



BANK OF ENGLAND

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Too big to fail: some empirical evidence on the causes and consequences of public banking interventions in the United Kingdom

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Andrew K Rose⁽¹⁾ and Tomasz Wieladek⁽²⁾

Abstract

During the 2007–09 financial crisis, the banking sector received an extraordinary level of public support. In this empirical paper, we examine the determinants of a number of public sector interventions: government funding or central bank liquidity insurance schemes, public capital injections, and nationalisations. We use bank-level data spanning all British and foreign banks operating within the United Kingdom. We use multinomial logit regression techniques and find that a bank's size, relative to the size of the entire banking system, typically has a large positive and non-linear effect on the probability of public sector intervention for a bank. We also use instrumental variable techniques to show that British interventions helped; there is fragile evidence that the wholesale (non-core) funding of an affected institution increased significantly following capital injection or nationalisation.

Key words: Nationalisation, capital injection, liquidity, crisis, foreign, empirical, data, logit.

JEL classification: G38.

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Summary

Beginning in late 2007, the public sector around the world helped their struggling financial sectors in a number of different ways. Some banks were offered government funding or central bank liquidity insurance schemes, others received capital injections or were nationalised outright, and some were offered no support at all. To maintain future financial stability, it is important to not only understand the vulnerabilities that led the public sector to assist banks during the global financial crisis of 2008, but also assess the effectiveness of public sector help in stabilising individual banks' funding.

In the first part of this study, we therefore ask empirically what determined the style and recipients of public interventions. We use a confidential Bank of England bank-level data set using information on the balance sheets of all UK-resident banks. Our results suggest that the size of a bank is an important determinant of key public British banking interventions: capital injections, nationalisations, and government funding or central bank liquidity insurance schemes. In particular, the size of a bank relative to that of the entire banking system increases the probability of an intervention, suggesting that large banks are more likely to receive public sector assistance. This finding is consistent with the idea that some banks in the British banking system were deemed to be 'too big to fail'.

In the second part of this study, we study the consequences of public sector interventions in the British banking system. We argue that during the global financial crisis, financial institutions were subject to a bank run in wholesale markets. To improve our understanding of the effectiveness of these various public sector interventions, we study their effect on individual banks' wholesale to total liabilities ratio. Typically it would be difficult to credibly isolate cause and effect in our question of interest, since the banks that received government help were also the ones that were obviously most affected by a run on their wholesale liabilities. Fortunately, we established that bank size is an important determinant of government intervention in the first part of our investigation. This is a structural feature and changes only slowly over time. It is unlikely to be affected by sudden movements in bank liabilities and can be used to predict government intervention. We therefore use a bank's relative size with respect to the whole banking system to isolate the causal effect of British public sector interventions on an individual bank's wholesale funding. We find that these interventions mattered in a tangible sense: they seemed to restore access to wholesale funding. More precisely, the share of wholesale (non-core) funding rose significantly following intervention. As one objective of UK public sector intervention during the global financial crisis was precisely to stabilise flighty financial market funding, it seems to have been effective.

1. Introduction and motivation

The Great Recession began as a financial crisis. Beginning in late 2007, governments around the world helped their struggling financial sectors in a number of different ways. Some banks were offered unusual liquidity support, others received capital injections or were nationalised outright, and some were offered no support at all. In this paper, we examine the nature of public sector assistance to banks.

We ask empirically what determined the style and recipients of public interventions, and whether these interventions had a measurable impact on bank behaviour. We use a confidential Bank of England bank-level data set using information on the balance sheets of all UK-resident banks. We find that a British bank's size had a strong effect on the likelihood of intervention: larger banks were more likely to be assisted. And these interventions mattered in a tangible sense: they seemed to restore access to wholesale funding. More precisely, the share of non-retail deposits in total liabilities rose by over 38% following intervention, an amount that is economically and statistically significant (though this evidence is not definitive). As one objective of crisis intervention was precisely to stabilise flighty financial market funding, it seems to have been effective.

2. Literature review

A fairly large literature studies the determinants of national banking crises with macroeconomic data. Caprio and Klingebiel (1997) find that excessive credit growth is an important determinant of banking crises across countries. In a comprehensive cross-country study with a multinomial logit model, Demirgüç-Kunt and Detragiache (1998) document that weak economic growth, high inflation and real interest rates are important predictors of banking crises. Eichengreen and Rose (2001) find that interest rates in advanced economies have a significant impact on the probability of a banking crisis in an emerging market. More recently, Hahm *et al* (2011) have used a probit model to show that the fraction of non-retail deposits (wholesale funding) in a banking system is an important predictor of credit crises, which are defined as sudden increases in money market rates.

A separate but related literature has examined the determinants of the proportion of overall state ownership in the banking system; this literature also uses mostly macroeconomic determinants. La Porta *et al* (2002) is the key reference; see also Levy-Yeyati *et al* (2007).

Previous work using micro-level bank balance sheet data has modelled the determinants of the probability of bank survival. For instance, Wheelock and Wilson (2000) use American data to

show that poor management determines bank failure, while low earnings, the capital: asset and loans: asset ratios are important determinants of acquisition. Whalen (1991) showed that the most important determinants of the probability of bank survival for American data from the 1980s were the capital: assets ratio, the non-performing loans ratio, the loan: asset ratio, a large certificate: deposit ratio, and the change in housing permits. For European banks, Poghosyan and Cihák (2009) find that the most important determinants of the probability of a bank distress event (defined as an episode of negative press coverage), are earnings, loan-loss provisions, and the capital: asset and non-performing loans: asset ratios. A related paper by Beltratti and Stulz (2010) examines the determinants of banks' equity returns between July 2007 and December 2008. They find that dependency on short-term wholesale market funding and the capital: asset ratio are the most important determinants of the change in equity returns during this period.

