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By *Thomas Conlon, John Cotter, and Philip Molyneux*

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Abstract

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Keywords: Regulatory Capital, Bank Risk, Regulatory Capital Arbitrage, Tier 1, Tier 2
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1. Introduction

This paper seeks to understand a complex and relatively unexplored question, namely, beyond common equity is bank insolvency risk sensitive to the quantity and mix of other secondary regulatory capital held? At the core of banking regulation is the concept of minimum capital requirements, but capital regulation has often struggled to keep pace with the evolution of bank financial and operational sophistication. Bank management, using innovative capital instruments and strategic risk modelling, contribute to the complexity of the nexus between capital and risk. Requiring a bank to hold greater quantities of capital is expected to be associated with reduced risk, but the ability of management to shift between capital of differing quality and to manipulate standardized risk-weights obfuscates the relationship.

The literature examining the relationship between capital and risk has largely focussed on equity capital or more comprehensive tier 1 capital.[1] In contrast, bank management have a feast of capital ingredients available to satisfy regulatory capital requirements. Tier 1 capital formally comprises paid-up share capital and disclosed reserves, and may include perpetual non-cumulative preference shares. We further decompose tier 1 capital into high quality tangible common equity and a lower quality residual component, termed non-core tier 1 capital (NCT1). Tier 2 capital is composed of undisclosed and asset revaluation reserves, loan-loss reserves, hybrid capital and subordinated debt. In quantifying regulatory capital, each of these is adjusted for asset risk utilizing a risk-weighted assets denominator. In this study we focus on the influence of NCT1 and tier 2 capital on bank insolvency risk, a topic which has received limited attention.

Bank income diversification, underpinned by the business model selected, is linked with

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[1]The relationship between equity capital and risk is documented by Abedifar *et al.* (2013), DeYoung and Torna (2013), Berger and Bouwman (2013), Delis and Staikouras (2011), Demirgüç-Kunt and Huizinga (2010), Iannotta *et al.* (2007) and Krishnan *et al.* (2005) amongst others. Laeven *et al.* (2016), Cohen *et al.* (2014), Hasan *et al.* (2014), Ellul and Yerramilli (2013), Aggarwal and Jacques (2001) and Estrella *et al.* (2000) highlight the link between tier 1 capital and risk. The connection between total capital and risk is studied by Fiordelisi *et al.* (2011) and Jacques and Nigro (1997). Beltratti and Stulz (2012) and Fahlenbrach *et al.* (2012) consider the link between bank performance and lagged tier 1 capital during the financial crisis.

bank risk (DeYoung and Torna, 2013; Stiroh, 2006). Banks may adopt a particular business model, with the intention of altering their risk profile but may be constrained in their objectives by regulatory capital requirements. As highlighted by Boyson *et al.* (2016) in the context of trust preferred securities, constrained banks may adopt a form of regulatory arbitrage in order to take more risk. Such regulatory arbitrage amounts to a shift from tangible equity to lower-quality NCT1 capital, without breaching tier 1 capital requirements. In this paper, we examine whether the potential for bank regulatory capital arbitrage is borne out in the associations between forms of capital and insolvency risk, whilst characterizing the underlying business model through income diversification.

Under the Basel III accord, a minimum 2% of risk-weighted assets will be held in the form of tier 2 capital, declining from 4% under previous frameworks. While there is little debate about the ability of tier 2 capital to act as buffer for lower ranked creditors during insolvency, the relationship with ongoing risk is less clear. The requirement for tier 2 capital as a component of regulatory capital is often justified in terms of market discipline. If securities such as subordinated debt reflect the perceived risk of an institution, this may discourage or prevent management from adopting excessive leverage, but empirical support for this hypothesis is mixed (see, for example, Chen and Hasan (2011) and Krishnan *et al.* (2005)). Focussing on general reserves, one contributor to tier 2 capital, Ng and Roychowdhury (2014) isolate a distinct association with bank failure, conditional upon the impact such reserves have on total regulatory capital. Here we determine whether any links between tier 2 capital and bank insolvency risk exist, building on previous work limited to the consideration of bank performance (Demirgüç-Kunt *et al.*, 2013).

