Assessing state support to the UK banking sector

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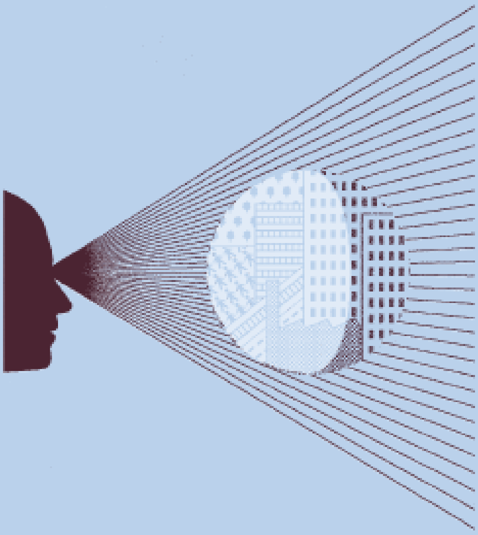

This report has been researched and written by Oxera on behalf of RBS. The report does not necessarily reflect the views of RBS.

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Executive summary

The recent financial crisis has raised important questions about the sources of systemic risk and the implications of state support available to banks. Specific concerns have been raised about banks that are perceived as ‘too big to fail’ (TBTF) or, more generally, ‘systemically important financial institutions’ (SIFIs). The argument is that such institutions benefit from implicit state support, which in turn may create incentives for excessive risk-taking and distort competition in the banking market.

Against this background, the Royal Bank of Scotland (RBS) asked Oxera to conduct independent economic analysis of the value of state support provided to the UK financial sector.

The study considers two main questions:

- what are the sources of state support, and what is the relationship between state support and the size of banks?
- how can the value of state support be quantified, and what are plausible ranges for the value of such support to UK banks?

The objectives of the study are to stimulate the debate surrounding state support and to inform future analysis by the Independent Commission on Banking.

Rationale for state support

State support is provided to the financial system to protect it from shocks that could cause a systemic event. Therefore, to understand the underlying causes driving the need for state support, it is important to understand the sources of systemic risk in the financial sector.

Systemic risk in turn depends on both the size and the nature of shocks that lead to the risk of failure of individual institutions or parts of the system (triggers), and the system characteristics that propagate shocks through the system and exacerbate their impact (channels of contagion).

There are many triggers that can create a shock to a financial system, and many mechanisms through which a shock can have systemic implications. Correspondingly, state support can be expected to be needed in many different situations that are of a systemic nature, and not just in the context of large, universal banks.

A body of academic literature has emerged recently on the measurement of systemic risk and the contribution of individual financial institutions to this risk. None of the studies reviewed provides any strong conceptual explanation for why one would expect a relationship between size of a bank and systemic risk, or why large banks disproportionately benefit from state support. The studies that do find such a relationship seem to rely on simulations and the underlying model assumptions are not always clear.

There also does not appear to be any strong evidence on the relationship between bank sector concentration and systemic risk, or any evidence that the expectation of state support is necessarily higher in a more concentrated financial system.

Actual bailouts versus forward-looking expected value of state support

The actual payments and other forms of state support provided to bail out the banks during the recent crisis are not the same as the forward-looking expected value of state support, and cannot be taken as a measure of the extent to which different banks benefit from an implicit state guarantee—ie, a larger bailout package does not imply that a particular bank received a disproportionately larger share of the guarantee.

What matters for the analysis of potential distortions related to state support is the expectation of state support, not the actual payments by the state once a failure has occurred. The actual payments made reflect only one of many potential market outcomes—they are realisations of particular scenarios in the distribution of possible market outcomes, and a different systemic shock could have resulted in a different market outcome and corresponding allocation of payments.

A comparison could be made with an insurance contract, where the insurance premium is clearly distinguished from claims on the insurance company if the risk event occurs. When analysing potential market distortions originating from state support in the financial system, the more relevant valuation metric is the 'insurance premium' rather than the 'claim in the event'.

Valuation of state support

This report sets out a framework for how an approximate valuation of state support to a financial system could be undertaken. It can be applied to give an insight into plausible ranges of the value of such support in the UK. The approach adopted seeks to value state support as the expected payment from the state to the financial system in the event of a systemic shock. This corresponds to valuing a put option—the underlying instrument is the asset value of the financial system and the strike price corresponds to the 'systemic threshold', defined as the maximum loss of asset value that could be absorbed by the financial system in response to a shock before the state would be required to step in.

The central base-case estimate of the forward-looking state support, implied by the observed market data (September/October 2010 is the cut-off point for the analysis in this report), is 8 basis points (bp) per £1 of assets. For a system with a total asset value of approximately £7 trillion,[1] this corresponds to an annual value transfer from the state of approximately £5.9 billion.

The most important driver of the value of state support is the riskiness of the bank assets in the financial system. The above base-case estimate of state support assumes annual asset volatility in the system of 4%, based on market data, but the report also presents sensitivities for a wider range of volatilities.

The value of the state support to the system is likely to exceed the actual cost to the state of providing the support—for example, because of the avoided economic costs of financial distress. While the estimation focuses on the value transfer from state to banks in terms of the costs to the state of the support, the basic model is extended to capture in the valuation the costs of financial distress as well.

One particular measurement challenge relates to the potentially asymmetric nature of shocks to system assets and the occurrence of fat-tail events—ie, significant downside shocks may be more likely than upside shocks of a similar magnitude. The central estimate of state support is based on a model that is symmetric in nature and where the probability of fat-tail

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[1] Estimated as the sum of the market value of equity and book value of debt in September 2010 for five UK listed banks: RBS, HSBC, Barclays, Lloyds, and Standard Chartered.

events is low. If these assumptions are breached, and the asymmetry of shocks is significant, the estimates of state support presented may be biased downwards because the fat-tail risk may be underpriced (ie, the risk of an extreme negative shock is underpriced). While there is no straightforward way to control for this potential bias, an attempt has been made in this report to take it into account by adopting a conservative (ie, relatively high) base-case estimate of asset volatility. For example, flexing the estimate of asset volatility by one percentage point (which is significant, given that the central estimate of asset volatility is 4%) changes the value of state support from the central point of 8bp (and £5.9 billion per annum) to 2bp (and £1.5 billion) for the lower end of the range and 22bp (and £16.2 billion) for the upper end.

In addition, extensions to the basic model are employed that seek to take account of asymmetric shocks and fat-tail events in the valuation of the put option. At the lower end of the range (a scenario where extreme shocks are assumed to be uncorrelated), the value of the state support is estimated at 0.9bp. If a more extreme model specification were used, in which extreme shocks were assumed to be perfectly positively correlated, the value of the state support would be estimated at 15.8bp.

An alternative modelling approach is adopted to examine the value of state support at the level of individual banks (ie, valuing the individual put options on the assets of each bank). Using implied asset volatilities for five UK banks as at September 2010, the average state support for the banks is estimated to be 10.1bp. However, this approach would require further (downward) adjustment to account for the fact that idiosyncratic shocks that affect the asset value of individual banks may not all have systemic implications and may not require state support—it is only systemic shocks that require state support, which is why the basic model in this report values state support at the system level (ie, as the put option on the system assets).

Although the range of estimates is wide, also depending on the modelling assumptions, it is of note that even the upper end of the range is lower than some of the existing estimates of state support for the UK. In particular, according to Haldane (2010),[2] the implicit state subsidy in 2009 was £103 billion per year for the top five UK banks, and the 2007–09 average is estimated at £55 billion. This is substantially higher than the base-case estimates obtained in this Oxera report.

There are a number of explanations for the difference. At the conceptual level, the main difference is that the framework proposed here considers state support at the system level, which is consistent with the argument that systemic risks originate at the system level rather than at the level of individual banks. Additionally, the framework distinguishes expected state support from actual bailouts—the valuation focuses on the forward-looking expected state support, akin to the academic studies that use a contingent-claims valuation framework to value systemic risk in the financial system.

By contrast, Haldane's valuation approach attributes state support to individual banks and implicitly captures the actual support provided in the recent crisis. The approach is based on the rating uplifts given by credit rating agencies to some banks as a result of the state support received by these banks during the crisis. The views of credit rating agencies have a degree of subjectivity. Reliance on this approach would mean that, prior to the crisis, the value of implicit state support was zero (because no rating uplifts were applied). It would also imply a zero state subsidy for those banks (including large, universal banks) that have no ratings uplift. In addition, the application of the approach to different, and more recent, data results in a significantly lower estimate.

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[2] Haldane, A.G. (2010), 'The $100 billion question', comments given at the Institute of Regulation & Risk, Hong Kong, March. Similar estimates are repeated in Bank of England (2010), 'Financial Stability Report', December.

A separate question is whether the benefits of any state support actually accrue to the banks and their shareholders, as opposed to their customers for example. While outside the scope of this study, analysis of this key question is also critical to establish whether any such subsidy actually distorts banks' behaviour and competition in the banking sector (and whether such a subsidy was at the heart of the problems that led to the crisis), and, if so, what reforms can be taken to reduce such a subsidy.

The ongoing regulatory reforms would be expected to lower the value of state support in the UK financial system. The range of estimates presented in the report indicates that the impact of the current regulatory reforms and reform proposals is likely to be significant, to the extent that the loss-absorbing capacity of the system is improved (eg, due to higher capital levels and more effective resolution) or asset volatility in the system is lowered (eg, due to de-risking), as a result of such reforms.

Contents

List of tables

List of figures

1 Introduction

The recent financial crisis has raised important questions about the sources of systemic risk and the implications of state support available to banks. Specific concerns have been raised about banks that are perceived as ‘too big to fail’ (TBTF) or, more generally, ‘systemically important financial institutions’ (SIFIs).

In its Issues Paper, the Independent Commission on Banking (ICB) also links problems in the banking market with the notion of TBTF banks.[3] The argument is that such institutions benefit from state support, which may in turn create incentives for excessive risk-taking and distort competition in the banking market.

Against this background, The Royal Bank of Scotland (RBS) asked Oxera to conduct independent economic analysis of the value of state support provided to the UK financial sector. The study addresses two main questions:

– what are the sources of state support, and what is the relationship between state support and the size of banks?

– how can the value of state support be quantified, and what are plausible ranges for the value of such support to UK banks?

The objectives of the study are to stimulate the debate and inform future analysis by the ICB of state support.

The report is structured as follows.

– Section 2 considers the sources of state support and sets out why, at the conceptual level, there is no clear reason to expect that state support would necessarily accrue disproportionately to large, universal banks. Appendix 1 presents initial data observations to examine the potential relationship empirically.

– Section 3 presents a framework for estimating the expected value of state support to UK banks, as well as the plausible range of estimates based on an option valuation approach. Appendix 2 compares the analysis with existing research on state support for UK banks, and Appendix 3 is a technical appendix.

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[3] See, for example, Independent Commission on Banking (2010), ‘Issues Paper’, September, paragraph 3.6.

2 Conceptual considerations on state support

This section provides a conceptual discussion on the sources of state support, focusing on those aspects that are relevant for defining the approach used in section 3 to quantify the value of state support. It also considers the specific concern that such support may accrue disproportionately to large universal banks that are deemed to be ‘too big to fail’.

2.1 Overview of state support

There are several separate elements of guarantees or state support available to banks: direct capital support from the state; extraordinary liquidity measures such as the Bank of England Special Liquidity Scheme; the more usual liquidity support provided by central banks from time to time; and the deposit guarantee scheme provided in the UK by the Financial Services Compensation Scheme.

In the UK, the asset protection scheme for banks is due to phase out—RBS, for example, intends to exit the scheme by 2012. Also, the Bank of England Special Liquidity Scheme is expected to wind down. However, some form of central bank liquidity insurance as well as the deposit guarantee scheme can be expected to remain. As such, there is always likely to be some element of guarantee and support available to (all) banks in the UK system and elsewhere.

Other than the deposit guarantee scheme, which is mainly industry-funded, explicit support is mainly targeted at short-term liquidity and is distributed equally to all players in the system through the discount window (based on the lending institutions’ collateral pool).

This study focuses on implicit state support. It explains that such support is aimed at protecting the financial system from systemic risk, and, as such, is not aimed at protecting specific institutions, including large universal banks.

The nature and quantum of implicit state support in the financial system and how it is allocated to individual banks are complex. The allocation of actual state bailouts among banks during the recent crisis is not indicative of the extent to which these banks benefit from a state guarantee—ie, a larger bailout package does not imply that a bank necessarily received a disproportionately larger share of the guarantee. Instead, what matters for the analysis of potential distortions related to state support is the expectation of state support, not the actual payments by the state once a failure has occurred.[4]

The actual payments to different players in the event of failure are not relevant for the analysis of distortions, since they would reflect only one of many potential market outcomes—ie, the actual payments that arise are realisations of particular scenarios, and a different shock could have resulted in a different allocation of payments. Over several decades before the crisis, there were no (or few) actual payments from the state to the financial system, although there was always an expectation of such payments in a crisis scenario.