To the best of our knowledge, ours is the first study of the determinants of public intervention at the micro level.

Previous work studying the *effects* of government interventions on financial markets has examined evidence from past crises as well as the Great Recession. Honohan and Klingebiel (2003) use a cross-country approach to show that public capital injections, blanket guarantees, open-ended liquidity support and debtor bailouts all significantly add to the eventual fiscal cost of banking system support during past systemic banking crisis. Laeven and Valencia (2009) confirm that blanket guarantees can be fiscally costly, but, using an event study methodology, find that blanket guarantees do alleviate liquidity pressures associated with deposit withdrawals.

There is also a growing body of work which examines the effectiveness of policies implemented during the recent global financial crisis. Several papers examine the impact of the Federal Reserves' Term Auction Facility (TAF) on money market outcomes. Taylor and Williams (2009) use an event study and do not find a substantive effect of the TAF on Libor spreads. On the other hand Christensen, Lopez and Rudebusch (2009) use a complete dynamic model of the term-structure and find that the TAF has reduced interbank rates. Similarly, Wu (2011) finds that the TAF reduced counterparty and liquidity risk premia by lowering liquidity risk. Studies focusing on the impact of financial sector policies across countries, on the other hand, typically perform event studies to estimate the effect of the announcement of a financial sector policy on either Libor spreads (Aït-Sahalia *et al* (2009)) or non-financial firms stock returns (Tong and Wei (2011)).

To our knowledge, none of the previous work attempts to estimate the direct effect of government interventions on the financial institutions in question. One reason for this is the

difficulty of obtaining an appropriate data set; more on this below. But another important problem is that, unlike some of the other studies, any estimates from empirical work at the bank level will be contaminated by endogeneity bias. At the time of the intervention, the state of a bank's liabilities is likely to induce the government to react. However, this response is itself likely to have an independent impact on the bank's liabilities, particularly at the level of the individual institution. Our strategy is to use our model of the *causes* of interventions to develop an instrumental variable estimator to allow us to study their *consequences*.

Our results suggest that the size of a bank is an important determinant of key public British banking interventions: capital injections, nationalisations, and participation in government funding or central bank liquidity insurance schemes. In particular, the size of a bank relative to that of the entire banking system enters with a positive coefficient, suggesting that large banks are more likely to receive government assistance. The effect is often non-linear; the square of a bank's relative size has a negative and often significant effect on the probability of public intervention. As a bank's size is a structural feature and changes only slowly over time, it is unlikely to be determined by changes in bank liabilities. We therefore use this variable as an instrumental variable to identify the effect of public intervention on a key manifestation of bank vulnerability/distress, access to wholesale funding. The latter (referred to as 'non-core' liabilities by Hahm *et al* (2011)) is significantly positive affected by public interventions, rising some 38% after dramatic interventions like public capital injections and nationalisations.

Given the scale and robustness of our estimates, we tentatively conclude that the policies that the British authorities undertook during the financial crisis seem to have been successful in restoring financial market confidence in UK banks, at least along the narrow dimension we consider. Whether this effect can be examined in isolation is of course quite a different matter, so we make no attempt to judge the net benefit of British financial interventions.

3. Methodology

3.1 Determination of public interventions

We use a reduced-form model to examine which bank characteristics affect a bank's *ex ante* probability of receiving government assistance:

$$P(\text{event}_i) = \alpha + \beta X_i + \varepsilon_i \quad (1)$$

where: $event_i$ is a dummy variable that takes a value of one if bank i has been affected by a given public sector intervention following the onset of the global financial crisis, and is zero otherwise; X is a vector of factors that drive the probability of public intervention; ε is a well-behaved residual that represents omitted factors such as ‘management quality’ or ‘interconnectedness with the rest of the global banking system’ and $\{\alpha, \beta\}$ are coefficients to be estimated.

We estimate this regression using a multinomial logit technique since we consider different types of discrete events. We adopt a cross-sectional approach because the sluggishness of the regressors does not seem to permit a sensible panel approach; we do not attempt to predict the *timing* of public interventions, only their *incidence* across banks.

Our choice of explanatory variables is motivated by the literature on government intervention in financial markets. Two of our important regressors come from the liability side. Banks that received public assistance are typically banks that were close to failing. In their study of American bank failure, Wheelock and Wilson (2000) find that inefficient management and a low equity (capital) to asset ratio increase the probability of failure. We do not observe the quality of management with quantitative measures available for our banks, an issue that comes back to haunt us later on. Still, one of the explanatory variables available to us is the capital: asset ratio. Similarly, in a case study of the failure of the British bank Northern Rock, Shin (2009) points out that the run on Northern Rock started in wholesale markets, some time before the bank actually requested liquidity support from the Bank of England. A second important variable is therefore the fraction of non-retail: total liabilities, which is measured as a residual item by subtracting retail deposits of UK residents from total liabilities.¹ (Hahm *et al* (2011) have since investigated the importance of ‘non-core’ liabilities further at the aggregate level.)