In determining minimum regulatory capital compliance, total regulatory capital, comprising tier 1 and tier 2 capital, is weighted according to the perceived risk of bank assets. Recent studies have, however, cast some doubt on the link between risk weighting and market implied asset risk. Acharya *et al.* (2013) suggest that banks use regulatory arbitrage to increase risk while maintaining or decreasing the level of risk-weighted assets. Risk-weighted assets have been shown to bear a scant relationship with market implied levels of bank risk (Vallascas and Hagendorff, 2013). Furthermore, Mariathasan and Merrouche (2014) find support for risk-weight manipulation, highlighting a decline in average risk weights after banks introduce the internal ratings-based approach. In light of these important findings, we examine whether risk weighting of capital undermines the relationship between the components of regulatory capital and realized bank risk.

A number of novel and significant findings are presented using a large sample of listed banks from 19 developed countries over the period 2002-2014. Considered collectively, tier 1 capital is not reliably associated with a reduction in risk. This finding does not carry over to the components comprising tier 1 capital. The unweighted tangible equity ratio is most consistently associated with lower future banking risk. In contrast, the NCT1 component of tier 1 capital is inconsistently associated with reduced risk and, in fact, has a positive relationship with insolvency risk for banks with a diversified business model, signified by abundant non-interest income. Taken collectively, these findings suggest that a bank substituting low quality capital for high quality equity, yet maintaining their regulatory capital levels, may impair the risk reduction properties of tier 1 capital. While tier 2 capital displays no link with insolvency risk when banks are considered en masse, a divergence is demonstrated for banks with different levels of total regulatory capital. The relationship between bank capital and risk is further weakened when normalized by risk-weighted assets, as opposed to total unweighted assets. Additional analysis considers non-systemic banks, accounting measures of risk, banks with distinct ex-ante capital levels and a wide range of specification tests.

Our contribution places the paper amongst the literature examining the benefits of banks holding further capital and that highlighting the potential for regulatory arbitrage. Although various studies highlight the importance of high-quality equity capital for bank performance, little attention has been paid to the components which comprise total regulatory capital. Closest to this paper is Demirgüç-Kunt *et al.* (2013), who examine the relationship between capital components and bank stock returns over the financial crisis. In contrast, our focus is on insolvency risk rather than performance and illustrates the relevance of capital elements throughout the cycle. In contrast to Berger and Bouwman (2013), and many previous studies, the focus here is on the contributing components of regulatory capital, rather than just tier 1 capital or total regulatory capital, shedding light on the individual underpinnings of the aggregate capital picture. Relative to these studies, our findings illustrate the inconsistent risk reduction benefits of low-quality capital and relate this to the underlying business model and absolute quantity of capital held.

The decomposition of tier 1 capital into tangible equity and non-core components reveals a heretofore unidentified variation in the risk reduction capacity of each, tantamount to regulatory capital arbitrage. This relates to recent papers which have examined the potential for regulatory arbitrage from specific capital instruments and shown heterogeneity amongst the characteristics of banks adopting low-quality capital (Boyson *et al.*, 2016). We develop this further, examining and documenting how the business model of the bank, previously linked with bank risk, is associated with the heterogeneity found between low-quality capital and risk. Finally, our finding of a weakened relationship between risk and the components of capital when the latter are normalized relative to risk-weighted assets, builds on literature examining the potential for misrepresentation of risk-weighted assets (Mariathasan and Merrouche, 2014; Acharya *et al.*, 2013; Vallascas and Hagendorff, 2013). If the sensitivity of risk weighting is impaired, minimum capital requirements specified relative to risk-weighted assets will have limited impact, in keeping with our results.

Ostensibly, many of the findings outlined in this paper are congruent with the renewed focus on high quality capital under the Basel III framework to be fully introduced by 2019. This framework will distinguish between non-core tier 1 capital and high quality common equity, requiring greater quantities of the latter. Banks will be required to hold a minimum 4.5% of risk-weighted assets in common equity, while remaining tier 1 capital will consist of securities (such as contingent convertible instruments) designed to provide loss absorbing capacity on an ongoing basis. This focus on greater quantities of equity capital is generally aligned with the loss reduction capacity of such capital outlined. As highlighted, however, links between insolvency risk and tangible equity are extinguished for banks holding greater than median tangible equity, indicating a potential limitation to the focus on greater quantities core equity capital under the Basel III framework. Moreover, alternative tier 1 components will be strictly comprised of high quality, subordinated perpetual instruments, thus limiting the potential for regulatory capital arbitrage. Finally, tier 2 capital will be restricted to 25% of the total minimum risk-weighted capital and treated as gone-concern capital. Reduction in the relative importance of such capital is appropriate, given the limited role in reducing going-concern banking risk highlighted here. This notwithstanding, requiring well capitalized banks to hold more tier 2 capital may be associated with increased insolvency risk.