A comparison could be made with an insurance contract, where the insurance premium is clearly distinguished from claims on the insurance company if the risk event occurs. When analysing potential market distortions originating from state support in the financial system, the relevant valuation metric is the ‘insurance premium’ rather than the ‘claim in the event’.

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[4] While the conceptual distinction is important, the ex ante value of state support may be correlated with the ex post payouts.

This study looks at the expectation of state support, and seeks to estimate the expected value of state support rather than the actual payments made in the crisis.

2.2 Rationale for state support: protection against systemic risk

From a conceptual perspective, the reason for the provision of state support to the financial system is to protect it from shocks that could cause a systemic event. Specifically, the state would be expected to provide support to the financial system to prevent systemic events and to avoid corresponding significant public costs. Therefore, in order to understand the rationale for state support, it is important to understand the sources of systemic risk in the financial sector.

Systemic risk is often defined with respect to the *effect*—ie, the risk that the financial system, or a major part of it, is put in real danger of collapse or serious damage with the likelihood of material damage to the real economy.[5] However, this does not help the analysis of the sources of systemic risk. As regards the sources, it is useful to distinguish between two components of systemic risk:

– shocks to the system (**triggers**) that lead to the failure of individual players or parts of the financial system; and

– characteristics that propagate shocks through the financial system (**channels of contagion**) and can exacerbate the impact of shocks.

The first source of systemic risk depends on the risk of individual players or parts of the system and their financial robustness to withstand shocks. As regards the second source, the academic literature identifies two main channels of contagion by which shocks are propagated through the system:

– **bank runs (liabilities mechanism)**—by transforming short-term liabilities (deposits, wholesale funding) into long-term assets, financial institutions are exposed to the risk that relatively small shocks to the system could trigger a loss of confidence and withdrawals of deposits and wholesale funds;[6]

– **fire-sales of assets (assets mechanism)**—coordinated liquidation of long-term assets by a number of institutions in response to a relatively small shock could depress the price of assets held by other institutions, increasing their financial fragility and exacerbating the impact of the original shock.[7]

Events around the recent crisis have shown that contagion in the system can occur without direct interconnectednes between financial institutions, through the evaporation of confidence in particular business models, or simply through a general increase in risk aversion in financial markets. For example, in addition to direct contagion concerns, the failure of Lehman in 2008 called into question the viability of all stand-alone investment banks, while the problems at Northern Rock raised similar questions about all other lenders with heavy reliance on wholesale funding.

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[5] See, for example, Institute of International Finance (2010), 'Systemic risk and systemically important firms: an integrated approach', May.

[6] See, for example, Diamond, D.V. and Dybvig, P. (1983), 'Bank runs, deposit insurance and liquidity', *Journal of Political Economy*, **91**, pp. 401–19; Aghion, P., Bolton, P. and Dewatripont, M. (1999), 'Contagious Bank Failures,' paper presented at 'Systemic Risk and Lender of Last Resort Facilities', Centre for Financial Studies Conference, 1999, Frankfurt; and Rochet, J.C. and Tirole, J. (1996), 'Interbank Lending and Systemic Risk', *Journal of Money Credit and Banking*, **28**:4, pp. 733–62.

[7] See, for example, Adrian T. and Shin H. (2008), 'Liquidity and Financial Cycles', BIS Working Paper No. 256; and Brunnermeier, M. and Pedersen, L. (2009), 'Market Liquidity and Funding Liquidity', *Review of Financial Studies*, **22**:6, pp. 2201–38.

While the measures taken by the state in the UK and elsewhere during the recent crisis included direct support to individual players (in addition to measures supporting the overall financial system), the economic rationale for these direct interventions was to support the system, to preserve essential services, and to avoid the adverse economic consequences of systemic failure. This suggests that state support is 'systemic' in nature—ie, state support protects against systemic risk, which in turn depends on the risk of individual failure in response to shocks, and the scope for contagion or spillovers that propagate shocks through the system. It also suggests, however, that there are many triggers that can create a shock to the system and cause individual failure, and many mechanisms through which a shock could have systemic implications. Correspondingly, state support can be expected in many different situations that are of a systemic nature and, as discussed next, not just in the context of large, universal banks.

2.3 The relationship between state support, systemic risk and bank size

While the failure of a large bank can have damaging effects and impose large-scale economic costs, this does not imply that bank size is the main driver of systemic risk. If the sources of systemic risk are as analysed above (ie, in terms of triggers and channels of contagion), the relationship between bank size and systemic risk is far from clear.

A financial system comprised of large banks would not necessarily be expected to be more prone to systemic risk than a system comprised of small banks. In fact, the traditional economic theory of bank runs focuses on small deposit-taking institutions where the failure of one institution results in wider confidence losses and withdrawals of deposits from other institutions in the system.[8]

Faced with an exogenous shock (eg, a liquidity shortage, the bursting of an asset price bubble, or the failure of a corporate or financial institution for idiosyncratic reasons) of a given size, a fragmented system with small banks may be as prone to systemic risk as a more concentrated system with large banks. This is consistent with findings in the academic literature: while some papers find that banks in concentrated markets are more likely to fail, others show that a systemic crisis is less likely in banking systems that are more concentrated.[9]

Earlier financial crises (eg, the US savings and loan crisis) show that the failure of small banks can create systemic problems. Similarly, in the recent financial crisis, a number of factors explain the propagation of the initial shocks through the system, but the size of individual banks and concentration of the system are not among these factors.[10] Indeed, there appears to be little correlation between the markets affected by, or insulated from, the recent crisis and the level of concentration in those markets. For example, concentrated markets such as those in Australia or Canada remained relatively unscathed by the crisis. In contrast, previous crises show that fragmented markets can be vulnerable to crisis.

Given the systemic nature of state support, the reasons for the provision of this support do not appear to relate so much to the characteristics of particular institutions, but rather to the nature of the shocks affecting the financial system. In general, it requires a larger shock (in absolute terms) to bring down a larger bank. Thus, while the failure of a large bank would have a greater impact than that of a small bank, the more relevant comparison of system stability is likely to be one that holds the size of the shock constant—ie, if a shock that brings down a large bank were applied to a system comprising only small banks, the results could

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[8] See, for example, Diamond, D.V. and Dybvig, P. (1983), 'Bank runs, deposit insurance and liquidity', *Journal of Political Economy*, **91**, pp. 401–19.

[9] See, for example, contrasting results in Boyd, J.H., De Nicoló, G. and Jalal, A. (2009), 'Bank Competition, Risk and Asset Allocations', IMF Working Paper, WP/09/143 and Beck, T., Demirgüç-Kunt, A. and Levine, R. (2006), 'Bank Concentration, Competition, and Crises: First Results', *Journal of Banking and Finance*, **30**, pp. 1581–603.

[10] For an overview of the triggers and channels of contagion that characterised the recent crisis, see Beck, T., Coyle, D., Dewatripont, M., Freixas, X. and Seabright, P. (2010), 'Bailing out the Banks: Reconciling Stability and Competition', CEPR.

be as damaging as those of the large bank failing. Hence, one would not necessarily expect the more concentrated system necessarily to require more state support to protect the system, or larger banks to receive a disproportionately higher share of any such support.

A comparison of the failure of a large and a small bank would be the same as comparing the impact of a large manufacturer failing with that of a small manufacturer failing. The impact of the large manufacturer failing would be much greater; however, this is not because size is a driver of systemic risk, but simply because the firm is larger (and it takes a larger shock to bring down that firm than to bring down the small manufacturer). The more relevant comparator to one large bank (say, with assets of £1.6 trillion) failing is not so much the failure of one small bank, but that of, say, 100 smaller banks (each with assets of £16 billion).

The above discussion has two main implications for the analysis of state support:

- first, from a conceptual perspective, state support can be viewed as accruing to all banks in the financial system in the event that the system is hit by a systemic shock, and cannot be exclusively attributed to any particular banks, including the large, universal banks;
- second, state support can be expected to exist in any market structure to protect the system from systemic shocks, be it a structure with a large number of small banks or a small number of large banks.

The academic research in this area is evolving, and a number of recent studies have focused on measuring systemic risk and individual bank contributions to this risk.[11] The studies often use a contingent-claims valuation framework—ie, the total systemic risk in the financial system is measured as the fair value of the insurance contract required to protect the financial system against extreme shocks, and the total is then allocated among individual banks using a set of assumptions about the nature of shocks affecting the financial system.

One example of such a study is Acharya et al. (2010), who develop a framework for measuring total systemic risk as the expected loss in the overall financial system: an individual bank's contribution to systemic risk is measured as the expected shortfall of this bank, measuring its propensity to be undercapitalised when the system as a whole is hit by a financial shock.[12] The authors observe a weak empirical relationship between size and systemic risk. They state that, in their framework of analysis, there are no a priori reasons to expect that size would have a disproportionate effect on systemic risk:

> The negative sign on log of assets suggests that size may not only affect the dollar systemic risk contribution of financial firms but also the percentage systemic risk contribution as well. That is, large firms may create more systemic risk than a likewise combination of smaller firms, according to this regression, though the significance of this result is weak (and our theory does not have this implication).[13]

Huang, Zhou and Zu (2010) construct a systemic risk measure that reflects the price of insurance against systemic financial distress (the 'distress insurance premium'). They assess individual banks' marginal contributions to the systemic risk, measured as the expected loss for a given bank in the event that the whole system experiences a large (systemic) loss.[14] Using this framework, the study applies simulation techniques to estimate the total systemic risk for the top 19 US banks and their individual contributions, which are set to be a function of size, default probability and asset correlation. The results show that there is a positive

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[11] A more complete review of papers is provided in European Central Bank (2010), 'Financial Stability Review', December, Appendix E.

[12] Acharya, V.V., Pedersen, L.H., Philippon, T. and Richardson, M. (2010), 'Measuring Systemic Risk', AFA 2011 Denver Meetings Paper, May.

[13] Ibid., p. 23.

[14] Huang, X, Zhou, H. and Zhu, H. (2010), 'Systemic Risk Contributions', Federal Reserve Board Working Paper, August.

relationship between the size and the systemic contribution of banks, and that this relationship is non-linear—ie, larger banks are found to be disproportionately more systemically important. However, it is not clear what drives the non-linear relationship in the model.[15]

An alternative methodology is developed in Tarashev, Borio and Tsatsaronis (2010).[16] The total systemic risk—which is again measured as the expected shortfall in the assets of the financial system—is allocated to individual players using concepts from game theory (the 'Shapley values'). Using constructed examples, the authors examine three drivers of systemic importance: size, the institution's risk profile, and the extent of exposure to common risk factors. The results of the simulations show that systemic importance increases with size, and that the contribution to system-wide risk increases faster than size. As the authors note: 'the basic intuition for the relationship between size and systemic importance is that systemic (ie tail) events are associated with extreme losses, in which large banks are more likely to participate than smaller ones.'[17] However, what drives the non-linear relationship between size and systemic importance in the model is again not very clear.

As noted earlier, the literature in this area is evolving. However, to date, there does not appear to be any strong theory or empirical evidence that demonstrates a relationship between the size of a financial institution and its contribution to systemic risk, nor is there much robust evidence to show that large banks benefit disproportionately from state support. There also does not appear to be any strong evidence on the relationship between bank sector concentration and systemic risk, or that the expectation of state support is necessarily higher in a more concentrated financial system.

Appendix 1 presents some initial data observations on the UK market that are relevant for the assessment of whether there is a relationship between the size of a bank and the quantum of state support to the bank. However, no attempt is made to estimate the expected state support and attribute it to individual UK banks—such analysis was outside the scope of this study. Instead, section 3 focuses on quantifying state support at the system level.

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[15] Huang et al. (2010) state that: 'An intuitive reason is that, when a bank is too big, its failure is considered as a systemic failure by definition' (p. 20). As noted earlier, the failure of a large player may have a more significant impact, but it also takes a larger shock to trigger such a failure. Holding the magnitude of shocks constant, one may not necessarily expect larger banks to have a higher systemic importance per £1 of assets than smaller banks.

[16] Tarashev, N., Borio, C. and Tsatsaronis, K. (2010), 'Attributing systemic risk to individual institutions', BIS Working Papers, 308, May.

[17] Ibid., p. 16.

3 Valuation of state support

This section sets out some key principles for how a reasonable valuation of state support to a financial system could be undertaken, and explores plausible ranges of the value of such support in the UK.

The valuation approach adopted here seeks to capture the main economic drivers of state support in the financial system—namely, the circumstances in which the state would be expected to support the financial system to protect it against systemic risk, and the likelihood that these circumstances would arise, given the level of risk in the system. This valuation approach is then applied to actual data for UK banks to provide an indication of the expected value of state support.