We also use two key variables taken from the asset side of the balance sheet. Barrell *et al* (2010) find that there is a strong link between property prices and banking crisis. To assess whether banks that were exposed to the UK property market had a greater probability of failing, we also include the fraction of a bank’s lending to the commercial real estate and household

¹ Strictly speaking, a bank’s capital is also recorded in its balance sheet on the liabilities side. Throughout this study, we exclude capital from our definition of total liabilities. This is because we want to measure to what extent non-core funding increases following an intervention. If capital were included in total liabilities, the ratio of non-core to total liabilities would of course be affected by a public capital injection almost by construction.

sector, as potential explanatory variables.² Following previous work, we also include the loan: asset ratio.³

Finally, we include bank size. We are interested in testing the often-cited conventional wisdom that public intervention during the crisis was motivated by the fact that certain banks were simply too big to fail. Accordingly, we include the size of a bank relative to that of the banking system as a whole; we also include the square of bank size to test the linearity of this effect. We focus on relative size, as it is a bank's relative size to the whole banking system which determines if it is 'too big to fail', though we have also experimented with an absolute measure.^{4,5,6}

3.2 Intervention consequences

Our primary interest lies in the determinants of public sector intervention in the financial sector, a topic of interest that has not been much explored at a micro level. However, a functional model of interventions naturally lends itself to exploring the consequences of these interventions, identification permitting. Accordingly, another objective of our project is to use the fitted values from our determination equation as an instrument to estimate the effect of interventions. We focus on the obviously interesting effects on a bank's liabilities. The regression model we estimate is:

$$Y_{i,t} = \gamma_i + \delta_y + \phi \text{Event}_{i,t} + \theta \text{Controls}_{i,t} + \varepsilon_{i,t} \quad (2)$$

where $\{\gamma, \delta\}$ are a set of bank and time-specific fixed effects, ε is a well-behaved residual, and ϕ is the coefficient of interest to us. We estimate (2) with instrumental variables, using the estimates from (1) to form an instrument.

The regressand we focus on is the fraction of non-retail bank funding, that is non-core or wholesale funding, a variable of much topical interest, though we also consider effective interest rate spreads. Our choice of this variable is driven by an emerging consensus that banks with a large fraction of wholesale funding were particularly vulnerable to failure during the global

² The largest part of British household lending consists of mortgage-related lending.

³ We have also experimented with additional income statement controls such as the profit/asset; non-performing loans/asset; and dividend/asset ratios.

⁴ We have tested and cannot reject the hypothesis that (the logarithm of) a bank's absolute size is irrelevant, conditional on including our measures of relative bank size. Using a bank's relative size is also advantageous since it is much more likely to be a stationary variable. On the other hand, the United Kingdom's banking system is globalised, housing one of the world's premier international financial centres in the City of London. Accordingly, it houses a large number of branches and subsidiaries of foreign banking groups. Some of the latter may be large when measured relative to the banking system in their home countries, but small relative to the British banking system. Thus, we think of our relative size measure as being substantially more accurate for British (as opposed to foreign) banks.

⁵ In their survey of 150 studies of bank mergers in Europe and the United States, DeYoung, Evanov and Molyneux (2009) argue that there is robust evidence that mergers among banks can be motivated by the desire to obtain 'too big to fail' status and the associated government subsidies.

⁶ We would also like to use 'too interconnected to fail', 'too systematically important to fail', and 'too politically connected to fail' but do not know how to measure these variables appropriately.

financial crisis. Diamond and Rajan (2009) argue that banks' reliance on short-term wholesale funding was one of the underlying causes of the credit crisis. In his account of the timeline of, and the vulnerabilities to the US financial system in the run up to the global financial crisis, Brunnermeier (2009) supports this view. Shin (2009) provides a detailed account of the circumstances leading to the failure of Northern Rock, the first British institution to be nationalised during the crisis. He documents that Northern Rock failed as result of a run on its wholesale market liabilities, which started with the sub-prime crisis in the summer of 2007. Individual government interventions into banks were probably aimed at stopping this run in wholesale markets and restore confidence in the affected financial institutions. Since we want to evaluate the success of these policies, non-core funding seems a natural choice.

4. The data set

Our objective in this study is to examine empirically the effect of government interventions on bank liabilities. To the best of our knowledge, no publicly available data set provides sufficient information to answer this question rigorously. Laeven and Valencia (2009) provide aggregate data on government interventions during past systemic banking crises. But aggregate data do not allow one to distinguish the effects on banks that received government help from those that did not. Ait-Sahalia *et al* (2009) provide data on various crisis interventions at the institutional level for the most recent global financial crisis. However, for European countries, bank balance sheet data provided by public sources, such as *BankScope*, typically only provides a limited coverage of the banking system, which may lead to misleading research conclusions.⁷

Fortunately, for the purposes of this investigation, the Monetary and Financial Statistics Division at the Bank of England have kindly provided us with an appropriate data set. It includes quarterly data with a host of information for all banks resident in the United Kingdom, from 2007 Q3 through 2010 Q3. This rich data set is substantially better suited to test our hypotheses than publicly available data sets. Unfortunately, it has a substantive disadvantage for academic research; for obvious reasons, the data set is confidential.⁸

The data set provides us with a complete set of balance sheet data for every institution in the British banking sector, as all banks operating in the United Kingdom must provide this

⁷ It is unclear how reliable and comprehensive *BankScope* data are for European countries; Ehrmann *et al* (2001) show in the case of euro-area countries, that *BankScope* data can suggest very different answers from more complete databases available at national central banks.

