Commission, UK government departments and government bodies throughout the world. It has also contributed to a number of Institute ESRC projects.

Production and price setting
The major country models rely on an underlying constant-returns-to-scale CES production function with labour-augmenting technical progress.

$$Q = \gamma\left[s(K)^{-\rho} + (1-s)(Le^{\lambda t})^{-\rho}\right]^{-1/\rho} \qquad \text{(A1)}$$

where *Q* is real output, *K* is the total capital stock, *L* is total hours worked and *t* is an index of labour-augmenting technical progress. This constitutes the theoretical background for the specifications of the factor demand equations, forms the basis for unit total costs and provides a measure of capacity utilization, which then feed into the price system. Barrell and Pain (1997) show that the elasticity of substitution is estimated from the labour demand equation, and in general it is around 0.5. Demand for labour and capital are determined by profit maximisation of firms, implying that the long-run labour-output ratio depends on real wage costs and technical progress, while the long-run capital output ratio depends on the real user cost of capital

$$Ln(L) = \left[\sigma \ln\{\beta(1-s)\} - (1-\sigma)\ln(\gamma)\right] + \ln(Q) - (1-\sigma)\lambda t - \sigma \ln(w/p) \qquad \text{(A2)}$$

$$Ln(K) = \left[\sigma \ln(\beta s) - (1-\sigma)\ln(\gamma)\right] + \ln(Q) - \sigma \ln(c/p) \qquad \text{(A3)}$$

where *w/p* is the real wage and *c/p* is the real user cost of capital. The user cost of capital is influenced by corporate taxes and depreciation and is a weighted average of the cost of equity finance and the margin adjusted long real rate, with weights that vary with the size of equity markets as compared to the private sector capital stock. Business investment is determined by the error correction based relationship between actual and equilibrium capital stocks. Government investment depends upon trend output and the real interest rate in the long run. Prices are determined as a constant mark-up over marginal costs in the long term.

Labour market

NiGEM assumes that employers have a right to manage, and hence the bargain in the labour market is over the real wage. Real wages, therefore, depend on the level of trend labour productivity as well as the rate of unemployment. Labour markets embody rational expectations and wage bargainers use model consistent expectations. The dynamics of the wage market depend upon the error correction term in the equation and on the split between lagged inflation and forward inflation as well as on the impact of unemployment on the wage bargain (Anderton and Barrell 1995). There is no explicit equation for sustainable employment in the model, but as the wage and price system is complete, the model delivers equilibrium levels of employment and unemployment. An estimate of the NAIRU can be obtained by substituting the mark-up adjusted unit total cost equation into the wage equation and solving for the unemployment rate. Labour supply is determined by demographics, migration and the participation rate.

Consumption, personal income and wealth

Consumption decisions are presumed to depend on real disposable income and real wealth in the long run, and follow the pattern discussed in Barrell and Davis (2007). Total wealth is composed of both financial wealth and tangible (housing) wealth where the latter data is available.

$$\ln(C) = \alpha + \beta \ln(RPDI) + (1-\beta)\ln(RFN + RTW) \qquad \text{(A4)}$$

where *C* is real consumption, *RPDI* is real personal disposable income, *RFN* is real net financial wealth and *RTW* is real tangible wealth. The dynamics of adjustment to the long run are largely data based, and differ between countries to take account of differences in the relative importance of types of wealth and of liquidity constraints. As Barrell and Davis (2007) show, changes in financial (dln*NW*) and especially housing wealth (dln*HW*) will affect consumption, with the impact of changes in housing wealth having five times the impact of changes in financial wealth in the short run. They also show that adjustment to the long run equilibrium shows some inertia as well.

$$\mathrm{dln}\,C_t = \lambda\left(\ln C_{t-1} - \ln PI_{t-1}\right) + b_1\,\mathrm{dln}\,RPDI_t + b_2\,\mathrm{dln}\,NW_t + b_3\,\mathrm{dln}\,HW_t \qquad \text{(A5)}$$

Al Eyd and Barrell (2005) discuss borrowing constraints, and investigate the role of changes in the number of borrowing constrained households. It is common to associate the severity of borrowing constraints with the coefficient on changes in current income (dln*RPDI*) in the equilibrium correction equation for consumption, where d is the change operator and ln is natural log.