3.1 Analytical framework

The objective is to measure the size of the value transfer from the state to the financial system that originates from the implicit expectation that the state would support the financial system in order to prevent a systemic failure. Through this implicit state commitment, the financial system may be expected to derive benefits in terms of, for example, a lower cost of capital, while the state would be expected eventually to incur the costs of supporting the system if a systemic event were to occur.

There appear to be two main ways of approaching this valuation. The first would involve looking at the effects of the support as reflected in, for example, the cost of capital of the financial institutions. Under such an analysis, the state support would be valued according to the difference between the cost of capital of the financial institutions with and without the support. A number of studies have sought to undertake this valuation (including Haldane (2010) for the UK, which is further reviewed in Appendix 2).[18] The main challenge with this analysis is the difficulty in estimating the counterfactual cost of capital that would be expected in the absence of state support. From a conceptual perspective, it also appears challenging to identify precisely how the cost of capital would be affected by state support, given that it would be triggered only in extreme circumstances when the systemic events occur (ie, the mechanism by which the implicit state support affects the cost of capital is different from more typical government guarantees on the liabilities of private companies).

The second approach—the one adopted in this report—is to estimate directly the expected value transfer from the government in the event that a systemic event occurs, based on the likelihood of a systemic shock occurring and the expected payment from the state that would be required to support the sector to avoid a systemic failure. This approach reflects the discussion in section 2; namely, that implicit state support is 'systemic' in nature since it is provided to protect the system against systemic risks.

3.1.1 Key parameters

The application of the second approach requires three parameters to be estimated, as follows.

- **The magnitude of shocks that would require the state to intervene and support the system**. The state would be expected to provide support to the financial system in response to a shock significant enough to trigger asset value losses in the system that could impair confidence in system stability and cause a systemic failure. In what follows, the 'systemic threshold' is defined as the maximum asset value loss that could be

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[18] Haldane, A.G. (2010), 'The $100 billion question', comments given at the Institute of Regulation & Risk, Hong Kong, March.

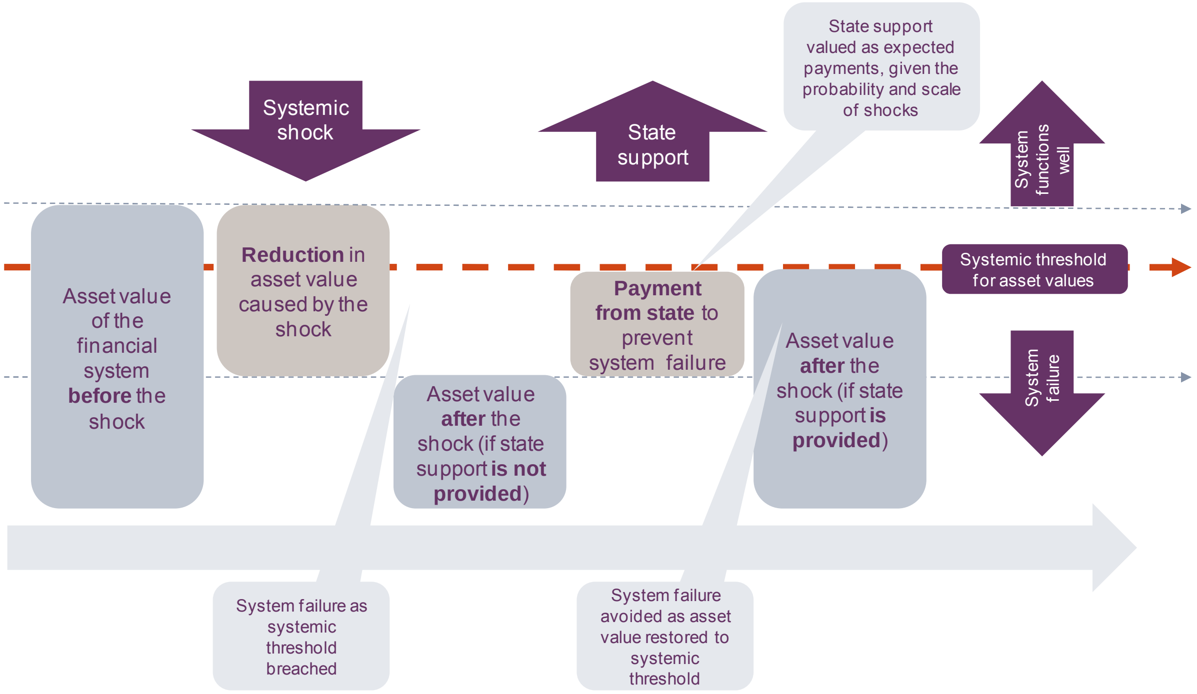
absorbed by the financial system before a loss of confidence is triggered and before the state would be required to step in. As noted in section 2, systemic events can occur through shocks to assets and liabilities. Taking a stylised approach, the model uses the term ‘asset value losses’ to imply shortfalls in assets, recognising that both sides of banks’ balance sheets are relevant.

- **The probability that a shock of such magnitude could occur**. This second parameter reflects the probability of shocks occurring that would breach the systemic threshold. This probability is driven by the riskiness of the assets of the financial system. All else equal, the riskier the assets, the greater the probability that the system would experience a significant asset value loss, and hence the higher the risk of breaching the systemic threshold.
- **The payment from the state required to protect the system if such a shock occurs**. This parameter reflects the payment that the state would be required to make in order to support the system if the systemic threshold were breached. This payment needs to be sufficiently high to restore the asset value of the system affected by the shock, up to the systemic threshold.

3.1.2 Overview of approach

Having established the systemic threshold (the scale of the shocks that would be expected to trigger systemic failure and hence require the provision of state support), the probability of such shocks occurring, and the required payment by the state if shocks hit the system, it is then possible to value state support as the expected payment from the state to the financial system in the event that a systemic shock hits the system.[19] Figure 3.1 presents a stylised summary of the links between these parameters and how they can be combined to value the state support.

Figure 3.1 Stylised illustration of the adopted valuation approach



Source: Oxera.

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[19] The valuation assumes that the intervention to restore the asset value is funded in full by public funds, whereas in practice private bailouts are also possible. In addition, the final actual cost to the state may be lower than the amount spent to restore the asset value (eg, due to recoveries). As such, the approach may overestimate the true net value transfer.

The stylised example in Figure 3.1 starts with the asset value before a shock hits the system (on the left). The example then proceeds (reading from left to right) to a systemic shock, which would cause a system failure without state support because the asset value of the system after the shock falls below the systemic threshold (depicted by the red dotted line).[20] Once the state observes that the shock will cause system failure, it intervenes, as expected, and props up the financial system with contributions. The value of payments from the state to the financial system equals the difference between the asset value after the shock and the systemic threshold. In other words, the state provides a sufficient amount to restore the asset value of the system up to the systemic threshold, as shown in the figure on the right (asset value of the system after the shock and after state support).

Once the systemic shock is defined, its probability estimated and the required payments to the financial system assessed, it is possible to value the state support as the discounted expected payment from the state if it is required to prop up the system to avoid a systemic failure.

This valuation approach is similar to option valuation techniques where the state support is seen as a put option on the system assets.[21] This put option is a type of insurance designed to protect the financial system against a drop in asset values. Such techniques have a considerable precedent in the existing literature—for example, Lehar (2004) uses the approach as a way of measuring systemic risks,[22] and Haefeli and Jüttner (2010) value the state support to Credit Suisse and UBS using option pricing techniques.[23] Huang et al. (2010) and Tarashev et al. (2010) also use a contingent-claims valuation framework to value systemic risks in the financial system as the cost of the insurance to protect the system against significant asset value losses (see section 2.3).

This approach values state support as expected payments from the state given the probability and scale of potential downside shocks affecting the financial system. This is different from the actual payment by the state if a systemic shock causing a failure actually occurs. This is the more relevant way of looking at state support because any potential distortions (in terms of both competition and financial stability) that may originate from implicit state support would be driven by the expectations of state support, as opposed to the actual payments by the state in the event of a failure.

As noted in section 2, a comparison could be made with an insurance contract, where the insurance premium is clearly distinguished from claims on the insurance company if the risk event occurs. The expected value of state support corresponds to the 'insurance premium', while the actual payments by the state correspond to 'claims in the event'.

A separate point is that the value of the guarantee that the government provides to the system may exceed its cost to the government, for example, because of the avoided costs of financial distress.[24] While the estimation presented here focuses on the value transfer from state to banks in terms of the costs of the support to the state, the basic valuation approach used in this report is extended to capture the costs of financial distress, as discussed below.

A final concluding remark on the conceptual framework is that the dynamics of crises are important and not explicitly captured in this model. For example, if the erosion of bank capital

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[20] As noted above, shocks can occur on both sides of banks' balance sheets, and the reduction in asset value considered in the illustration should be interpreted as a shortfall in assets relative to liabilities. Also, to the extent that banks hedge their assets and liabilities (eg, against interest rates), the reduction considered here is in the net value.

[21] The approach is more appropriate for 'permanent' shocks and may not work as well for liquidity shocks that are more temporary. The nature and dynamics of shock and type of state support (ie, capital as opposed to liquidity support) are outside the scope of this report.

[22] Lehar, A. (2003), 'Measuring Systemic Risk: A Risk Management Approach', University of Vienna.

[23] Haefeli, M. and Jüttner, M.P. (2010), 'The Value of the Liability Insurance for Credit Suisse and UBS', FINRISK Working Paper No. 609.

[24] See, for example, International Monetary Fund (2009), 'The economics of bank restructuring: Understanding the options', IMF Staff Position Note, June 5, SPN/09/12.

does not take place over a short period and capital markets are still functioning then banks themselves may decide to recapitalise or may be forced to by regulators. However, if the fall in asset value occurs very sharply and/or banks cannot access capital markets in order to recapitalise, the government may have to step in. The model does not capture the fact that not all falls in asset value indicated in Figure 3.1 will require state intervention—ie, in this respect, the model tends to overestimate the value of state support.

3.2 Quantification of state support

Applying this framework in practice requires estimation of the systemic threshold and the volatility of system assets. These two parameters can then be used to estimate the probability that the state would be required to make payments to support the financial system and the scale of such payments, which can then be converted into the expected payments from the state and hence the value of state support.

3.2.1 Systemic threshold

A robust estimation of the scale of shocks that the financial system would be able to withstand without state intervention is difficult because of the challenges associated with measuring the wide range of factors affecting this threshold (including, for example, the level and nature of confidence in system stability). Given these challenges, drivers that would be expected to determine the systemic threshold are set out below, together with what the corresponding reasonable threshold estimates might be. These estimates are then cross-checked against the evidence from the latest crisis on the significance of shocks and resulting asset value losses.

In principle, the systemic threshold reflects the loss-absorbing capacity of the financial system. The greater this capacity, the larger the shocks that the system would be able to withstand without state support. Similarly, if this capacity were low then even small shocks could cause a loss of confidence in the system and trigger systemic failures.

The loss-absorbing capacity depends on the solvency and liquidity of the financial system, and on the level of confidence in its stability. The latter is critical because, for financial systems characterised by low levels of confidence, even small shocks have the potential to lead to bank runs or fire-sales of assets, triggering system failures. Therefore, the total amount of loss-absorbing capital is used as the starting point in the estimation of the systemic threshold; the role of liquidity and the confidence are then captured through adjustments to this starting point.

The amount of Tier 1 capital provides a reasonable estimate for the amount of loss-absorbing capital. Assuming an actual Tier 1 capital ratio of 11–11.5% of risk-weighted assets (RWA)[25] and a ratio of RWA to total assets of 50%,[26] this would imply a level of loss-absorbing capital of about 5.5% of total assets. This means that if a shock leads to a reduction in the asset value of the financial system of more than 5.5%, the state would be expected to prop up the system; the system would, however, be able to withstand all shocks that lead to a combined reduction in the asset value of the system of less than 5.5%.

The 5.5% threshold could be seen as the upper end for the systemic threshold, since confidence may deteriorate well before Tier 1 capital is completely wiped out. Put differently, the state may need to step in even if smaller shocks hit the financial system because the confidence may be impaired and liquidity crunches can occur well before all Tier 1 capital is lost. In particular, a bank may experience liquidity shortages because of confidence issues if its actual Tier 1 capital falls below the regulatory requirements, although it would still remain

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[25] In 2009, the Tier 1 capital ratio for the UK was 11.8%. Bank of England (2010), 'Financial Stability Report', June.