⁸ This data set has many common elements with that used by us in Rose and Wieladek (2011). It is available on a locational (as opposed to a consolidated) basis. This difference in reporting may be important for some questions regarding cross-border lending, but it is irrelevant for ours. Consolidated data records 'pure' cross-border lending at the banking group level as an external claim, netting out within-banking group transfers

information to the Bank of England under the present regulatory regime.⁹ Internally, the Bank of England uses this confidential data set to help carry out its financial and monetary stability objectives. Externally, the data has historically been passed on to the Financial Services Authority for the purposes of bank regulation and to the Office for National Statistics, where it features as one of the building blocks of the United Kingdom's national accounts. The accuracy of this data set is an important priority of the Bank of England: it is compiled in accordance with the Bank's published Statistical Code of Practice and Data Quality Framework.¹⁰

Reporting institutions must provide the data to the Bank of England in several 'forms'. The BT form of the data set provides a complete set of balance sheet information, including a detailed breakdown of assets and liabilities. The 'ER' form provides effective interest rate data on a bank pays on its liabilities. Variables gathered from these forms permit us to study how various forms of interbank and non-bank liabilities affect the probability of a government intervention, as well as the effects of interventions.¹¹ We also take advantage of data provided by the PL form, which contains in-depth information of the reporting institution's income/expenditure statement. We use additional data from this form to construct control variables such as the non-performing loan ratio and profitability, though this is only available for about half the banks in our sample. Further details on the construction of our variables are available in the data appendix.¹²

Which of the British banks in our sample have been affected by public interventions during the sample period? In early August 2010, we conducted bank-by-bank Google searches for 'bank name' nationalisation nationalize privatize' where 'bank name' was the precise name of the individual bank in question (according to the Bank of England data set). The clues we discovered from these searches lead us to investigate approximately 150 banks in detail. As we found convincing evidence of public interventions, we constructed suitable binary dummy variables (which take on the value of one at the time of and after public intervention, and are otherwise zero). We have subsequently used a number of other disaggregated data sets on public interventions in banks to check and corroborate our classifications.¹³

⁹ To maintain transparency, we do not try to adjust the data for mergers and acquisitions. If one bank is bought by another, then the former drops out of our sample, while the latter's lending artificially expands by the acquired institution.

¹⁰ For more details, please see: www.bankofengland.co.uk/statistics/pages/about/code.aspx

¹¹ Data from both forms are available at monthly and quarterly frequencies.

¹² In times of financial crisis and bank runs in particular, bank balance sheet variables are difficult to measure with reliability. Above and beyond accounting measurement error, a bank's capital to asset ratio may be zero or negative because of bank distress. We therefore did not exclude outliers in the variables used in our investigation, unless otherwise stated. Nevertheless, we note that all of the results reported here are robust to excluding these outliers.

¹³ For instance, our classification turns out to be consistent with the database on policy interventions in the current crisis (including bank nationalisations), provided by Ait-Sahalia *et al* (2009) in the accompanying Excel file.

We gathered data on different types of public intervention: unusual access to loans, guarantees or liquidity, and injections of public capital. We use discrete 0/1 dummy variables for these events, though they are in some sense continuous variables. Some banks were effectively nationalised when they received capital injections, a clear discrete occurrence. But it is difficult to measure accurately the government's effective influence on the bank after many public capital injections, since private bank capital is difficult to measure during the very times of crisis when capital is injected. Some banks received capital injections that were minor compared with existing capital; they remained essentially private institutions. Others were effectively nationalised; indeed, we find that the two groups operate similarly below, which seems sensible given that nationalisation is, in some sense, an extreme form of capital injection. Measurement of participation in government funding or central bank liquidity insurance schemes is also problematic, since these forms of assistance are heterogeneous in unobservable ways.¹⁴ Regardless of the size of the intervention, we consider access to special liquidity facilities or public capital injection (including obviously nationalisation) as a strong sign of sovereign support for the affected financial institution. To the extent that investors interpret this as a signal of safety, any intervention should help to stabilise non-retail liabilities and restore confidence in a bank. As a result, we argue that treating public interventions as binary dummy variables is reasonable.

As shown in Table 1, over our sample period, 26 British banks participated in government funding or central bank liquidity insurance schemes, fourteen received public capital injections, and five banks were nationalised. Of the foreign banks, ten¹⁵ participated in government funding or central bank liquidity insurance schemes, 57 received public capital injections, and fifteen were nationalised.¹⁶ Since we use locational data, more than one bank (all entities within a banking group) will be affected in our sample, when the whole banking group is affected by these interventions. In the case of the part-nationalisation of the Royal Bank of Scotland Banking Group for example, all of the individual banks belonging to this group, for instance Coutts, will be recorded as nationalised entities. Our data set consists of a total of 611 banks.

¹⁴ By participation in government funding or central bank liquidity insurance schemes, we refer to cases where banks received larger amounts of liquidity against assets of lower quality than would have been permitted in normal times. Not all banks chose to participate in these facilities during the crisis (in some countries the degree of access was public information; in these countries, the associated stigma led to a degree of adverse selection among the institutions with access to these schemes). Our Google searches only pick up announcements of interventions at the time of implementation. That is our data set does not contain information on the Bank of England's Special Liquidity Scheme (SLS) or Emergency Liquidity Assistance (ELA) scheme.

¹⁵ Compared to the total number of foreign banks in our sample, this number may seem small. However, to avoid the 'stigma' associated with the use of such facilities, a lot of this information was not publicly disclosed at the time when we collected our data. As a result our data set may not include all of the relevant cases in this category.

¹⁶ Our wholesale funding measure is based on the fraction of retail to total sight and time deposits. For some banks, this was slightly negative, as a result of rounding error. To ensure that our results are not driven by these banks, we excluded them in the regressions reported in Tables 7 and A4. Nevertheless, it is important to note that results reported in Tables 7 and A4 are robust to the inclusion of banks with a retail to total deposit ratio which exceeds one.

However, lending data are only available for larger banks;¹⁷ these account for about 90% of lending to the UK economy and make up roughly 60% of the reporting population. Including lending data is thus equivalent to excluding small banks. Given the determinants, model (1) is estimated on this smaller sample of up to 374 larger banks, while model (2) is estimated on both samples.