The remainder of the paper is organized as follows. Section 2 provides a short overview of literature relevant to capital regulation and bank risk. In section 3, the data sample is described and summary statistics provided. Section 4 provides empirical results and sensitivity tests, while section 5 concludes.

2. Related Literature

Prudential bank regulation is designed to promote the safety and stability of the banking sector and the wider economy. The regulatory requirement for banks to hold capital is related to the safety net provided by government guarantees. The regulatory safety net, inclusive of deposit insurance, may be subject to agency problems, costs of financial distress and a potential reduction in market discipline (Berger *et al.*, 1995). Moreover, regulators are concerned about the possibility of systemic risk and associated social costs. Notwithstanding this, imposing severe capital requirements may impact the extent of intermediation as regulatory costs may be passed onto customers. This results in a tradeoff between the costs of negative externalities and the social cost of intermediation when setting regulatory capital requirements (DeAngelo and Stulz, 2015; Santomero and Watson, 1977).

Separate to minimum regulatory capital requirements, markets may also encourage banks to hold capital for a variety of reasons. Starting with the Modigliani-Miller proposition assuming perfect financial markets, an absence of bankruptcy costs, corporate taxation and other market imperfections, the value of a firm can be shown to be independent of capital structure (Modigliani and Miller, 1958). Relaxing these stringent assumptions, the market value of the firm may be optimized by altering the proportion of equity relative to debt. Bank capital structure (in the absence of regulatory capital requirements) is related to many internal and external factors (Gropp *et al.*, 2010; Berger *et al.*, 1995).

Bank shareholders have limited liability, creating a convex payoff to equity holders (John *et al.*, 1991). Any additional profitability associated with an increase in bank risk accrues to shareholders, while liability holders bear the majority of the downside (Duran and Lozano-Vivas, 2014; Hovakimian and Kane, 2000). By decreasing the size of their stake, equity holders may be able to create risk shifting opportunities. Prudential capital regulations attempt to overcome this problem by imposing capital restrictions on banks, with the potential implication that banks may be forced to hold capital over and above that prescribed by market forces. For a bank constrained by capital requirements, two possibilities exist; first, by changing capital composition they might be able to reduce the amount of equity capital held, while maintaining a constant level of regulatory capital (Boyson *et al.*, 2016). Second, they might choose to arbitrage risk weights associated with the regulatory capital denominator, using, for instance, asset-backed commercial paper to cosmetically transfer risk off the balance sheet (Acharya *et al.*, 2013; Jones, 2000). Given the potential for bank regulatory arbitrage, in this paper we examine whether substitute forms of capital offer similar risk reduction potential.

Boyson *et al.* (2016) link the propensity of banks to use regulatory arbitrage to their underlying business model. Banks with transactional business models seek a higher level of risk to maximise shareholder value but regulatory capital requirements act as an impediment. Related to this, a range of studies have examined links between bank income diversification and risk, many detailing greater risk for banks more exposed to non-interest income (Stiroh, 2006; DeYoung and Torna, 2013; De Jonghe, 2010; Lepetit *et al.*, 2008). Little consideration has been given to the links between bank's business models, use of secondary capital and insolvency risk. In light of recent and ongoing changes to regulatory capital policies, any evidence consistent with regulatory arbitrage highlights a need to account explicitly for the underlying business model in setting bank capital. We consider these issues in detail here.

Banks hold capital as a buffer for potential future losses, in an attempt to reduce the possibility of future distress. While the motivation for holding capital seems clear, the theoretical link between bank risk and the level of capital held is less so (VanHoose, 2007). Keeley and Furlong (1990), Furlong and Keeley (1989) and Jeitschko and Jeung (2005) argue that value-maximising banks will seek to decrease risk-taking as capital increases. In contrast, Besanko and Kanatas (1996) and Koehn and Santomero (1980) postulate that capital regulation may increase bank risk-taking, by encouraging banks to select riskier assets due to an asset substitution effect. Kim and Santomero (1988) and Rochet (1992) suggest that the relationship between capital requirements and portfolio risk may be ambiguous, perhaps even resulting in increased portfolio risk for greater quantities of capital. Calem and Rob (1999) reconcile these contrasting views, suggesting a U-shaped relationship between bank risk and capital, whereby very low or high levels of capital induce banks to increase their risk levels. Common to the aforementioned papers is a concentration on equity as representative of bank capital.