[26] See, for example, Figure A1.2 in Appendix 1.2, which plots the ratio of RWA to total assets for a sample of UK banks (as at 2006). The ratio for the banks in the sample has fallen since, so the 50% assumption is conservative (ie, it results in an underestimate of the systemic threshold).

solvent in market-value terms. Therefore, another benchmark that could be used for informing the systemic threshold is the amount of capital buffer in the financial system—ie, the actual amount of Tier 1 capital in excess of regulatory requirements. Assuming a capital buffer of 3 percentage points between the actual and required Tier 1 capital ratio (and, again, a ratio of RWA to total assets of 50%), the loss-absorbing capacity of the financial system would imply a systemic threshold of approximately 1.5%. This means that the system would be able to withstand shocks of up to 1.5% of its total assets before a system crisis arises and the state would be required to provide support. This level of systemic threshold is used as the base-case estimate.

In principle, the confidence in the stability of a bank could deteriorate even before its capital ratios hit the regulatory requirements—ie, before the capital buffer is wiped out. To capture this potential effect, the analysis also explores the sensitivity to the above central estimate, instead using 0.3% of total system assets as the systemic threshold. This corresponds to approximately 20% of the total capital buffer, and implicitly considers a scenario where confidence would be impaired if one large bank with 20% of total system assets reached the regulatory minimum, or, put differently, if a bank with 20% of total system assets lost 1.5% of its asset value.

To summarise, the analysis uses three scenarios for the systemic threshold:

– **high confidence**: 5.5% of total assets corresponding to Tier 1 capital in the system;

– **base case**: 1.5% of total assets to reflect the total capital buffer in the system, corresponding to the difference between actual and required Tier 1 capital;

– **low confidence**: 0.3% of total assets, reflecting 20% of the total capital buffer, implicitly considering a scenario where a large bank accounting for 20% of system assets sees its Tier 1 capital drop to the regulatory minimum (or where such a bank loses 1.5% of its asset value).

It is useful to cross-check the above estimates against the scale of shocks experienced by the financial system during the recent crisis. Table 3.1 presents a number of estimates of the scale of these shocks.

Table 3.1 Estimates of shocks experienced during the recent crisis

Source	Description	Amount (£ billion)	Amount (% of assets)[1]
Bank of England	Reduction in market value of assets for major UK banks from June 2007 to June 2009[2]	390	5.3
Bloomberg	Total writedowns and credit losses[3] for UK banks	125	1.7
HM Treasury	Financial interventions by the UK government and Bank of England schemes	110	1.5

Note: [1] Based on the total assets of the UK financial system in July 2008 (£7.3 trillion), estimated as the sum of the market value of equity and book value of liabilities for the top eight UK banks: RBS, Barclays, Lloyds, HSBC, Bradford & Bingley, Alliance & Leicester, Standard Chartered, and HBOS. [2] Bank of England (2009), 'Financial Stability Report', June. Based on weekly moving average prices of traded instruments used as proxies for the market value of similar banking book exposures. The banks included are Banco Santander, Barclays, HSBC, Lloyds, Nationwide, Northern Rock and RBS. International exposures include the USA and Europe only.
[3] Writedown and loss totals from Q3 2007 to Q1 2010, taken from Bloomberg WDCI.
Source: Bank of England, Bloomberg and HM Treasury; Oxera analysis.

The Bank of England estimates of the reduction in the market value of assets of the UK banks appear most relevant for informing the estimates of the scale of shocks that affected the UK financial system during the recent crisis. These estimates suggest that shocks resulted in a reduction of 5.3% of the total assets of the system. This is above the base-case assumption set out above, but is broadly in line with the high-confidence scenario. The other two estimates could be seen as providing downward-biased estimates because they reflect only a fraction of the total shocks. Nonetheless, none of the three sets of estimates is below the central scenarios presented above, which suggests that the above scenarios could be seen as reasonable for the analysis of state support, and that the base case may indeed be a conservative estimate that may underestimate the systemic threshold (and hence may bias upwards the resulting value of state support).

3.2.2 The volatility of system assets

The volatility of assets in the financial system would determine the probability and scale of the downside shocks that could affect the system. Specifically, the volatility of assets would determine the probability of the system experiencing a shock of systemic magnitude and the asset value loss associated with such a shock. In combination with the systemic threshold described above, this would enable the value of state support to be estimated as the expected payment from the state required to restore the asset value of the financial system.

The volatility of assets depends on how risky the assets of each bank are and the extent to which they tend to co-move in response to shocks (ie, correlation). For example, the riskier the banks that make up the financial system, the higher the volatility of the assets in the system, and the greater the probability and scale of potential downside shocks. Similarly, even if the risk of each individual bank in the system is relatively low, high correlation between banks may lead to a significant downside shock.

The volatility of assets in the system can be estimated directly using the observed volatility of banks' share prices.[27] This is done here in three steps: the first is to estimate the volatility of equity for UK listed banks. Here, this is estimated as the average annual implied volatility for five UK listed banks over the period from October 2009 to September 2010. The implied volatility provides an estimate of market expectations of the future volatility of banks' equity. It is based on the observed prices of the derivative instruments written on the shares of the top five UK banks used in this analysis: RBS, HSBC, Lloyds, Barclays and Standard Chartered. Alternatively, volatility could be estimated using past share prices for these banks. The difference is that this volatility relies on past data and therefore reflects historical volatility, which may be different from the forward-looking estimates of the volatility implied by the current market expectations. The implied volatility provides such a forward-looking view and is therefore seen as a preferred measure.

The second step is to use the equity volatility for each bank to estimate the combined volatility for the financial system using the observed correlations and relative weights of each bank in the total system. The volatility of the financial system, where the sample of five banks mentioned above is used as a proxy for the industry, is obtained by using the standard formula for estimating the volatility of a portfolio comprising several assets.[28] The correlation between the equity returns of the banks in the sample was estimated using long-term historical data over the period from 1995 to 2010. The resulting equity volatility for the industry based on forward-looking implied volatilities is broadly in line with the observed historical volatility of the total equity of UK listed banks.

The third step in the analysis is to convert the estimated equity volatility for the industry into the volatility of assets. The standard corporate finance approach would be to multiply the

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[27] The use of market data to estimate volatilities in this context is subject to criticism, including a potential endogeneity problem if market expectations are based on an implicit guarantee assumption. However, other data is not available.

[28] The following formula is used:

$$\sigma_p^2 = \sum_i w_i^2 \sigma_i^2 + \sum_i \sum_{j \neq i} w_i w_j \sigma_i \sigma_j \rho_{ij},$$

,

where σ reflects the standard deviation and w the weights in the portfolio p of the equity of banks i and j.

equity volatility by the ratio of equity to the total value of assets.[29] The adjusted corporate finance approach would be to control for the probability of debt defaulting and therefore attribute some volatility to debt. The standard framework for risky debt developed in Merton (1974) could be used to implement the adjusted corporate finance approach in practice.[30] These two approaches produce similar results because the probability of default on debt implied by the observed equity volatility and gearing levels seems rather low. Specifically, the evidence seems to suggest that forward-looking market expectations imply a relatively low probability of default on debt in the banking market.[31] The key estimates are summarised in Table 3.2.

Table 3.2 Indicative estimates of the volatility of system assets (%, per annum)

	Equity volatility (%, annual), based on:		**Asset volatility** (%, annual)			
	implied volatility	historical volatility[1]	**Standard approach**		**Adjusted approach**[2]	
			Gearing = 94%[3]	Gearing = 88%[4]	Gearing = 94%	Gearing = 88%
Financial system	32.2	32.0	1.93	3.86	1.93	3.87

Note: Equity volatilities for each bank are estimated as one-year averages of the implied volatilities over the period from October 2009 to September 2010 using monthly data. Correlation between banks is estimated as the correlation between daily equity returns over the period from 1995 to 2010 (pair-wise correlations range from 46% to 69%). Gearing estimates are based on the ratio of the book value of total liabilities to the sum of the market of value of equity and book value of liabilities for the five banks. The upper end of the range corresponds to the average; the lower end corresponds to the minimum. [1] Estimated over the period from January 2002 to October 2010 using the total market value of equity for all listed UK banks over this period. [2] Adjusted for the probability of default on debt using the Merton (1974) risky debt framework. [3] This corresponds to the average leverage ratio for all listed UK banks over the period from January 2002 to October 2010, estimated using the market value of equity and book value of liabilities. [4] This corresponds to the minimum leverage ratio for all listed UK banks over the period from January 2002 to October 2010, estimated using the market value of equity and book value of liabilities.
Source: Datastream, Bloomberg, and Oxera analysis.

The drivers of the estimated asset volatility are the gearing and equity volatility. The analysis suggests that, for leverage in the range of 88–94%, the volatility of assets is around 2–4% in order for the volatility of equity to be in line with the observed data.

These estimates of asset volatility appear to be in line with the results obtained in the academic literature. For example, Lehar (2003) estimated that the median annual asset volatility of the European banks is around 3.5%.[32] Similarly, Haefeli and Jüttner (2010) estimate the volatility of assets for Swiss banks to be around 1% before the crisis and 2% after it.[33]

The base-case estimate of the volatility used in the valuation is 4%, which corresponds to the upper end of the above range (corresponding to a 94% gearing assumption). This upper end is adopted in order to retain the overall conservative nature of the valuation. It is also adopted to seek to control for additional costs of financial distress that are not explicitly captured in the base-case scenario, as well as for the issue of a skewed distribution of

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[29] The corresponding formula is $\sigma_V = \sigma_E \frac{E}{V}$, which is similar to the usual approach to de-levering the equity betas when estimating the cost of capital. E is equity and V is the total value of assets; in this approach, debt is assumed to be riskless. See Merton, R.C. (1974), 'On the Pricing of Corporate Debt: The Risk Structure of Interest Rates', *Journal of Finance*, **29**, pp. 449–70.

[30] Merton (1974), op. cit.

[31] There is a potential endogeneity problem if the market data reflects the implicit guarantee. However, no other data is available. Other caveats also apply. For example, some of the volatility of bank equity will come from fluctuations in the value of banks' franchise value and some from changes in the probability of systemic risk, not all of which is linked directly to what is on the balance sheet.

[32] Lehar, A. (2003), 'Measuring Systemic Risk: A Risk Management Approach', University of Vienna, Figure 2.

[33] Haefeli, M. and Jüttner, M.P. (2010), 'The Value of the Liability Insurance for CS and UBS', FINRISK Working Paper No. 609, Figure 3.

banks' asset returns, as discussed further below. To test for the sensitivity of the estimates to asset volatility, a range of scenarios based on a range for volatility between 2% and 6% is explored.

3.2.3 Estimates of state support

Using a range of estimates for the systemic threshold and the volatility of assets, state support is valued as the present value of the expected payment from the state to the financial system in the event that the systemic threshold is breached. The standard Black–Scholes formula is used to estimate the value of a European put option with one year to expiry.[34] The underlying instrument for such a put option is the asset value of the financial system, and the strike price corresponds to the systemic threshold. The interpretation of this approach is that the value of state support represents the discounted expected payment from the state to the financial system in the event that the asset value of the system falls below the systemic threshold. Table 3.3 summarises the resulting indicative range of estimates, expressed as a percentage of the total supported assets in the system.[35]

Table 3.3 Indicative estimates of state support (% of supported assets, per annum)

		Volatility of assets (% per annum)				
		2.0%	3.0%	4.0%	5.0%	6.0%
Systemic threshold (% of assets)	**5.5%** (high confidence)	0.0000	0.0001	0.0045	0.03	0.09
	1.5% (base case)	0.00	0.02	**0.08**	0.22	0.41
	0.3% (low confidence)	0.002	0.05	0.17	0.36	0.60

Source: Datastream, Bloomberg, and Oxera analysis.

As can be seen from Table 3.3, in the base-case scenario the value of state support is 8bp for each £1 of assets protected by the state. As would be intuitively expected, the higher the volatility of assets, the higher the value of state support, since higher volatility means that a significant downside shock is more likely. Similarly, the lower the systemic threshold—ie, the smaller the shock that can be internalised by the system without state intervention—the higher the value of state support because there is a wider range of shocks in response to which the state would be required to step in.

The estimate of state support as a percentage of assets can be converted into monetary terms by multiplying it by the total value of the assets in the financial system. For an asset value of the system of about £7 trillion,[36] the central estimate of state support of 8bp per £1 of assets corresponds to about £5.9 billion per year.