5. Results

5.1 Causes

Prior to a formal econometric analysis, it is worth looking at the average relative size of the banks across interventions. Table 2 shows that the relative size of the British banks that received public support is substantially larger than the size of banks that did not. It is unclear if a similar pattern applies for foreign banks from Table 2, but this is probably because our data set only captures the British component of foreign banks (which are presumably larger in their home markets). Our more formal econometric analysis below essentially verifies this preliminary finding.

Table 3 presents our results from estimating equation (1). We estimate an overparameterized general model initially and subsequently reduce it down to a more tractable model on the basis of statistical tests. The regressors were averaged over a ten-year period up until the third quarter of 2007, the start of the global financial crisis; analogous results where the regressors were averaged over a two-year period are similar and recorded in Appendix Table A1.

The default omitted ‘cell’ for the analysis of Table 3 is ‘no intervention’ so that each of the coefficients recorded shows the effect of a given regressor (recorded in rows) on the probability of a particular type of intervention (recorded in columns) compared with the default of no intervention. We consider six different types of interventions, and model each with different coefficients initially. In particular, we differentiate between a) domestic and b) foreign public interventions, and between a) participation in government funding or central bank liquidity insurance schemes, b) public capital injections, and c) bank-nationalisation.¹⁸

¹⁷ The size cut-off here is one billion pound sterling. This means that every included bank would have been eligible to apply for Bank of England liquidity facilities.

¹⁸ Some banks experienced more than one type of intervention; for instance they both participated in government funding or central bank liquidity insurance schemes and received public capital injections. In such cases, we only use the value of the most invasive intervention for the dependent variable; nationalisation is the most invasive intervention, followed by public capital injection, and finally participation in government funding or central bank liquidity insurance schemes. Thus if a bank has both participated in government funding or central bank liquidity insurance schemes and been nationalised (for example), we only record that it was nationalised.

Even though the model specified in Table 3 is relatively general, it does not fit the data particularly well. The quasi- R^2 is low, and most of the coefficients are insignificantly different from zero at standard levels of statistical significance. While a number of factors seem to be relevant in explaining British bank nationalisations, it is much more difficult to explain interventions for foreign banks, particularly the provision of liquidity support. While each of the variables has a statistically significant effect for at least one intervention, most of our regressors have little discernible effect for most interventions. The exception is our measure of size, which seems to have a positive but declining effect for most interventions.

The model reported in Table 3 is manifestly overparameterized; over 40 coefficients are estimated on a cross-section with fewer than 400 observations. Accordingly, we explore different avenues to reduce down this general model to a more parsimonious specific model. In Table 4, we report a series of chi-square tests which test hypotheses for equivalence across different cells of the regressand. Thus the top row reports that the test statistics for equality between the coefficients for British and foreign provision of participation in government funding or central bank liquidity insurance schemes. The test statistic is 15.6, implying that the null hypothesis of equality can be rejected at greater than the 5% significance level. Table 5 contains an analogous set of test statistics for equality not of the entire model but of individual coefficients. Thus the top-left entry indicates that the null hypothesis of an equal effect of wholesale funding across all three British cells cannot be rejected at even the 10% significance level.

We interpret the results of Table 4 as suggesting that treating British public capital injections and nationalisations similarly seems reasonable, though participation in government funding or central bank liquidity insurance schemes, for British banks seems to require a different empirical model. This conclusion is further reinforced by the basis of the evidence in Table 5. It is unclear to us from Table 4 whether foreign interventions can be aggregated together, but aggregating all three interventions together in the case of foreign banks does not seem unreasonable given the results of Table 5. While the effects of commercial real estate seem to differ across foreign interventions, the other coefficients seem similar. In the interests of parsimony, we impose equality across all three foreign cells, noting that the effects of commercial real estate may be different across cells.

We then impose our two constraints: identical models for all three foreign interventions and equality for British bank nationalisations and public capital injections. The results from this more specific model are tabulated in Table 6. We realise that we could reasonably impose more

coefficient restrictions on the model, such as eliminating any effect of wholesale funding on intervention. However, we choose not to impose this restriction for obvious reasons; the non-effect (given the presence of other determinants) is intrinsically interesting. Some sensitivity analysis on the specific model is presented in Appendix Table A2.

Predicting government interventions is not an easy task even *ex post*. Nevertheless, it is useful to assess the goodness of fit of our proposed multinomial logit model. We classify a prediction as correct if the probability of an intervention predicted by the model is greater than 20%.

Based on this measure, the last row of Table 6 shows that our model can predict a reasonable proportion of interventions: 30%, 62.5% and 50% of British special access to liquidity facilities, British public capital injection/nationalisation and foreign interventions, respectively. This suggests that our model has reasonable in-sample fit, but unobservable factors such as managerial quality are still important.

The single most striking feature of Table 6 is that a bank's size relative to the British banking system plays a positive and statistically significant role for each of the public interventions that we model. This effect seems to be non-linear and declining in size; the quadratic terms are all negative, though they vary in statistical significance. The mean of the relative size variable is .36% with a standard deviation of 1.03; the largest bank in the sample constitutes roughly 10% of the British banking system. Similarly, the mean of the of the quadratic relative size term is 1.19 with a standard deviation of 7.26. From Table 6 then, an one standard deviation increase in relative size increases the probability of British bank participation in government funding or central bank liquidity insurance schemes, British public capital injection/nationalisation, and foreign interventions by 1.4%, 2.7% and 1%, respectively. Based on relative size alone, the largest bank in the sample has a probability of government intervention of around 24%.

5.2 Effects

We now have a functional (if imperfect) model of the determinants of public interventions in the banking sector. A bank's size relative to the banking system is a robust predictor of the probability of a bank receiving public assistance; by way of contrast, wholesale funding is not. We now use this model to explore the consequences of public intervention. We are motivated by the fact that a bank's size relative to the banking system evolves only slowly over time, whereas changes in access to wholesale funding can change quickly.