Financial markets

We generally assume that exchange rates are forward looking, and 'jump' when there is news. The size of the jump depends on the expected future path of interest rates and risk premia, solving an uncovered interest parity condition, and these, in turn, are determined by policy rules adopted by monetary authorities as discussed in Barrell, Hall and Hurst (2006):

$$RX(t) = RX(t+1)\left[(1+rh)/(1+ra)\right](1+rprx) \qquad \text{(A6)}$$

where *RX* is the exchange rate, *rh* is the home interest rate set in line with a policy rule, *ra* is the interest rate abroad and *rprx* is the risk premium. Nominal short term interest rates are set in relation to a standard forward looking feedback rule. Forward looking long rates are related to expected future short term rates:

$$\left(1+LR_t\right) = \prod_{j=1}^{T}\left(1+SR_{t+j}\right)^{1/T} \qquad \text{(A7)}$$

We assume that bond and equity markets are also forward looking, and long-term interest rates are a forward convolution of expected short-term interest rates. Forward looking equity prices are determined by the discounted present value of expected profits

Public sector

We model corporate (*CTAX*) and personal (*TAX*) direct taxes and indirect taxes (*ITAX*) on spending, along with government spending on investment and on current consumption, and separately identify transfers and government interest payments. Each source of taxes has an equation applying a tax rate (*TAXR*) to a tax base (profits, personal incomes or consumption). As a default we have government spending on investment (*GI*) and consumption (*GC*) rising in line with trend output in the long run, with delayed adjustment to changes in the trend. They are re-valued in line with the consumers' expenditure deflator (*CED*). Government interest payments (*GIP*) are driven by a perpetual inventory of accumulated debts. Transfers (*TRAN*) to individual are composed of three elements, with those for the inactive of working age and the retired depending upon observed replacement rates. Spending minus receipts give us the budget deficit (*BUD*), and this flows onto the debt stock.

$$BUD = CED \times (GC + GI) + TRAN + GIP - TAX - CTAX - MTAX \tag{A8}$$

We have to consider how the government deficit (*BUD*) is financed. We allow either money (*M*) or bond finance (*DEBT*):

$$BUD = \Delta M + \Delta DEBT \tag{A9}$$

and rearranging gives:

$$DEBT = DEBT_{t-1} - BUD - \Delta M \tag{A10}$$

In all policy analyses we use a tax rule to ensure that Governments remain solvent in the long run (Barrell and Sefton 1997). This ensures that the deficit and debt stock return to sustainable levels after any shock. A debt stock target can also be implemented. The tax rate equation is of the form:

$$TAXR = \mathrm{f}(\text{target deficit ratio} - \text{actual deficit ratio}) \tag{A11}$$

If the Government budget deficit is greater than the target, (e.g. -3 % of GDP and target is -1% of GDP) then the income tax rate is increased.

External trade

International linkages come from patterns of trade, the influence of trade prices on domestic price, the impacts of exchange rates and patterns of asset holding and associated income flows. The volumes of exports and imports of goods and services are determined by foreign or domestic demand, respectively, and by competitiveness as measured by relative prices or relative costs. The estimated relationships also include measures to capture globalization and European integration and sector-specific developments. It is assumed that exporters compete against others who export to the same market as well as domestic producers via relative prices; and demand is given by a share of imports in the markets to which the country has previously exported. Imports depend upon import prices relative to domestic prices and on domestic total final expenditure. As exports depend on imports, they will rise together in the model. The overall current balance depends upon the trade balance and net property income from abroad, which comprised flows of income on gross foreign assets and outgoings on gross foreign liabilities. Gross National Product (*GNP*) is gross Domestic Product (*GDP*) plus net factor income from foreigners.

Appendix 2: Tests for orders of integration and cointegration

All variables used in the analysis were initially checked for stationarity. Augmented Dickey-Fuller (ADF) tests were applied to each series separately and variables were tested for the presence of a unit root. If presence of a unit root could not be rejected, then series were differenced and checked again for stationarity. Test results are illustrated in Table A.2.1 below. It is clear that only in case of the corporate wedge (*corpw*) and the credit risk (investment) premium (*iprem*) can we reject the null hypothesis of a presence of a unit root; all other variables can be considered as non-stationary and integrated of order one (I(1)). If a dependant variable is non-stationary then a corresponding cointegrating combination of independent variables is found and the variable is modelled in error correction form. To make sure that there is a true long-run relationship between variables, residuals from estimated cointegrating relationships are checked for stationary as well (Table A.2.2). Table A.2.3 finally shows a break test on the corporate wedge (*corpw*) and investment premium (*iprem*) series.