Beyond equity capital, established regulatory frameworks also permit supplementary forms of capital such as hybrid capital (having features from both debt and equity) and subordinated debt.[2] Subordinated debt should help to impose market discipline on a bank, through both market monitoring and market influence (Flannery, 2001). During periods of financial distress, however, investors in subordinated debt may have preference for riskier

[2]Recent regulatory adjustments, such as the Basel III Accord, further allow banks to hold contingent capital, convertible to equity when a bank faces financial distress. See Sundaresan and Wang (2015) and Glasserman and Nouri (2012) for a theoretical examination of the features of convertible contingent capital.

assets (Gorton and Santomero, 1990). Blum (2002) and Levonian (2001) present models of subordinated debt, highlighting weaknesses with potential to result in more intensive bank risk-taking. In contrast, Chen and Hasan (2011) detail a model in which subordinated debt might limit the moral hazard problem for banks, thus reducing risk-taking.

In light of somewhat disparate conclusions from the theoretical literature, we also look to empirical literature for guidance on the relationship between banking risk and various forms of regulatory capital. Considering accounting measures of risk, documented links between the adjustment in risk taking and increased capital are inconsistent (Camara *et al.*, 2013; Altunbas *et al.*, 2007; Aggarwal and Jacques, 2001; Jacques and Nigro, 1997).[3] The level of bank equity capital has largely been indicated as having a negative relationship with risk (Abedifar *et al.*, 2013; Delis and Staikouras, 2011; Iannotta *et al.*, 2007). Furthermore, there is strong evidence that holding more capital reduces likelihood of bank failure (Berger and Bouwman, 2013; Estrella *et al.*, 2000). Clustering of bank failures means the latter analysis provides little guidance on the propensity of increased capital to provide risk reduction over all periods. Demirgüç-Kunt *et al.* (2013) and Beltratti and Stulz (2012) find evidence that better capitalized banks have better stock market performance during the global financial crisis. In contrast to aforementioned studies, focus here is on components of capital, especially those perceived as lower-quality, and their relationship with insolvency risk.

A related empirical literature considers the ability of debt markets, in particular subordinated debt, to limit bank risk taking. Focus has largely been on the relationship between subordinated debt yields and ex-post risk but evidence for the effectiveness of market discipline on bank risk-taking is somewhat mixed. Various studies indicate that subordinated debt decreases bank risk-taking (Goyal, 2005; Sironi, 2003; Flannery and Sorescu, 1996), but others do not find strong links between changes in credit spreads and risk-taking (Krishnan *et al.*, 2005; Avery *et al.*, 1988). While many studies consider subordinated debt

[3] A related strand of literature examines the relationship between changes in the capital buffer, or capital excess over regulatory stipulations, and risk taking (Jokipii and Milne, 2011; Lindquist, 2004; Ayuso *et al.*, 2004).

credit spreads as risk indicators, the association between the quantity of such debt held and risk has received only limited attention. Ashcraft (2008) finds that increased quantities of subordinated debt reduce the probability of bank failure and a substitution of equity for debt is associated with increased likelihood of failure. Camara *et al.* (2013) consider some major components of bank capital individually, determining that changes in the quantity of subordinated debt are associated with an increase in risk-weighted assets, but find only limited links with changes in accounting risk.

At the core of micropruduential regulation and thus central to the regulatory capital limits imposed on banks are the risk weightings assigned to the assets held. While risk weightings should be sensitive to the portfolio risk of banks, empirical support is weak. Mariathasan and Merrouche (2014) find that reported bank risk levels are lowered post introduction of the Basel II internal ratings-based approach. Vallascas and Hagendorff (2013) demonstrate that risk-weighted assets are not representative of bank portfolio risk. Considering a measure of capital shortfall, Acharya *et al.* (2014) find that risk-weighted assets have a low correlation with market measures of risk. In light of this strong evidence that risk-weighting masks accurate assessment of bank risk, it is natural to ask whether the use of risk-weighted assets in calculating regulatory capital masks the expected risk reduction relationship, an important question we address here.