Table 7 explores the effects of interventions on wholesale funding access. The coefficients are estimated with panel data; bank and time-specific fixed effects are included throughout. We

focus on one key type of public intervention: public capital injections or nationalisations of British banks. We do this for a number of reasons. First, our empirical model (in Table 6) performs better for those interventions (note that both size and its square enter at conventional levels of statistical significance). We restrict ourselves to British banks since our measure of relative bank size is likely to be less accurate for foreign banks, for the reasons given above. A British focus also allows us to ignore the issue of potential inappropriate aggregation we uncovered with respect to foreign commercial real estate lending. Finally, these are the most dramatic and visible public interventions; as such, they seem a natural first place to look.

The OLS estimates of Table 7 indicate that public interventions did have a detectable effect on access to wholesale funding; the coefficient is positive with a t-statistic of 2.41 (significantly different from zero at a level of .05). However, when we use size as an instrumental variable, the coefficient rises dramatically by a factor of four; the point estimate indicates that intervention raises wholesale funding by some 38%, an economically large effect.¹⁹ The coefficient is different from zero at all conventional levels of statistical significance, and a Hausman test indicates that the OLS and IV results are significantly different, throwing serious doubt on the former. This result is unaffected by including the capital: asset ratio as a control. We also report the Stock and Yogo (2005) F-statistic for weak instruments. These are substantially above the values tabulated by Stock and Yogo, suggesting that our estimates do not suffer from a weak instrument problem.

Our results are not uniformly strong however. When we restrict ourselves to the 366 banks for which we have income statement information such as the profit: asset and NPL: asset ratios, the coefficient becomes negative, though insignificantly different from zero.^{20,21} The weak negative coefficient is mostly the result of the smaller sample size, as the column at the extreme right of Table 7 shows, but these results temper the strength of our results. These results are robust when we re-estimate model (2) on the smaller sample of larger banks (Table A3). Our caution is strengthened by the estimates in Appendix Table A4; this presents some results analogous to those of Table 7, but where we use interbank deposit rate spreads as the regressand. Unfortunately, interest rate data are only available since 2004 Q1 for a relatively small number of the largest UK banks, and none of our results are statistically significant.²²

¹⁹ In order to be conservative, we only use the quadratic size effect as an instrumental variable.

²⁰ The reader will note that we do not have many control variables in regression 2; unfortunately, it is not possible to include more control variables without constraining the sample size substantially.

²¹ This is a surprising finding, which will be investigated in future research.

²² One could easily imagine looking at other effects of intervention, such as the loan/asset ratio.

6. Summary and conclusion

Our main contribution in this paper has been a micro-level investigation of the determination of extraordinary public interventions during the recent financial crisis. Using a confidential data set available at the level of individual banks, our most interesting finding is that size matters. We find strong and robust evidence that the size of a bank (relative to that of the entire banking system) has a positive but declining effect on the probability of an official rescue.

Our model of determination enabled us to develop an instrumental variable for the consequences of intervention, using size as our key instrumental variable. Using this strategy, a key indicator – access to wholesale funding markets – does indeed respond positively to intervention. British bank nationalisation or public capital injection permits a bank to raise its access proportion of wholesale funding by over 38%, though this result is sensitive. Judged on this narrow metric, we tentatively conclude that British banking interventions seem to have been successful during the crisis.

Table 1: Government Interventions by Type

No. Banks:	Liquidity	Capital Injection	Nationalisation	Total
British	26	14	5	45
Foreign	10	57	15	82
All	36	71	20	127

Table 2: Means of Relative Bank Size by Government Intervention and Bank Nationality

Mean Relative Bank Size:	Liquidity	Capital Injection	Nationalisation	No Intervention
British Bank	1.87	2.03	2.7	.04
Foreign Bank	.13	.56	.07	.13

Relative Bank Size defined in text

Table 3: Determinants of Public Interventions, General Multinomial Logit Estimates

Intervention:	Liquidity Support	Capital Injection	Nationalisation	Liquidity Support	Capital Injection	Nationalisation
Banks:	British	British	British	Foreign	Foreign	Foreign
Wholesale	-.01	-.01	-.03**	-.00	-.00	-.01
Funding	(.02)	(.02)	(.01)	(.01)	(.01)	(.01)
Commercial	-.01	.02	.05**	-.01	.00	.03**
Real Estate	(.02)	(.02)	(.02)	(.02)	(.01)	(.01)
Loans/Assets	.00	.06**	.05**	-.02	.005	.01
	(.02)	(.02)	(.01)	(.02)	(.007)	(.01)
Capital/Assets	.062**	-.000	-.006	-.01	.011	.001
	(.016)	(.003)	(.005)	(.006)	(.012)	(.015)
Size	1.3*	3.0**	2.7**	14	1.2**	11.3
	(.61)	(.9)	(.6)	(10)	(.4)	(9)
Size ²	-.07	-.30*	-.20**	-30	-.11*	-31.
	(.06)	(.12)	(.05)	(22.1)	(.05)	(21.4)
% Correct Predictions	30	45	40	0	24	33

Notes: 372 bank observations; McFadden's $R^2 = .19$. Coefficient estimates from multinomial estimation, with robust standard errors recorded parenthetically. Coefficients significantly different from zero at .05 (.01) confidence level marked with one (two) asterisk(s). 'Correct predictions' tabulated for $p(\text{event}) > .2$. Intercepts included for each cell estimated but not recorded. Regressors averaged over 1997 Q2-2007 Q2.