Table A.2.1: Test statistics from ADF unit root test results for series stationarity

lendw	*level*	*first difference*
uklendw	-0.79	-5.89
uknwpi	-1.54	-5.37
uklevrr	-2.38	-3.62
ukarr	-2.09	-3.49

ccrate	*level*
ukccrate	-1.59
ukint	-2.18
uklendw	-0.79

rmort	*level*	*first difference*
ukrmort	-1.23	-4.94
uklendw	-0.79	-5.89
ukint	-2.18	-5.83

cc	*level*
log(ukcc/ukced)	-1.99
log(ukrpdi)	-0.51
ukrccrate	-6.35

Note: ukrccrate=ukccrate - ((ukced/ukced(-1))^4-1)

morth	*level*	*first difference*
log(ukmorth/ukced)	-0.85	-3.72
log(ukph/ukced)	-0.92	-4.75
log(ukrpdi)	-0.51	-6.34
ukrrmort	-1.92	-5.79

*Note: ukrrmort=ukrmort - (ukced(+1)/ukced(-1)-1)*400*

corpl	*level*
log(ukcorpl/ukced)	-0.62
uklrr	-1.58
log(ukgprc/ukced)	-0.12
ukcorpw	-2.76

iprem		
	level	*first difference*
iprem	-3.55	-
corpw	-2.76	-

Table A.2.2: Long – run properties of single equations – ADF test statistics of unit root test results on residuals

	t-test
lendw_lr	-4.03*
rmort_lr	-4.47***
corpl_lr	-3.81**
morth_lr	-3.88***
ccrate_lr	-3.86**
cc_lr	-4.00***

Note: tests include constant and are conducted in levels

Table A.2.3: Probabilities from ADF test stationarity test results, including break test

	without break dummy	with break dummy
ukiprem(-1)	0.053	0.000
ukcorpw(-1)	0.226	0.022

Note: Both variables are in monthly frequency. And are denoted *ukiprem* and *ukcorpw* to distinguish them from the model variables

Appendix 3: US corporate borrowing costs

In the paper by Barrell, Davis, Karim and Liadze (2009) the effects of capital adequacy and liquidity in determining bank borrowing costs are assessed in the case of the US. Borrowing costs from banks (which are defined as a difference between borrowing and deposit rates for non financial corporations (*corpw*)) are analysed against explanatory variables such as corporate insolvency (*insolvr* – an insolvency rate), the ratio of liquid to total assets (*liqr*), the non-risk weighted capital adequacy ratio (*levrr*) and an inverse of the difference between this variable and a measure of a target for capital adequacy (*invhead*). Table A.2.1 reports on the stationarity properties of the variables. Given the short data periods for some series and the nature of the variables the authors were willing to accept evidence of stationarity at the 10 per cent level.

Table A.3.1: Test statistics from unit root test results on individual series

	Variables in levels	*Variables in first differences*
CORPW	*-2.755**	-
INSOLVR	*-2.431*	*-2.929***
LEVRR	*-0.692*	*-3.903****
INVHEAD	*-4.316****	-
LIQR	*-1.866*	*-4.260****

Note: *, **,*** indicate significance at 10%, 5% and 1% levels

As our dependent variable is stationary and three of the driving variables are stationary in first differences we require that those three form a cointegrating set with a stationary residual before we can include them in the regression. A Johansen test showed this to be the case. The estimated equation for the US was (t stats in brackets):

$$\underset{}{corpw} = \underset{(4.06)}{-0.88} + \underset{(12.42)}{0.18 \times levrr(-1)} + \underset{(8.88)}{0.09 \times liqr(-1)} \qquad \text{(A12)}$$

Sample: 1988Q1–2008Q1

Residuals from the final specification are stationary with an Augmented Dickey-Fuller test (presence of a unit root is rejected at least at 10% significance level (t stat 3.83)). Capital adequacy and the liquid asset ratio play a significant role in determining the corporate borrowing mark-up set by banks in the US. The insolvency rate was found to be insignificant in explaining corporate wedge, which may be attributed to the peculiarity of a bankruptcy low in the US. *invhead* – the difference between actual and target capital, has no effect on the corporate wedge in our analysis as well. As spare capital disappears lending charges would rise relative to deposit rates in order to ration funds and also recoup capital from an increased gross operating surplus. The absence of this indicator in the US may suggest that over given data period it was operating with adequate spare capital for the majority of the time.

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