3. Empirical Model and Data

In order to test empirically the relationship between components of regulatory capital and bank risk, we estimate variants of the following model (Demirgüç-Kunt *et al.*, 2013; Beltratti and Stulz, 2012),

$$DD_{i,j,t} = \alpha + \delta DD_{i,j,t-1} + \beta^1 C^k_{i,j,t-1} + \beta^2 X_{i,j,t-1} + \beta^3 d_{j,t} + u_{i,j,t} \qquad (1)$$

where subscript i corresponds to individual banks, j to countries and t to the year of measurement. In our main specifications, $DD_{i,j,t}$ is distance to default at time t, $C^k_{i,j,t-1}$ is either a single capital metric vector or a matrix of k capital metrics, $d_{j,t}$ is a matrix of time and country dummy variables and $X_{i,j,t-1}$ is a matrix of bank-level control variables. The matrix of time and country dummy variables is included to account for omitted effects at the country and time level. Equation 1 relates bank insolvency risk at time t to capital adequacy metrics and control variables estimated at time $t-1$.

We examine a comprehensive database of listed financial firms. Annual fundamental and accounting data for a range of listed European and North American banks are obtained from Bankscope, resulting in a sample of $1,366$ banks in the period 2002 to 2014.[4] Focus is on listed banks as this allows us impute the market-implied distance to default as our primary measure of risk.[5] To remove ambiguity and double-counting of institutions, banks were selected at the highest corporate level possible, often at the holding company level.[6] Equity market data for each bank are retrieved from Datastream, a division of Thompson-Reuters. Previous studies have demonstrated the importance of considering bank capital adequacy during both periods of financial turmoil and normal times (Demirgüç-Kunt *et al.*, 2013; Berger and Bouwman, 2013). Following on from this, in addition to looking at banks over the entire period $2002-2014$, we further consider the relationship between capital and risk over the volatile period $2008-2011$ encompassing the global financial crisis and subsequent European sovereign debt crisis.

We also consider the links between risk and capital forms for a variety of moderating factors. First, considering bank size, the prospective losses from large banks in the event of failure are extensive, making them of particular interest to regulators. Furthermore, the danger of contagion to other banks leads us to analyse banks with total assets greater than

[4]Listed banks from 19 different European and North American countries are incorporated in this study. Countries included are Austria, Belgium, Canada, Denmark, Finland, France, Germany, Great Britain, Greece, Ireland, Italy, Luxembourg, Netherlands, Norway, Portugal, Spain, Sweden, Switzerland and the United States.

[5]In terms of specialization, our sample of listed banks is dominated by bank holding companies (67%), commercial banks (25%), savings banks (2.3%) and cooperative banks (1.46%).

[6]Focus in this paper is on financial institutions that are deposit-taking and loan-making. To this end, a minimum deposit to assets ratio of 20% and a minimum loan to assets ratio of 10% are imposed on the sample (Beltratti and Stulz, 2012).

\$50 billion.[7] Given the previous evidence for links between risk, diversification and capital, Demsetz and Strahan (1997), we also consider whether the links between capital and risk vary according to banks net-interest income. We further distinguish between banks with low and high levels of capital, using both tangible equity and total regulatory capital.

All variables are winsorized at the 1% and 99% levels, to remove the influence of outliers or reporting errors. Selection bias is mitigated by inclusion of banks which were acquired, merged, nationalized or filed for bankruptcy.

3.1. Banking Risk

Little consensus regarding a definitive measure of banking risk exists in the literature. Accounting based measures of risk are sometimes used, due to their availability for all bank types (listed and private) but may be influenced by managerial discretion and weighted towards previous performance rather than current and future banking risk (Fiordelisi *et al.*, 2011). In this paper, we wish to consider the ability of regulatory capital to reduce the likelihood of bank insolvency. To this end, the primary measure of risk considered is bank distance to default, eminating from the Merton (1974) structural credit risk model. Distance to default, calculated as the value of assets less adjusted liabilities divided by asset volatility is commonly adopted as a measure of bank risk (Anginer *et al.*, 2017; Milne, 2014).

The Merton (1974) model expresses the market value of a bank as a call option on the bank's assets:

$$V_E = V_A N(d_1) - X e^{-rT} N(d_2) \tag{2}$$

where V_E is the market value of a bank's equity, V_A is the market value of a bank's assets, X is the face value of debt maturing at time T, r is the risk-free rate. d_1 and d_2 are given by

$$d_1 = \frac{ln(A/D) + (r + \sigma_A^2/2)T}{\sigma_A \sqrt{T}}; \qquad d_2 = d_1 - \sigma_A \sqrt{T} \tag{3}$$

[7]This breakpoint is in keeping both with the literature, (Demirgüç-Kunt *et al.*, 2013; Berger and Bouwman, 2013) and with size cohorts considered as systemically important financial institutions by regulators. Alternative size splits are also considered in the sensitivity analysis.