Table 4: Tests of Model Equivalence Across Cells

	Chi-Square Test Statistic
EQUALITY AMONG FOREIGN & BRITISH INTERVENTIONS	
Liquidity Support	15.6**
Capital Injection	15.6**
Nationalisation	14.5**
Liquidity Support, Capital Injection, and Nationalisation simultaneously	85.4***
EQUALITY AMONG BRITISH INTERVENTIONS	
Liquidity Support = Capital Injection	24.8***
Capital Injection = Nationalisation	4.9
Liquidity Support = Nationalisation	34.36***
Liquidity Support = Capital Injection = Nationalisation	41.2***
EQUALITY AMONG FOREIGN INTERVENTIONS	
Liquidity Support = Capital Injection	6.25
Capital Injection = Nationalisation	8.41
Liquidity Support = Nationalisation	9.58
Liquidity Support = Capital Injection = Nationalisation	23**

Coefficients significantly differently from zero at .10/.05/.01 confidence levels marked with one/two/three asterisks.

Table 5: Tests of Coefficient Equality Across Cells

Chi-Square Test Statistics	Wholesale Funding	Comm. RE	Loans/ Assets	Capital/ Assets	Size	Size²
BRITISH INTERVENTIONS						
Liquidity = Nationalisation = Capital Injection	3.0	7.2***	7.55**	16.9***	4.33	3.66
Liquidity = Nationalisation	1.8	7.1***	6.2**	13.8***	4.2**	3.4*
Liquidity = Public Capital Injection	.1	3*	5.9**	11.9***	2.8*	2.7*
Nationalisation = Public Capital Injection	2.2	1.3	.19	2.2	.17	.9
FOREIGN INTERVENTIONS						
Liquidity = Nationalisation = Capital Injection	.28	4.73*	2.29	3.39	2.83	3.91
Liquidity = Nationalisation	.0	.49	2.04	1.34	.04	.8
Liquidity = Public Capital Injection	.18	.14	1.1	2.5	1.62	1.83
Nationalisation = Public Capital Injection	.21	4.73**	.81	.01	1.23	2.1
BRITISH & FOREIGN INTERVENTIONS						
Nationalisation = Capital Injection = Liquidity (British = Foreign Simultaneously)	5.9	11.5**	18.5***	16.97***	12.7**	8.8

Coefficients significantly differently from zero at .10/.05/.01 confidence levels marked with one/two/three asterisks.

Table 6: Determinants of Public Interventions, Specific Multinomial Logit Estimates

Intervention:	Liquidity Support	Capital Injection/ Nationalisation	Any Intervention
Banks:	British	British	Foreign
Wholesale	-.006	-.02	-.003
Funding	(.02)	(.01)	(.007)
Commercial	-.01	.03*	.012*
Real Estate	(.02)	(.01)	(.006)
Loans/Assets	.004	.06**	.006
	(.02)	(.01)	(.005)
Capital/Assets	.055**	-.001	.007
	(.02)	(.003)	(.008)
Size	1.26**	2.7**	1.0**
	(.6)	(.6)	(.3)
Size ²	-.07	-.22**	-.09*
	(.06)	(.07)	(.04)
% Correct Predictions	30	62.5	50

Notes: 372 bank observations; McFadden's $R^2=.19$. Coefficient estimates from multinomial estimation, with robust standard errors recorded parenthetically. Coefficients significantly differently from zero at .05 (.01) confidence level marked with one (two) asterisk(s). Intercepts included for each cell estimated but not recorded. 'Correct predictions' tabulated for $p(\text{event}) > .2$. Regressors averaged over 1997 Q2-2007 Q2.

Table 7: Consequences of British Capital Injections/Nationalisations for Wholesale Funding

	OLS	IV	IV	IV	IV
British Intervention	9.8*	37.9**	37.5**	-3.8	-3.8
	(4.1)	(8.9)	(8.9)	(2.0)	(2.0)
Capital/Assets			-.02	-.09**	-.01
			(.01)	(.03)	(.01)
Profits/Assets				.16*	
				(.06)	
NPL/Assets				.39**	
				(.08)	
Observations	17,501	17,501	17,501	7,678	7,678
# Banks	611	611	611	366	366
Hausman Test		22.0**	21.5**	11.9**	13.1**
Weak IV Test		24.7**	24.7**	27.9**	27.9**

Each column represents a different model; estimator recorded in first row (Size² used as instrumental variable for interventions). Last two columns estimated on reduced sample for which income statement data are available. Time span of data: 1997 Q3-2010 Q4. Coefficients, with robust standard errors in parentheses. Coefficients significantly differently from zero at .05 (.01) confidence level marked with one (two) asterisk(s). Intercepts, bank and time-specific fixed effects are included but not recorded.

Table A1: Determinants of Public Interventions, General Logit, Two-Year Averaging

Intervention:	Liquidity Support	Capital Injection	Nationalisation	Liquidity Support	Capital Injection	Nationalisation
Banks:	British	British	British	Foreign	Foreign	Foreign
Wholesale Funding	-.05* (.03)	-.06 (.05)	-.08 (.05)	.022 (.04)	.01 (.014)	-.023* (.013)
Commercial Real Estate	.01 (.03)	.046* (.027)	.07*** (.02)	.017 (.023)	.003 (.01)	.045*** (.016)
Loans/Assets	-.07 (.05)	.16** (.07)	.13** (.06)	-.041 (.05)	.013 (.008)	.032* (.013)
Capital/Assets	.055** (.026)	-.45 (.18)	-.28* (.15)	-.15 (.11)	.006 (.017)	-.008 (.035)
Size	.48 (.74)	4.54** (2.31)	3.48** (1.72)	52.4 (36)	1.02** (.45)	14.4 (9.8)
Size ²	.01 (.06)	-.31 (1.57)	-.28* (.15)	-173.9 (118.4)	-.08 (.05)	-24.2 (17.4)
% Correct Predictions	50	85	50	20	42	44

Notes: 190 bank observations; McFadden's $R^2=.30$. Coefficient estimates from multinomial estimation, with robust standard errors recorded parenthetically. Coefficients significantly differently from zero at .05 (.01) confidence level marked with one (two) asterisk(s). Intercepts included for each cell estimated but not recorded. 'Correct predictions' tabulated for $p(\text{event})>.2$. Regressors averaged over 2005 Q2-2007 Q2.