The basic valuation using the Black–Scholes formula does not account explicitly for the costs of financial distress, which, as discussed above, tend to drive a wedge between the value of the state support to the system and the cost to the state of providing this support. As such, the above results present an estimate of the value transfer from the state to the banks in the system in terms of the costs of the support to the state (as opposed to the value of the support to the banks). However, since the calculations are based on a conservative estimate of the underlying asset volatility (see section 3.2.2 above), this may control for some of the additional value created due to the avoided costs of financial distress. In addition, further

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[34] The assumption of a European put option results in some undervaluation since it does not consider scenarios where the asset value drops below the threshold and recovers before the expiry of the option—European options can be exercised only at the expiration date. An American-style option, which can be exercised at any time up to expiration date (and therefore can have a higher value) would be more appropriate, but the calculations are much more complex. This effect tends to be offset by assumptions that work in the opposite direction and result in overvaluation. For example, the model does not explicitly allow for the possibility that banks recapitalise themselves in the event of shocks or are forced to do so by regulators (such that the threshold shifts and less or no state support is required).

[35] A risk-free rate of 5% is used in the valuation. The sensitivity of the results to this specific parameter is low.

[36] Estimated as the sum of market value of equity and book value of debt in September 2010 for five UK listed banks: RBS, HSBC, Barclays, Lloyds and Standard Chartered.

analysis was undertaken to model directly the impact of financial distress costs on the value of state support. Under plausible assumptions for the costs of financial distress, the resulting state support value that captures the surplus created due to avoided financial distress costs is estimated to be in the range of 17bp to 31bp.[37]

The above valuation implicitly assumes that shocks affecting the financial system are symmetric in nature and that fat-tail events are unlikely to happen—ie, the system is just as likely to experience a positive shock as a negative shock of the same magnitude, and the probability of a large shock is very low. Given the recent crisis, this may appear problematic. If the assumption of symmetry and low probability of tail events is breached, the estimates of state support presented here may be biased downwards because the fat-tail risk may be underpriced (ie, the risk of an extreme negative shock is not adequately captured). The model seeks to control for this potential bias by adopting a conservative (ie, relatively high) estimate of asset volatility, as discussed above.

In addition, the model tests for the extent to which the adoption of conservative (ie, high) estimates of asset volatility corrects for biases that could originate if shocks to the financial system were asymmetric in nature. These sensitivity tests examine the impact of a potential downside-biased distribution of shocks on the value of state support.

Market data on derivatives traded on the equity of UK banks was used to estimate the extent to which shocks affecting the financial system are skewed with high probability of tail events,[38] and to examine how this affects the value of state support. The results of this modelling are presented in Table 3.4 (with a more detailed description of the modelling approach reported in Appendix 3).[39]

Table 3.4 Additional analysis assuming potentially asymmetric distribution of shocks and fat-tail events

Scenario 1: extreme shocks assumed to be *uncorrelated*	
Asset volatility (%)	3.4%
Kurtosis (%, estimated, measure of likelihood of extreme events)	59.2
Value of state support (% of supported assets)	***0.009***
Scenario 2: extreme shocks assumed to be perfectly *positively correlated*	
Asset volatility (%)	4.5%
Kurtosis (%, estimated, measure of likelihood of extreme events)	71.6
Value of state support (% of supported assets)	***0.158***

Note: See Appendix 3 for details of the modelling approach. All results are reported for the base-case systemic threshold of 1.5% and a gearing assumption of 94%.
Source: Bloomberg data, and Oxera analysis.

The results indicate that allowing for potential skewness of shocks and fat-tail events increases the value of state support. Using the higher gearing of 94%,[40] and modelling the

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[37] The assumed parameters are 1.5% for the systemic threshold, 3% for asset volatility (to reflect that, unlike in the base case, the costs of financial distress are now modelled explicitly) and costs of financial distress of 10–20% of asset value. While the costs of financial distress are likely to vary between failures and over time, these ranges reflect estimates reported in the corporate finance literature, and are also referred to in International Monetary Fund (2009), 'The economics of bank restructuring: Understanding the options', IMF Staff Position Note, June 5, SPN/09/12.

[38] That is, tail events are more likely than those predicted by the normal distribution.

[39] The approach used here is only one of many different approaches available for modelling the dynamics in asset values, including stochastic volatility and other jump models. See, for example, Hull, J.C. (2011), *Options, futures and other derivatives*, New Jersey: Prentice Hall.

[40] In the base case, the value of state support was based on asset volatility of 4%. This corresponds to an 88% gearing assumption, which is the minimum gearing observed over the period January 2002 to September 2010—ie, a higher asset volatility (associated with lower gearing, based on the measured equity volatility) was used in order to be conservative. In Table

tails of the distribution directly under the assumption that extreme shocks in the system are uncorrelated between banks, results in a value of state support of 0.9bp. This estimate is still lower than the base-case estimate reported in Table 3.3 (of 8bp). This shows that the conservative assumption with respect to asset volatility adopted in the base-case scenario works to offset the impact of a potentially downside-biased distribution of shocks.

If a more extreme model specification were used (ie, where extreme shocks are assumed to be perfectly correlated between banks), the value of state support would increase from 0.01bp to 15.8bp. This set of assumptions can be seen as providing the upper end of the range for the value of state support because the assumption of perfect correlation between shocks is likely to overestimate the level of risk in the financial system.[41] This extreme estimate is above the base case reported in Table 3.3, but below the upper end of the range under the assumption of a higher estimate of asset volatility (ie, 5%).

3.2.4 An alternative modelling approach: state support for individual bank failures

The approach used in this report is to model bank failures from a system-level perspective—ie, by valuing state support as a put option on the system assets. A key rationale for this approach is that state support is provided to protect against systemic risk, and hence only events that lead to systemic failures are taken into account when valuing state support. Other events that might affect the value of the assets of a particular bank, but do not necessarily cause other banks to fail, should not be considered since idiosyncratic shocks that trigger bank failures in isolation, without any systemic consequences, may not warrant state support.

An alternative approach is to consider each bank separately and value the state support required for each individual bank (ie, by valuing the individual put options on each bank's assets). This approach is challenging because, at the individual level, it is difficult to separate the events that cause systemic failure from those that do not. Nevertheless, the following provides an analysis of the implied state support which is given by either a weighted average (weighted by equity market capitalisation) or a simple average of the state support for individual banks. This is done both for the symmetric model (Black–Scholes) used for the base-case calculations (as reported in Table 3.3) and a model that assumes an asymmetric distribution of shocks and fat-tail events (as reported in Table 3.4).

The average state support calculated using the Black–Scholes model for each individual bank is based on the same basic parameter assumptions as before: 1.5% systemic threshold, one-year maturity and a risk-free rate of 5%. The individual bank equity volatilities are the implied equity volatilities of the traded options of each bank on September 30th 2010, which are then converted into estimates of asset volatility using the same gearing assumption of 88% as before. Again, the aim is to be conservative and use higher asset volatilities than what is implied by market data. The average implied equity volatility across the sample of five banks used in the calculations is 35.4%, which converts into asset volatilities with an average value of 4.2%.

3.4, the value of state support is based on the 94% gearing assumption, which is the average gearing over the period January 2002 to September 2010. Instead of adopting a higher asset volatility to deal with potentially asymmetric shocks and fat-tail events, as is done in the base case, the approach used here is to model such shocks explicitly (and assume gearing to be 94%, which is still slightly below the levels of gearing in 2010).

[41] In principle, the upper end of the results could be increased further by adjusting the gearing assumptions and increasing the assumed asset volatility in the system, in addition to considering the adjustments in the two scenarios that involve explicit modelling of asymmetric shocks and fat-tail events. For example, assuming a gearing of 88% would significantly increase the estimated value of state support in scenario 1, to 51bp. However, such a 'double' adjustment would not be expected to deliver a plausible range of estimates, based on existing market data.

Based on these assumptions, the weighted average state support is 10.1bp for each £1 of assets protected.[42] This state support is 2.1bp higher than the 8.1bp of the base-case scenario where bank failures arise due to systemic events (presented in Table 3.3).

As regards the model that allows for asymmetric distribution of shocks, where skewness and fat tails are incorporated in the modelling of assets, the weighted average state support for the individual banks is 39.1bp for each £1 of assets protected by the state.[43] This state support is 23.3bp higher than the value of state support assuming that extreme shocks are perfectly correlated (scenario 2 in Table 3.4).

As expected, these alternative measures of state support are higher than those calculated in the main system-level approach adopted in this report (Tables 3.3 and 3.4). They are an overestimate of the expected value of state support that is provided in the event of systemic failures. Measures which are based solely on individual bank failures require a further adjustment to reflect the fact that shocks to the asset value of an individual bank are either systemic or idiosyncratic to specific banks—but it is only systemic shocks that require state support.[44] Thus, if the individual values of state support are adjusted so that only systemic risk is priced, the mean (weighted or unweighted) state support resulting from the individual bank failure approach (under both the Black–Scholes and the skewness with fat-tails models) would decrease.

3.2.5 Benchmarks for the value of state support

A number of benchmarks, detailed below, are available to understand the relative magnitude of the range of estimates obtained under this valuation framework.

– **Other estimates of state support** to UK banks are available in Haldane (2010), and subsequently in the Bank of England's Financial Stability Report (using a similar approach to Haldane). According to Haldane's analysis, state support for the top five UK banks in 2009 was £103 billion in the year. For the period 2007–09, the support to the top five banks amounted to £55 billion per year.

  These estimates are significantly higher than the base-case estimates reported above. There are a number of explanations for the difference—in particular, the proposed framework takes a system view on state support. Additionally, the framework distinguishes expected support from actual bailouts. In contrast, Haldane's valuation approach attributes state support to individual players and does not distinguish the expectations of state support from the actual payments from the state during the crisis. Also, whereas the above approach relies on observed market data and uses scenario analysis to test the sensitivity of results to particular estimates, Haldane's valuation uses credit rating agencies' assessments, which can be characterised by a degree of subjectivity. (For example, credit rating agencies seem to have changed their assessments regarding the sources of the credit strength of large banks after the crisis.) A more detailed review of Haldane's analysis is reported in Appendix 2.

– The **UK bank levy** proposed by the coalition government in the June 2010 Budget and introduced with effect from January 1st 2011 is set at 0.07% of relevant bank liabilities (with a lower rate applying in 2011) and is expected to raise about £2.5 billion per year.[45] This is less than half of the base-case estimates for the value of state support.

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[42] The simple mean of state support is 12.6bp for each £1 of assets protected by the state. If pre-crisis data is employed (ie, if the implied equity volatilities as at May 31st 2007 are used, which have a sample average of 23%) and other assumptions are retained, the weighted and simple average state support values are 0.9bp and 1.5bp for each £1 of assets protected by the state.

[43] As in the system-level valuation approach, the equity volatilities are converted into asset volatilities using 94% gearing.

[44] For example, there are many cases where individual risk events (eg. large trading losses) have not led to public bailout.

[45] HM Treasury (2010), 'Bank Levy: Draft Legislation', Written Ministerial Statement, October 21st, available at http://www.hm-treasury.gov.uk/d/banklevy_wms211010.pdf.

Additional levies are paid to the UK Financial Services Compensation Scheme in relation to protected retail deposits.[46]

- The **Federal Deposit Insurance Corporation (FDIC) levy**—the pre-funded deposit guarantee scheme in the USA sets levies that since April 2009 have ranged from about 7bp to 43bp of protected deposits for banks in risk categories I and II.[47] Under the assumption that deposits are about 50% of assets,[48] this would correspond to a levy of 4–24bp of assets. By comparison, the above base-case estimates for state support are about 8bp of assets.

When considering the interpretation of these results, it is important to understand the underlying drivers. The key driver is the volatility of the assets in the financial system. The observed volatility of equity and relatively high leverage in the financial system mean that the assets of the system are robust, with relatively low volatility. This, in turn, implies a relatively low probability of significant downside shocks and hence low value of state support. While there is uncertainty around the precise levels of asset volatility, the estimates reported are based on observed market data.

3.3 The impact of regulatory reforms on the value of state support

The regulatory reforms currently in train would be expected to significantly lower the value of state support compared with pre-crisis levels, for a number of reasons. First, a resolution regime, which is one of the reform proposals, would be expected to increase the systemic threshold and thereby lower the value of state support. A well-functioning resolution regime would be expected to limit contagion in the financial system, increase the level of confidence, and enable banks to internalise greater shocks without impairing confidence. In addition, higher capital requirements introduced as part of Basel III would be expected to further raise the systemic threshold by increasing the amount of loss-absorbing capital in the system. In addition to the capital effects, the liquidity buffers would strengthen the system’s ability to withstand shocks that have the potential to trigger confidence losses. For example, the low confidence scenario reported in Table 3.3 (ie, with an assumed systemic threshold of 0.3%) could be seen as representative of the pre-reform conditions. Compared with the base-case scenario (with an assumed threshold of 1.5%), the value of state support would be more than twice as high.

In addition to raising the systemic threshold, the current regulatory reforms and industry changes would be expected to reduce the volatility of assets, for example through divestitures and tighter risk management regimes. Considering again the estimates in Table 3.3, if a higher volatility assumption (eg, 5% asset volatility instead of 4%) were combined with a low confidence scenario, the estimated value of state support would also be twice as high.