where σ_A is the volatility of the asset's value, which is related to equity volatility, σ_E,

$$\sigma_E = N(d_1)\frac{A}{D}\sigma_A. \tag{4}$$

The above series of equations are simultaneously solved to determine the value of A and σ_A. σ_E is the annualized standard deviation of daily equity returns. The time to default, T, is taken as one year, and r is the 1-year treasury-bill rate for the country of origin. Merton's distance to default is then calculated as:

$$DD = \frac{ln(A/D) + (r - \sigma_A^2/2)T}{\sigma_A\sqrt{T}} \tag{5}$$

Companies do not tend to have debt exclusively maturing at the same point in time. Longer term debt may be assumed to have a lower influence on default, due to trending asset growth (Milne, 2014). For this reason, we adopt the procedure proposed by Mooody's KMV, assuming a one year horizon and weighting bank debt with a maturity greater than one year at 50% of face value.

To determine the consistency of results, we also consider various other risk metrics. First, we consider equity volatility, measured using the annualized standard deviation of daily stock returns. Further sensitivity tests examine systematic risk and idiosyncratic risk. The study of equity market-derived risk allows us to distinguish the cross-sectional characteristics of risky versus safe banks during both crisis periods and more normal times, not always possible with other measures of risk such as binary failure indicators (Berger and Bouwman, 2013). Furthermore, market based measures of risk are inherently forward looking, in contrast to accounting based counterparts. Second, two accounting related measures of risk are considered, chosen so as to limit the possibility of introducing endogeneity.[8] The first, non-

[8] An alternative to the risk measures described is to consider bank distress as a binary measure of banking risk, where distress may be defined as bank failure, nationalization, a requirement for capital injection or financial support amongst others (for example, Arena (2008)). The difficulty with this approach is that bank failures tend to cluster, meaning that such analysis tells little about cross-sectional bank risk during

performing loans to gross loans, is a backward looking measure of the proportion of loans that that are past due by 90 days or on an accrual basis. This measure represents bank credit risk. One caveat with this measure is that management may decide to make provision for such loans, hence impacting the magnitude of loan loss reserves and the level of equity capital. This metric has been applied as a measure of banking risk throughout multiple studies including Abedifar *et al.* (2013) and Delis and Staikouras (2011). A further measure employed is the standard deviation of return on assets, $\sigma(ROA)$. To calculate $\sigma(ROA)$, data from the three most recent years is used. This measure of accounting risk has been considered previously in numerous studies including Gropp *et al.* (2013); Delis and Staikouras (2011); Lepetit *et al.* (2008) and Iannotta *et al.* (2007).

3.2. Capital Adequacy

The objective of this paper is to determine whether differing forms of capital, in particular those outside of tangible equity, are related to bank insolvency risk. A variety of capital adequacy metrics are promoted both by regulators and in the banking literature, and we attempt to distinguish the differential risk reduction capacity of each. Furthermore, we investigate the impact of risk weighting on normalized capital. Each of these is described below and summarized in table A.1.

Tier 1 capital is the backbone of the Basel II regulatory framework and primarily consists of shareholder funds (common stock, disclosed reserves and retained earnings), qualifying noncumulative perpetual preferred stock (including related surplus), senior perpetual preferred stock (issued under support plans such as TARP from 2008 onwards), trust preferred securities, related interest in equity of consolidated subsidiaries, less goodwill and other intangible assets (Basel Committee on Banking Supervision, 2006). While tier 1 is generally considered as high quality fundamental capital, individual regulators have permitted ele-

intervening periods. A different approach is to use rating agency downgrades as a measure of bank risk (Distinguin *et al.*, 2006). It has been suggested, however, that rating agencies may have been a contributor to the banking crisis, perhaps making rating downgrades an inappropriate indicator of bank condition (White, 2010). For the reasons given, our primary focus is on forward-looking market-based measures of risk.

ments such as trust preferred securities, which act as a regulatory substitute for equity but do not necessarily have the same loss absorbing properties (Boyson *et al.*, 2016). Moreover, during the turmoil of the global financial crisis, many investors focussed on a more stringent measure of bank capital, tangible common equity (TCE). Tangible common equity is defined here as total common equity consisting of ordinary share capital and retained earnings, with goodwill, intangibles and deferred tax assets removed. This measure closely parallels the common equity tier 1 capital metric, introduced in the recent Basel III proposals.[9]