Table A2: Additional Determinants of Public Interventions, Specific Multinomial Logit Estimates

Intervention:	Liquidity Support	Capital Injection/ Nationalisation	Any Intervention
Banks:	British	British	Foreign
Wholesale	-.04	-.01	.00
Funding	(.02)	(.02)	(.01)
Commercial	-.015	-.02	.014*
Real Estate	(.04)	(.02)	(.007)
Loans/Assets	-.06	.07**	.01
	(.03)	(.02)	(.01)
Capital/Assets	.05	.001	.014
	(.03)	(.004)	(.01)
Size	1	3.2**	1.2**
	(1.0)	(1.1)	(.4)
Size ²	-.04	-.29*	-.10*
	(.1)	(.14)	(.04)
Profit/Assets	-.05	.9	.13
	(.15)	(.9)	(.24)
NPL/Assets	.01	-2.3	-.3
	(.4)	(1.3)	(.3)
% Correct Predictions	50	91	75

Notes: 245 bank observations. Coefficient estimates from multinomial estimation, with robust standard errors recorded parenthetically. Coefficients significantly differently from zero at .05 (.01) confidence level marked with one (two) asterisk(s). Intercepts included for each cell estimated but not recorded. 'Correct predictions' tabulated for $p(\text{event}) > .2$. Regressors averaged over 1997 Q2-2007 Q2.

Table A3: Consequences of British Intervention on Wholesale Funding excluding small banks

	OLS	IV	IV	IV	IV
British Intervention	9.8* (4.3)	32.9** (8.1)	31.3** (7.9)	-4.48* (2.1)	-3.7* (2.1)
Capital/Assets			-0.17 (.027)	-0.21** (.05)	-0.21** (.05)
Profits/Assets				-0.04 (.10)	
NPL/Assets				.48** (.08)	
Observations	12,021	12,020	12,020	5587	5587
# Banks	374	373	373	257	257
Hausman Test		16.3**	14.3**	12.2**	13.9**
Weak IV Test		24.6**	24.6**	27.9**	27.9**

Each column represents a different model; estimator recorded in first row (Size² used as instrumental variable for interventions). Last two columns estimated on reduced sample for which income statement data are available. Time span of data: 1997 Q3-2010 Q4. Coefficients, with robust standard errors in parentheses. Coefficients significantly differently from zero at .05 (.01) confidence level marked with one (two) asterisk(s). Intercepts, bank and time-specific fixed effects are included but not recorded.

Table A4: Consequences of British Capital Injections/Nationalisations for Interbank Deposit Spreads

	OLS	IV	IV	IV	IV
British Intervention	.02 (.46)	-.28 (.25)	-.31 (.25)	-.31 (.25)	-.30 (.25)
Capital/Assets			.03 (.01)	.03 (.01)	.03 (.01)
Profits/Assets				.01 (.04)	
NPL/Assets				-.004 (.003)	
Observations	587	586	586	568	568
# Banks	33	32	32	30	30

Each column represents a different model; estimator recorded in first row (Size and Size² used as instrumental variables for interventions). Last two columns estimated on reduced sample for which income statement data are available. Coefficients, with robust standard errors in parentheses. Coefficients significantly differently from zero at .05 (.01) confidence level marked with one (two) asterisk(s). Intercepts, bank and time-specific fixed effects are included but not recorded.

Data appendix

We collect the raw data from the AL, BT, ER and PL forms. A detailed description of these forms (along with the forms themselves) is available at www.bankofengland.co.uk/statistics/pages/reporters/defs/default.aspx. The variables used in our regressions are transformed from the raw data as tabulated below.

Variable	Item in form
Wholesale Funding	$(BT20 \text{ [Total Liabilities]} - BT19[\text{Total Capital}] - BT2H \text{ [Retail Sight Deposits]} - BT3H[\text{Retail Time Deposits}]) / (BT20 \text{ [Total Liabilities]} - BT19[\text{Total Capital}])$
British Bank	Institutional Nationality is identified by the Bank of England (over time) in www.bankofengland.co.uk/statistics/pages/reporters/institutions/default.aspx
Size	$BT 40 \text{ [Total Assets]} \text{ of Bank } i / \text{Sum of } BT 40 \text{ across all Banks}$
Loan Growth	Growth rate of $AL 19 \text{ [Total Lending to UK residents]}$
Capital/ Assets ((Capital + Reserves)/Total Assets)	$BT 19 \text{ [Capital and Other funds]} / BT 40 \text{ [Total Assets]}$
Non Performing Loan Ratio	$PL 20B \text{ [Financial Level of Provisions for Bad and Doubtful Debts]} / BT 40 \text{ [Total Assets]}$
Profitability	$PL 19 \text{ [Retained Profit before Provisions for Bad and Doubtful Debts]} / BT 40 \text{ [Total Assets]}$
Loans/Assets	$AL 19 \text{ [Total Loans to UK residents]} / BT 40 \text{ [Total Assets]}$
Commercial Real Estate Lending/ Total Lending	$AL 10 \text{ [Lending to the 'Real Estate, professional services and support activities' sector]} / AL 19 \text{ [Total Loans to UK residents]}$

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