Therefore, the range of estimates in Table 3.3 indicates that the impact of the current regulatory reforms could be significant, either because the loss-absorbing capacity of the system is improved (eg, due to higher capital levels in the system and more effective resolution), or because of lower asset volatility in the system (eg, due to de-risking).

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[46] UK deposit-takers pay levies to the Financial Services Compensation Scheme which, including interest on the government loan to March 2010, amounted to just under £400m in total in the year. See Financial Services Compensation Scheme (2010), ‘Plan and Budget: 2010/11’, available at http://www.fscs.org.uk/uploaded_files/Publications/Plan_and_Budget/Plan_and_Budget_2010-11.pdf.

[47] http://www.fdic.gov/deposit/insurance/assessments/proposed.html

[48] Unlike the UK Financial Services Compensation Scheme, the FDIC covers more than retail deposits alone.

A1 Data observations on bank size and state support

This appendix presents data observations that are relevant for the empirical assessment of a potential relationship between bank size and support. More specifically, it formulates a number of hypotheses or expected effects if large banks do indeed benefit disproportionately from state support, and then considers whether the data is consistent with these hypotheses or expected effects.

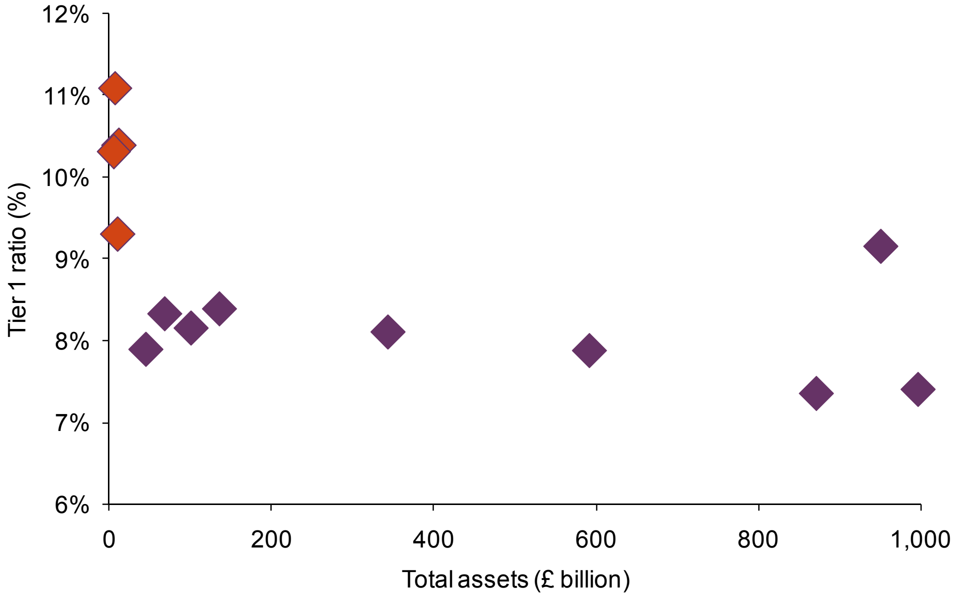
The results should be interpreted as data observations rather than robust evidence based on detailed empirical analysis that would seek to control for other factors that may influence the observed patterns in the data.

A1.1 Bank size and extent of risk-taking

If it were the case that larger banks benefit disproportionately from state support then one would expect to find observable differences in the behavioural patterns of large banks compared with smaller banks. In particular, larger banks would be expected to take greater risks because the upside of the high-risk strategy would accrue to the banks, while downside losses would be borne by taxpayers.

Figure A1.1 plots the Tier 1 capital ratio for UK banks (and some building societies) of different sizes in the years before the crisis. The Tier 1 capital ratio reflects the financial risk taken by a bank for a given level of asset risk—ie, the lower the Tier 1 ratio, the lower the capital buffer and the higher the financial risk. If state support accrued disproportionately to larger banks and induced them to take greater financial risk, one would expect a negative relationship between the Tier 1 capital ratio and the size of the bank.

Figure A1.1 Average Tier 1 ratio and bank size (pre-crisis)



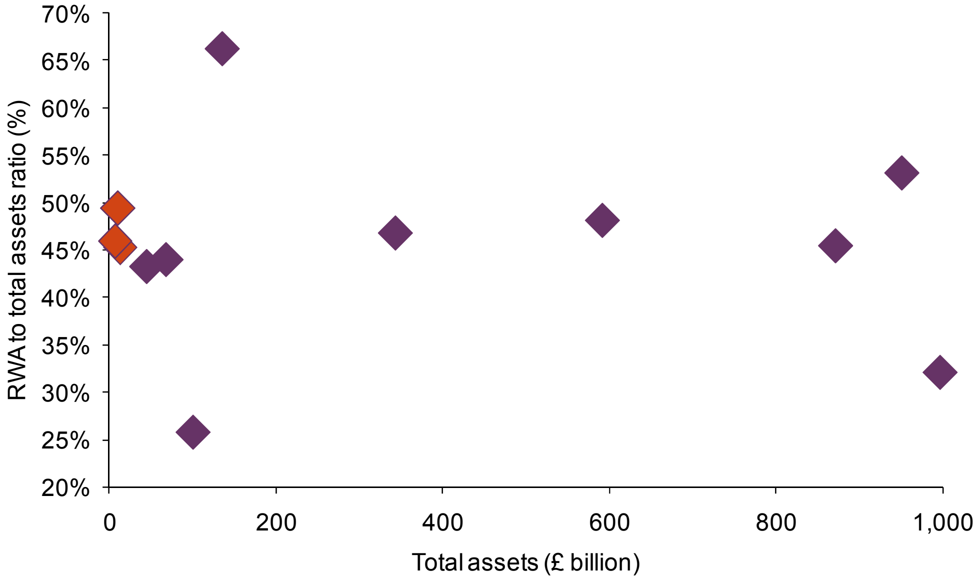
Notes: The purple (red) bullets represent a sample of UK banks (building societies). This figure plots the Tier 1 capital ratio (Tier 1 capital divided by RWA) against the size of different banks, as measured by the total book value of assets. The Tier 1 capital ratio is calculated as the average of the ratios during 2004–07; size is assets as at end 2006. The y axis is truncated to begin at 6%.
Source: Bloomberg data, and Oxera calculations.

The observed data does not suggest a strong relationship between size and financial risk-taking in the years before the crisis (as measured by the Tier 1 capital ratio). Since the crisis, banks have generally increased the Tier 1 capital ratio, and the increase appears larger for some of the large banks. The observed pattern in Tier 1 capital ratios is therefore not consistent with the premise that larger banks take more risk because they benefit from disproportionate state support.

Another risk metric considered is the ratio of RWA to total assets. Under the hypothesis of disproportionate state support to larger banks, one would expect this to be reflected in larger banks taking on higher asset risk such that they have a higher ratio of RWA to total assets—ie, one would expect to observe a positive relationship between size and asset risk, as measured by the ratio of RWA to total assets.

Figure A1.2 plots the ratio of RWA to total assets for banks of different sizes. The focus here is again on the pre-crisis years 2004–07, although the observed pattern is similar for the period since the crisis. The data does not suggest a strong relationship between the risk metric and bank size.

Figure A1.2 Average RWA to total assets ratio and bank size (pre-crisis)

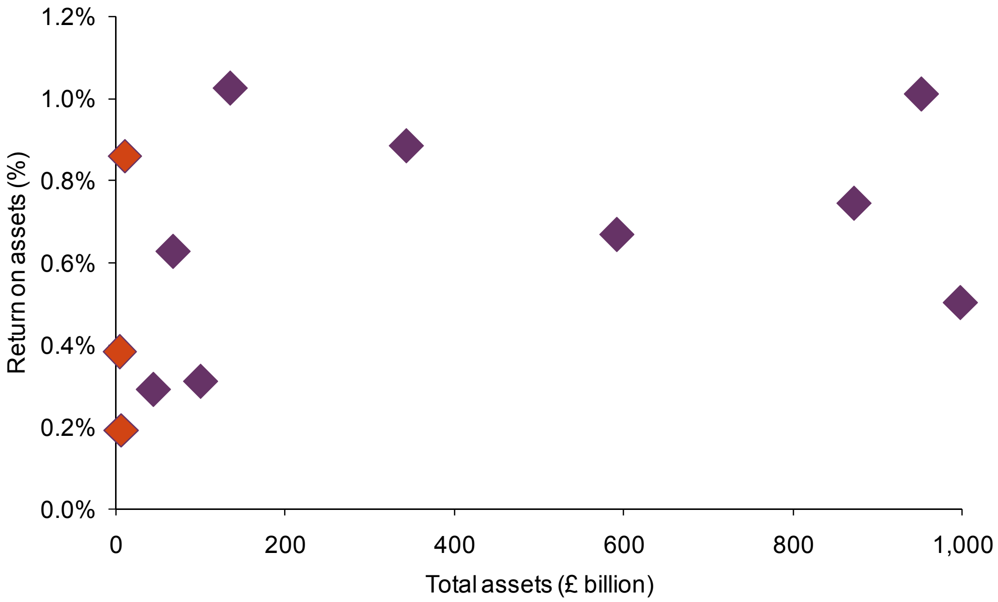


Notes: The purple (red) bullets represent a sample of UK banks (building societies). This figure plots the ratio of RWA to total assets against the size of different banks, as measured by the total book value of assets. The ratio is calculated as the average of the ratios during 2004–07; size is measured by assets as at end 2006. The y axis is truncated to begin at 20%.
Source: Bloomberg data, and Oxera calculations.

Any higher-risk profile of larger banks as a result of a disproportionate guarantee could be expected to result in higher rates of return in good times, while shifting the losses in bad times to the state—ie, one would expect a positive relationship between profitability and bank size, at least in the years before the crisis.

Figure A1.3 below plots profitability—here proxied by the simple average return on assets before the crisis—against the size of different banks. The data observations are not consistent with a strong positive relationship between this profitability metric and bank size.

Figure A1.3 Average return on assets and bank size (pre-crisis)



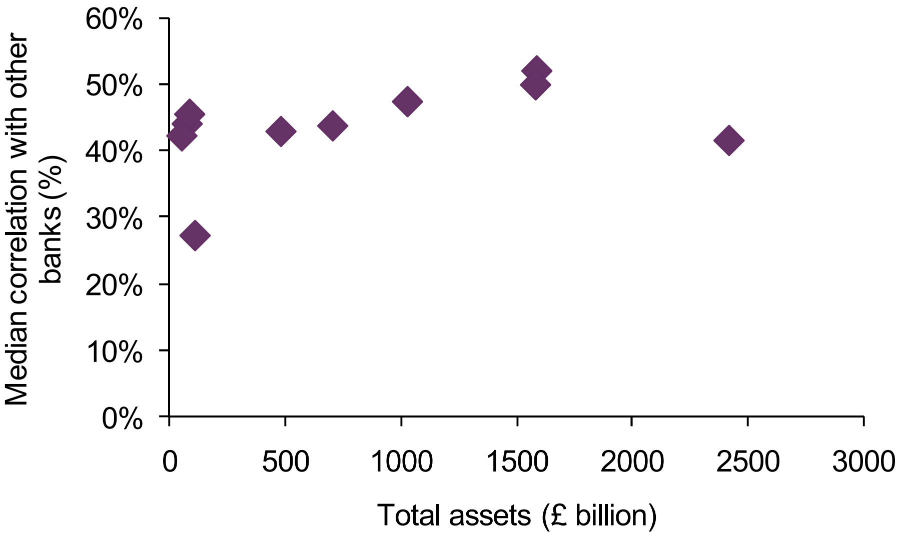
Notes: The purple (red) bullets represent a sample of UK banks (building societies). This figure plots the rate of return on total assets against the size of different banks, as measured by the total book value of assets. The return on assets ratio is calculated as the average of the ratios during 2004–07; size is measured by assets as at end 2006.
Source: Bloomberg data, and Oxera calculations.

A1.2 Bank size and measures of contribution to systemic risk

Consistent with the discussion in section 2, two main elements determine systemic risk (and hence can be thought of as drivers of the value of implicit state support to the financial system): the resilience of individual institutions to withstand shocks, and the correlation between institutions in the system. Correspondingly, larger institutions would receive a disproportionate share of the overall state support if they contributed disproportionately to systemic risk—ie, if they had higher stand-alone risk and/or disproportionately contributed to industry correlation.

Figure A1.4 below looks at the relationship between bank size and one particular measure of a bank's contribution to industry correlation: the median correlation of the equity returns of a bank with other banks in the system. There appears to be no strong correlation between size and this measure.