TCE is the major component of tier 1 capital. Beyond the TCE element, the remainder of tier 1 capital comprises elements described above. As such securities may not provide the same level of loss absorption as TCE, we further consider the residual component of tier 1 capital in isolation. To this end, we deduct TCE from tier 1 capital, terming this residual element *non-core tier 1 capital* (NCT1). In many ways, this measure parallels the *alternative tier 1 capital* metric contained in the Basel III framework.[10]

Tier 2 or supplementary capital is also held by banks, as a buffer for prospective losses and limited to 100% of tier 1 capital under Basel II rules. Tier 2 capital consists primarily of undisclosed reserves, revaluation reserves, general provisions, hybrid debt capital instruments and subordinated term debt. While only limited research has considered the relationship between aggregate tier 2 capital and bank risk, a variety of studies have considered the risk reduction characteristics of component elements such as subordinated debt (Chen and Hasan, 2011; Goyal, 2005; Sironi, 2003; Flannery and Sorescu, 1996). Many of these studies focus, however, on the ability of subordinated debt to provide market discipline, through signals

[9]Unfortunately, over the period studied it is not possible to exactly replicate the calculation of common equity tier 1 capital, as banks did not adequately disclose the full list of capital items and regulatory adjustments. To this end, Basel III proposes to introduce mandatory disclosure of all capital components to "address the problem that at present there is a disconnect in many banks' disclosure between the numbers used for the calculation of regulatory capital and the numbers used in the published financial statements", (Basel Committee on Banking Supervision, 2011).

[10]Similar to the case of common equity tier 1 capital, banks in our cross-country sample did not make sufficient data available to permit retrospective calculation of alternative tier 1 capital over the sample period considered. However, components of alternative tier 1 capital will mainly consist of preferred stocks, trust preferred securities (for US banks with assets less than $15 billion) and additional paid in capital that do not satisfy the standards of common equity tier 1.

implied from market prices of such securities. In contrast, we consider the relationship between insolvency risk and and the quantity of tier 2 capital held, both independently and simultaneously with tier 1 and its components. A final capital metric considered in this study, total regulatory capital, comprises both tier 1 and tier 2 capital, and represents the sum of all regulatory capital held by an institution.

Banks may respond to stringent capital requirements by increasing their portfolio risk in an attempt to improve expected returns. To mitigate incentives for banks to hold excessively risky portfolios, regulatory capital requirements are calibrated to account for the riskiness of assets held. The Basel Accords attempt to ensure that capital allocated to assets is commensurate with risk through the medium of risk-weighted assets. Many academic studies linking bank performance and risk to capital consider tier 1 capital proportional to risk-weighted assets, often referred to as the *tier 1 regulatory capital ratio* (Berger and Bouwman, 2013; Beltratti and Stulz, 2012). The Basel III accord proposes to add an additional criterion, forcing banks to have a minimum 3% leverage ratio, measured as tier 1 capital to their exposure measure (Basel Committee on Banking Supervision, 2013).[11] To capture overall bank exposure, in this paper we calibrate each of the capital metrics using both regulatory risk-weighted assets and unweighted assets. The latter is represented by tangible assets, consisting of total assets, minus goodwill, other intangibles and deferred tax assets. This calibration has previously been considered by Bayazitova and Shivdasani (2011), Demirgüç-Kunt *et al.* (2013) and Estrella *et al.* (2000), amongst others.

3.3. Additional Controls

In our empirical analysis, we control for a number of additional characteristics which have been shown to contribute to bank risk.[12] First, bank profitability or earnings quality is

[11]The exposure measure is specified to capture aggregate unweighted bank risk exposure, consisting primarily of on-balance sheet assets, off-balance sheet assets and derivative exposures. As with core- and additional tier 1 capital, banks do not report sufficient data to calculate this metric over the period examined. The tangible assets metric described proxies for total exposure over the bank over this period.

[12]Alternative controls are considered in robustness tests, resulting in no quantitative alteration to results.

captured using the return on average equity (RoAE), measuring net income over stockholders equity (Champagne and Coggins, 2012; Distinguin *et al.*, 2006). The expected sign on RoAE is inconclusive. A positive relationship with risk might indicate that more profitable banks take on riskier or lower quality assets to boost earnings, while a negative relationship might signal that banks use retained earnings to boost their capital position, reducing the chance of experiencing financial distress.