Figure A1.4 Relationship between bank size and correlation with other banks



Note: The purple bullets represent a sample of UK banks. This figure plots the size of different banks (as measured by the total book value of assets) against a metric that proxies a bank's contribution to systemic risk. The proxy metric shown here is the median correlation of a particular bank with the other banks. Correlations are measured using daily data on the market value of equity over the period from December 2000 to October 2010 (or the latest available date—for a few banks, the period is shorter). Asset size is also measured at October 2010 and is therefore different from the asset value shown in the pre-crisis charts in Figures A1.1 to A1.3.
Source: Datastream data, and Oxera calculations.

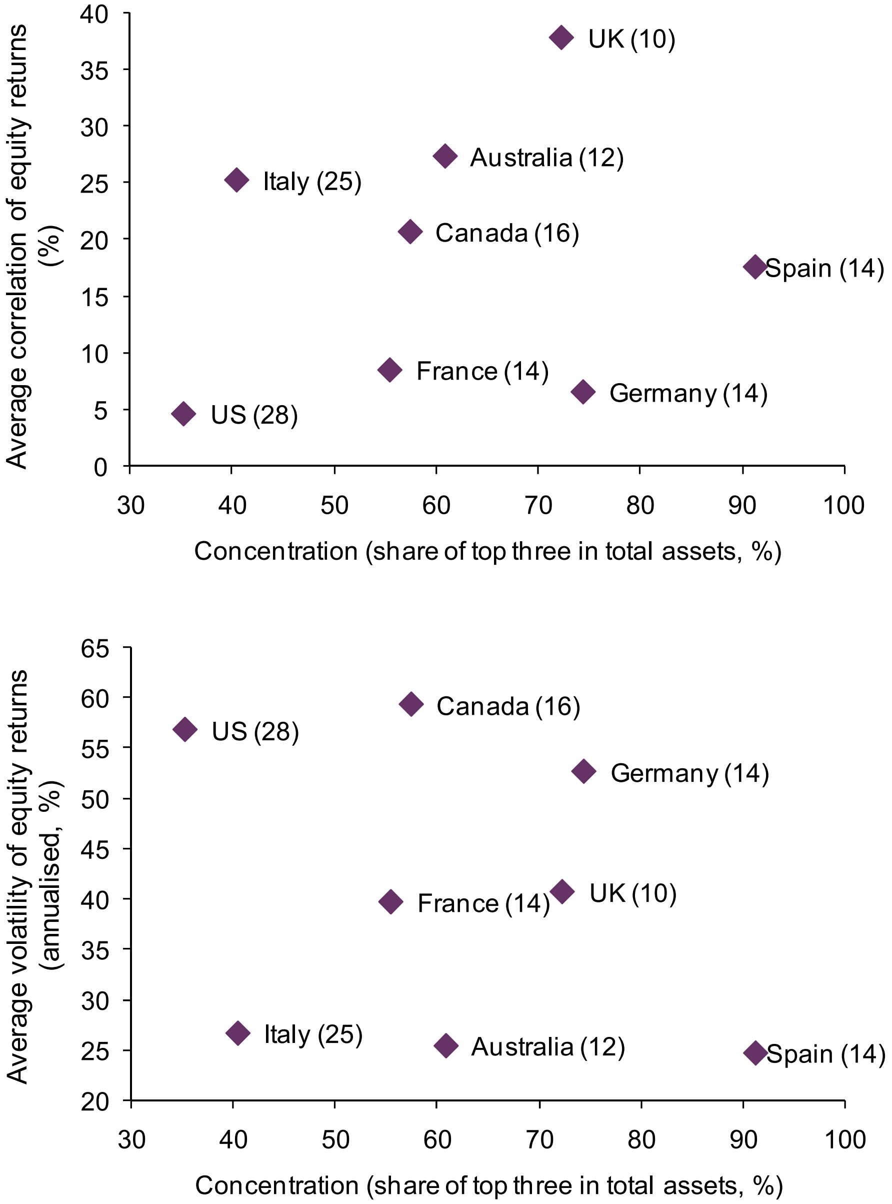
A1.3 Market concentration and quantum of state support

A related issue is whether more concentrated financial systems are characterised by higher systemic risk, and hence whether higher overall state support is required to protect more concentrated systems.

Data was gathered to examine the relationship between the concentration of the banking sector in different countries and metrics that may be considered proxies for risk in the system. Given data availability across the sample of countries, concentration is measured by the share of total assets of the top three banks in the country. The two proxies for risk are the average correlation of equity returns across banks in the country; and the average volatility of the banks' equity returns.

The results of this initial analysis are presented in Figure A1.5 below. Under the hypothesis of more concentrated banking sectors being associated with higher systemic risk (and hence a higher value of implicit state support), one could expect to observe a positive relationship between concentration and both the average correlation and the average volatility of banks' equity returns. The data does not suggest a strong relationship between concentration and the measures of system risk.

Figure A1.5 Bank sector concentration and average correlation and volatility of banks' equity returns



Notes: Bank concentration is measured by the share of total assets held by the top three banks in the country in 2008, taken from the World Bank financial structures database. Average correlations and volatility are measured for a country sample of banks (with the number of banks in the sample shown in brackets), based on daily data on the market value of equity over the period December 2000 to October 2010 (or the latest available date—for a few banks, the period is shorter). The volatility is the standard deviation of equity returns (annualised, in %). The x axis is truncated in both graphs to begin at 30%; in addition, the y axis in the graph showing volatility of equity returns is truncated to begin at 20%.
Source: World Bank financial structures database, Datastream data, and Oxera calculations.

A2 Review of existing estimates of state support to UK banks

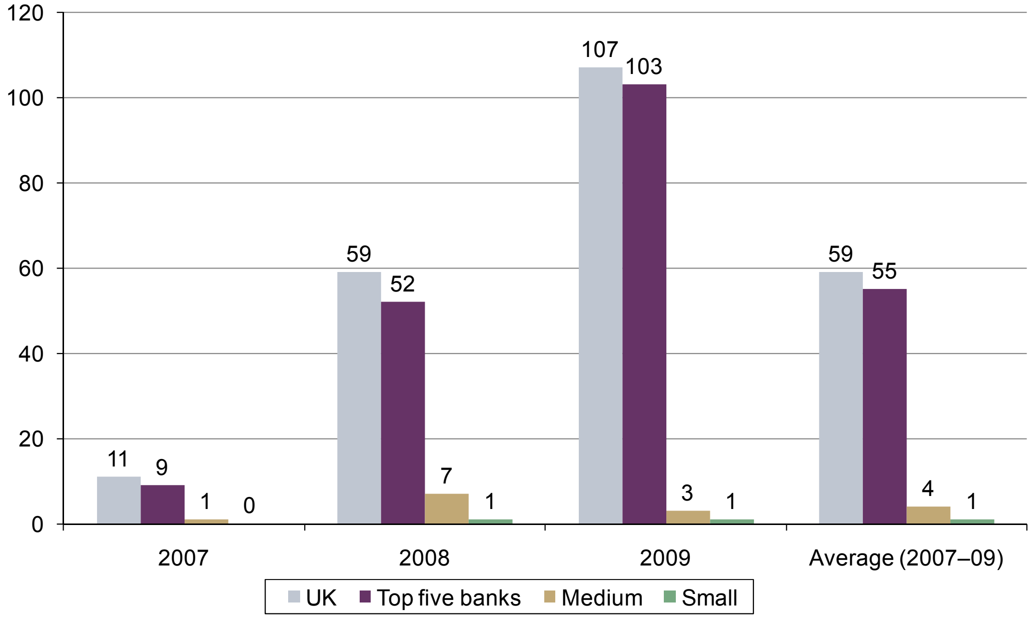
A number of other studies have sought to value state support. In the context of UK banks, this includes, most notably, Haldane (2010).[49] The December 2010 Financial Stability Report by the Bank of England also presents estimates of the implicit subsidy for banks from taxpayers, which are similar to those in Haldane (2010). The following provides a short overview of Haldane's approach, and explains the main differences with the approach proposed here.

A2.1 Overview of Haldane (2010) approach and results

Haldane (2010) adopts an approach to value the implicit state support for a number of UK and global financial institutions that is based on the rating uplifts for state support, as assumed by certain credit rating agencies. For example, Standard & Poor's (S&P) and Fitch report the banks' stand-alone credit ratings and the uplifts for the expected support from the state in the event that banks experience financial difficulties. The value of the implicit state support is then estimated as the reduction in funding costs using the yield differentials implied by rating uplifts and multiplying this difference by the rating-sensitive liabilities of the banks.

Haldane's estimates of state support for UK banks and building societies over the period from 2007 to 2009 are shown in Figure A2.1.

Figure A2.1 Estimates of state support based on Haldane (2010) (£ billion)



Note: The sample contains 16 UK banks and building societies in 2007 and 2008 and 13 in 2009, sub-divided according to their size.
Source: Based on Haldane (2010).

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[49] Haldane, A.G. (2010), 'The $100 billion question', comments given at the Institute of Regulation & Risk, Hong Kong, March.

As can be seen from Figure A2.1, according to Haldane (2010) the average state support in 2009 for the top five UK banks was approximately £103 billion, with the average per bank being around £26 billion.

The estimate of state support to banks was based on the average rating uplift. This uplift for large banks in 2009—about 4.7 notches—was then converted into a value according to the yield differential implied by the rating uplift and total liabilities of financial institutions.

A2.2 Robustness of the estimates

The approach seeks to quantify the value of state support from the reduction in banks' funding costs, based on the average difference between the stand-alone and support ratings of banks. This raises questions about the use of credit ratings in this context, and the relationship between ratings and yields. As discussed in section 3, defining the counterfactual funding costs without state support is difficult, and the ratings uplift approach used in this context can be criticised along a number of dimensions.

Haldane (2010) does not provide any evidence on how rating uplifts assumed by credit rating agencies are priced in by the markets for the banks used in the sample, or whether they actually lead to interest rate differentials as assumed in the valuation. For example, notwithstanding the fact that larger banks had higher rating uplifts throughout the period considered in the study, there is no evidence that larger banks have lower yields than smaller banks. Figure A2.2 shows the average yields for the large and smaller UK banks by maturity bucket. Although the results are based on an initial analysis only (eg, the sample is not consistent across banks, maturities and currencies), there appears to be no evidence that yields depend significantly and systematically on the size of banks, even though these banks have different credit ratings and credit rating uplifts.

Figure A2.2 Comparison of yields for selected traded debt for the large and smaller UK banks before and after the crisis

Bank	Total assets (£bn)	Rating	Average yields, post-crisis (%)				Rating	Average yields, pre-crisis (%)			
		(post-crisis)	0–2 yrs	3–5 yrs	6–8 yrs	9–15 yrs	(pre-crisis)	0–2 yrs	3–5 yrs	6–8 yrs	9–15 yrs
RBSG	1,696.5	A	2.9 (68)	4.1 (46)	5.2 (16)	6.0 (11)	AA- (Sept-07)		4.9 (2)	5.4 (9)	5.5 (3)
HSBC	2,364.5	AA- (Aug-10)	2.6 (16)	4.1 (32)	6.3 (2)	2.5 (7)	AA- (Aug-07)			5.2 (3)	
Barclays	1,378.9	AA-	3.9 (126)	3.3 (108)	3.1 (77)	3.2 (65)	AA (Nov-07)		5.3 (22)	4.6 (22)	5.3 (36)
Lloyds	1,027.3	A	1.0 (9)	2.8 (15)	8.7 (1)	2.4 (7)	AA- (Aug-07)				6.0 (1)
Average	**1,616.8**		**3.4 (219)**	**3.6 (201)**	**3.6 (96)**	**3.4 (90)**			**5.2 (24)**	**4.8 (34)**	**5.4 (40)**
Santander	285.3	AA	1.8 (64)	2.9 (15)			n/a		5.0 (7)	5.1 (2)	
Nationwide	191.4	A+	2.0 (26)	3.3 (10)		5.2 (5)	A+ (Sept-07)		4.6 (4)	5.4 (1)	
Clydesdale	42.4	A+	1.5 (2)				AA- (Mar-07)		5.2 (2)		
Yorkshire	22.7	A-	2.4 (31)	2.9 (4)		8.7 (2)	A (Mar-07)				
Skipton	15.6	NR	2.2 (2)	1.9 (1)			NR				
Co-operative	15.0	NR	3.8 (15)	4.4 (5)			NR		5.5 (1)		
West Brom	9.2	NR	2.2 (2)		2.0 (1)		NR				
Principality	6.2	NR	2.1 (3)	2.1 (1)			NR				
Average	**73.5**		**2.2 (145)**	**3.2 (36)**	**2.0 (1)**	**6.2 (7)**			**4.9 (14)**	**5.2 (3)**	
Difference (Small vs Large)			**–1.2**	**–0.4**	**–1.6**	**2.8**			**–0.3**	**0.4**	n/a

Note: Average yields are estimated using all traded sterling-, euro-, dollar- and yen-denominated debt issued in the UK, excluding structured products, government-guaranteed debt, covered bonds and securities with embedded options. Yields are averaged over the six months to July 2010 (post-crisis) and the six months to September 2007 (pre-crisis). The number of instruments is shown in parentheses. Ratings are from S&P. Post-crisis ratings are taken as at July 2010, except for HSBC, which is as at August 2010. The dates of pre-crisis ratings are shown in parentheses.
Source: Bloomberg data, Oxera analysis.

The approach also relies on the crisis period. The data for the period 2007 to 2010 would be expected to be driven to a significant extent by the impact of shocks that hit the financial system during the crisis. Therefore, the valuation picks up the effects of the crisis and hence implicitly reflects the actual value transfer from the state to the financial system that occurred during the crisis. This would provide an upward-biased estimate of the value of state support because the appropriate basis for valuation is the expected rather than the actual payments.

In this context, it is worth noting that, before the crisis, credit rating agencies assumed no (or low) uplifts for implicit state support. For example, S&P reports in 2007 repeatedly clarify that there has been no uplift for large banks on the basis of potential state support:

> Standard & Poor's does not factor the probability of government support into the ratings on U.K. private sector banks such as HSBC Bank. We classify the U.K. as a 'supportive' country, where the government relies on prudential policies to maintain a sound banking sector. The ratings on private sector banks in supportive countries receive no uplift for potential external extraordinary support.[50]
>
> The ratings on RBSG do not include any uplift for external support.[51]
>
> Standard & Poor's does not factor the probability of government support into the ratings on U.K. private sector banks such as Lloyds TSB.[52]

Therefore, if this valuation approach were applied to this pre-crisis data, it would suggest that the value of state support was zero, but this would not be correct because there was always an expectation of state support in the event of a crisis, and this implicit expected support was factored in by the markets.

This indicates that the valuation approach captures the actual value transfer from the state to the financial system during the crisis and that this provides an upward-biased estimate of the expected state support, which existed before the crisis and would be expected to continue to exist going forward.

From a practical perspective, the results may not be robust because they rely exclusively on credit rating agencies' views, which incorporate a degree of subjectivity.

While the ratings used by Haldane provide rating uplifts for state support for large and small banks, S&P factors in state support for RBS and Lloyds only, but not for the most recent ratings for HSBC and Barclays. Hence, under the ratings uplift methodology, this implies that these banks would not receive any implicit support from the state in the event of a failure.

However, a shock that would lead to the failure of a bank the size of HSBC or Barclays could be expected to be of systemic magnitude, and therefore the government would be expected to support these banks. This means that there is a degree of state support to these banks, although the application of Haldane's (2010) methodology would suggest otherwise.

A similar logic could be applied to financial institutions of a smaller size. If a shock of systemic magnitude affected the financial system, leading to the failure of a large number of relatively small banks, the government could be expected to step in and support these smaller banks, even though the credit rating agencies do not factor in any explicit uplifts to reflect state support. This indicates a lack of robustness in any state support valuation approach based entirely on credit rating agencies' views.

Additionally, S&P's current views on the sources of the credit strength of large banks are significantly different from its views before the crisis. While S&P currently assumes uplifts for

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[50] Standard & Poor's (2007), 'HSBC Bank PLC', August 30th, p. 4.

[51] Standard & Poor's (2007), 'The Royal Bank of Scotland Group PLC, September 3rd, p. 5.

[52] Standard & Poor's (2007), 'Lloyds TSB Group PLC', August 31st, p. 4.

state support for large banks, as noted above, before the crisis it stated that the credit rating strength exhibited by the large banks was due to factors such as earnings, market position and corporate strategy, the strength of the bank's funding base and cost efficiency, as well as risk diversification. This again highlights a degree of subjectivity in the credit rating agencies' views.

A2.3 Application of Haldane (2010) methodology using most recent data

The application of Haldane's methodology to the latest data and S&P rating uplifts results in a value of implicit state support of approximately £8 billion per year for RBS. The average for the top four UK banks would be £3.5 billion, driven largely by the fact that neither HSBC nor Barclays has received a ratings uplift from S&P. This is significantly lower than the figure of £26 billion on average per bank per year, as estimated by Haldane (2010). This could be explained in two ways.

- First, Haldane suggests that, in 2009, the top four UK banks received an average rating uplift for state support of almost five notches. In the case of RBS, S&P's credit rating factors in a three-notch uplift for the implicit state support in 2010, while the average rating uplift for the top four UK banks is 1.5 notches. These differences may be explained by the date of the analysis (Haldane uses 2009 data, while the most recent S&P uplifts for UK banks are available for 2010) and by the chosen credit rating agency (Haldane refers to Moody's uplifts, while the comparison is based on S&P uplifts). These differences seem to highlight the potentially subjective nature of credit rating uplifts, which would not make them a robust basis for valuation of state support.

- Second, Haldane's estimates of the yield differential corresponding to a one-notch uplift appear to be at the higher end of those implied by the indices corresponding to RBS's stand-alone and all-in ratings. Specifically, the difference between the BOFA ML A-rated index and the BOFA ML BBB rated index (where A is RBS's all-in rating and BBB is the stand-alone rating) is 0.57%,[53] which is approximately 0.19% per notch. Table A2.1 sets out the data used to cross-check and update Haldane's results based on new data.

Table A2.1 Illustrative estimates of the value of implicit state support for the top four UK banks, using the Haldane (2010) methodology

Bank	All-in credit rating	Uplift for implicit state support (notches)	Implied stand-alone rating	Implied yield uplift (one-year average, %)	Total liabilities (£ billion), as at Dec 31st 2009	Guarantee value (£ billion)
RBS (July 2010)	A	3	BBB	0.57	1,442	8.2
Lloyds (June 2010)	A	3	BBB	0.57	983	5.6
HSBC (Aug 2010)	AA–	0	AA–	0	1,372	0
Barclays (Jan 2010)	AA–	0	AA–	0	1,320	0
Average						**3.5**

Note: The following indices are used to calculate yield differences: A–BOFA ML £ CORP & COLLAT A (E); BBB–BOFA ML £ CORP & COLL BBB (E).
Source: S&P (2010), 'Royal Bank of Scotland Group Plc' July; S&P (2010), 'Lloyds Banking Group Plc', June; S&P (2010), 'HSBC Holding Plc', August; S&P (2010), 'Barclays Bank Plc', January; RBS (2009), Annual report and accounts 2009; Lloyds (2009), Annual report and accounts; HSBC (2009), Annual review; Barclays (2009), Annual report; Datastream, Oxera calculations.

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[53] The yield differential is estimated over a one-year period between September 3rd 2009 and September 3rd 2010 using the following indices: (A) BOFA ML £ CORP & COLLAT A (E) - RED. YIELD and (BBB) BOFA ML £ CORP & COLL BBB (E) - RED. YIELD.

A3 Outline of the approach used to test the impact of potentially asymmetric shocks and tail events

In section 3, state support is valued as the present value of the expected payment from the state to the financial system in the event that the system threshold is breached. The basic model used relies on the standard Black–Scholes formula for estimating the value of a put option. The underlying instrument for such a put option is the asset value of the financial system, and the strike price corresponds to the systemic threshold. The interpretation of this approach is that the value of state support represents the discounted expected payment from the state to the financial system in the event that the asset value of the system falls below the systemic threshold.

One of the main shortcomings of the Black–Scholes model is that it is not able to capture higher moments of the distributions of returns, which have an important effect on the value of put and call options. The base-case estimates of the value of state support obtained therefore implicitly rely on the assumption of symmetric shocks; however, a relatively high estimate of asset volatility was used to attempt to correct for the potential bias.

In addition, further analysis was undertaken to extend the basic model presented in section 3 to test for the sensitivity of the estimates to the potentially asymmetric distribution of shocks. The following sets out the modelling approach.

A3.1 Overview of the approach

The extension to the valuation of the put option on banks' assets is based on the model proposed by Kou (2002),[54] which is designed to capture, among other factors, large sudden changes in the price of assets. The Kou model consists in modelling prices with Gaussian shocks (as in the Black–Scholes framework), upward jumps, and downward jumps. In particular, in this model, the equity log-returns follow the process:

$$d\ln S = \mu dt + \sigma dW + J^{+}dN^{+} + J^{-}dN^{-} \qquad \text{Equation A3.1}$$

where μ is the drift; σ the volatility of the Gaussian process (Brownian motion) W; J^{+}, J^{-} are the sizes of positive and negative jumps respectively; and N^{+}, N^{-} are Poisson processes that signal the arrival of jumps up and down respectively, with intensities λ^{+}, λ^{-}. Moreover, the distribution of the size of the jumps is exponential with parameters η^{+}, η^{-} for the positive and negative jumps respectively. Finally, all the components of the stock model in Equation A3.1 are independent.

Since the objective is to value put options written on a basket of five UK banks (Barclays, HSBC, Lloyds, RBS and Standard Chartered), it is assumed that the share prices of each bank follow the dynamics of the Kou model and that the Gaussian processes of each bank are correlated according to a 5x5 variance–covariance matrix.

A3.1.1 Estimation of the correlations between five banks

To estimate the historical correlations it is necessary to address the fact that the model assumes that there are jumps in prices. Therefore, before estimating the correlations between the Gaussian part of each bank, the jumps in the equity returns are filtered. The

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[54] Kou, S.G. (2002), 'A jump-diffusion model for option pricing', *Management Science*, **48**:8, pp. 1086–01.

jump filter employed here is a recursive filter that singles out returns that are three standard deviations away from the mean of returns. This is done using share price data from December 2nd 2005 to December 2nd 2010. Once the jumps in prices have been removed, it is straightforward to measure the correlations between the banks' returns. Table A3.1 shows the estimates of the variance–covariance matrix of the Gaussian component of the five banks.

Table A3.1 Estimates of variance–covariance matrix

	Bank 1	Bank 2	Bank 3	Bank 4	Bank 5
Bank 1	1	0.51	0.67	0.50	0.65
Bank 2	0.51	1	0.57	0.57	0.48
Bank 3	0.67	0.57	1	0.54	0.62
Bank 4	0.50	0.57	0.54	1	0.47
Bank 5	0.65	0.48	0.62	0.47	1

Source: Oxera calculations.

A3.1.2 Calibration of risk-neutral parameters

The put and call options are priced using a risk-adjusted measure of the model in Equation A3.1 above.[55] The Carr and Madan (1999)[56] procedure is employed to extract the risk-adjusted parameters. Options data is used for six consecutive days starting on November 29th 2010. Since the objective is to price put options with one year to expiry, the risk-adjusted parameters are extracted from call and put options that expire between 1 and 1.25 years. This procedure is used for each day to obtain the risk-adjusted parameters, which are then averaged across all the days in the sample. The main scenario presented used both call and put options data for the estimation of the risk-adjusted parameters, while the other scenario employed put options data only. Tables A3.2 and A3.3 show the risk-adjusted parameter estimates.

The model parameters λ^+, λ^- and σ are all reported in annual terms. For example, λ^+, λ^- are interpreted as the average number of jumps up and down respectively that are observed in one year.

Table A3.2 Data on call and put options with expiry dates between 1 and 1.25 years

	σ	λ^+	λ^-	η^+	η^-
Bank 1	0.14	4.79	330	59	19,246
Bank 2	0.39	7.74	347	4	17,898
Bank 3	0.20	5.89	782	2	10,897
Bank 4	0.27	7.12	383	9	9,262
Bank 5	0.13	4.99	7	2	6,073

Source: Oxera calculations.

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[55] Similar to Kou (2002), op. cit., it is assumed that $\mu = 0.5\sigma^2 + \kappa^+ + \kappa^-$, so that the discounted risk-adjusted dynamics of prices is a martingale process.

[56] Carr, P. and Madan, D. (1999), 'Option valuation using the fast fourier transform', *Journal of Computational Finance*, **2**, pp. 61–73.

Table A3.3 Data on put options with expiry dates between 1 and 1.25 years

	σ	λ^+	λ^-	η^+	η^-
Bank 1	0.17	5.35	17.21	2	6,770
Bank 2	0.29	6.43	6.70	8	27,685
Bank 3	0.27	5.40	404.36	2	5,426
Bank 4	0.26	11.57	488.08	24	11,956
Bank 5	0.20	5.51	8.70	2	7,042

Source: Oxera calculations.

Put option on banks' assets

The put option is valued using Monte Carlo methods. Moreover, the gearing adjustment is applied to the volatility parameter and to the jump size parameter. In other words, for each bank, the gearing *g* is employed to scale:

$$\sigma \longrightarrow (1-g)\sigma \text{ and } \eta \longrightarrow \frac{\eta}{1-g}.$$

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