The cost-to-income ratio is included as a measure of operational efficiency (Gropp *et al.*, 2013; Mannasoo and Mayes, 2009). It is calculated as the ratio of total expenses over total revenues and is expected to be positively related to bank risk (more efficient banks will have lower cost-to-income ratios and lower perceived risk). A bank's business model may be diversified across traditional commercial bank activities or interest operations, and into non-interest activities such as commission or trading. We capture this exposure through net interest income to total assets, and expect the relationship to be negative, as interest related activities are often perceived to have lower risk (Beltratti and Stulz, 2012). Liquidity is measured as the proportion of liquid assets to customer and short term deposits, with a negative expected sign for the relationship with bank risk (Chiaramonte and Casu, 2013; Distinguin *et al.*, 2006). Finally, implicit state guarantees may induce large banks to take on additional risk, as they may be deemed 'too big to fail' in the event of distress. For this reason, bank size is controlled for in all specifications using the natural log of the accounting value of bank assets (Demirgüç-Kunt *et al.*, 2013; Arena, 2008).

Country specific regulatory and structural variables also contribute to the explanation of bank risk, and help to reduce omitted variables bias (Delis and Staikouras, 2011). Three regulatory variables are included in the study, each taken from surveys of bank regulations conducted by the World Bank in 2001, 2003, 2007 and 2011 (Cihak *et al.*, 2012). Capital stringency is an index capturing regulatory oversight of bank capital and reflects sources of funds counted as capital, whether such sources are verified and whether risk elements are considered in calculating capital (Ongena *et al.*, 2013). Capital stringency consists of eight survey questions, taking value between 0 and 8, with larger values indicative of stricter regulation. The second regulatory variable included is market discipline, reflecting the extent to which regulations encourage the private sector to monitor banks. Market discipline takes values between 0 and 9, with larger values signalling higher dependence on private sector monitoring. Activity restrictions is an index of regulatory restrictions on banking activities, such as securities market activities, real estate activities, insurance activities and ability to own non-financial firms. Finally, in more concentrated banking systems, bank franchise value may be increased due to an ability to earn monopoly rents. We include a measure of concentration, measured as the ratio of the assets of the three largest banks divided by total banking sector assets in each country, and expect a negative relationship with risk.

All explanatory variables are windsorized at the 1% and 99% levels. Fixed effects are accounted for in all models. Year dummy variables are used to control for systematic differences in risk over time. Country fixed effects are also incorporated to account for differences in the economic climate in the home market of each bank.

3.4. Data Outline and Summary Statistics

Detailed descriptions for each of the capital metrics and control variables introduced are given in Appendix A. For example, tangible equity is defined as total equity minus goodwill, other intangibles and deferred tax assets.

Summary statistics for banks are outlined in table 1 for the period 2001 through 2014. For the main dependent variable of interest, bank distance to default, the average cross-sectional level over all years is 3.992, where a smaller value indicates greater insolvency risk. This average value masks somewhat the considerable time variation. Average distance to default in our sample over the period 2002 through 2007 is 4.49, decreasing to 2.54 over the years coinciding with the global financial crisis and European sovereign debt crisis, 2008 through 2011. Following 2011 the average distance to default rises to an average of 4.96, greater than the pre-crisis level.

[Table 1 about here.]

The primary contribution of this paper centres around the role of differing capital metrics in reducing banking risk. Table 1 summarises the range of capital metrics examined. Tangible equity to tangible assets measures the core equity capital held by a bank, and is found to account for 7.753% of tangible assets and 11.340% of risk-weighted assets. NCT1, which represents the component of tier 1 capital not counted in tangible equity, makes a small contribution to overall capital. When measured relative to tangible assets, NCT1 accounts for 0.999% of tangible assets and 1.378% of risk-weighted assets. However, these low average levels of NCT1 capital mask considerable cross-sectional variation. The standard deviation of NCT1 to tangible assets is 1.62% and the 25^{th} and 75^{th} percentiles are 0% and 1.902% respectively. As this form of capital is not employed by some banks, it is hypothesized that the influence of such capital will be primarily associated with a sub-section of banks.

Tier 1 capital is decomposed into tangible equity and non-core tier 1 capital in this study, but also considered in aggregate. On average banks hold tier 1 capital accounting for 8.735% of tangible assets and 12.703% of risk-weighted assets. Furthermore, levels of tier 1 capital normalized by tangible assets are found to display cross-sectional variation, from 7.145% at the 25^{th} percentile to 10.111% at the 75^{th} percentile. The 25^th percentile of tier 1 capital to risk-weighted assets is well above the Basel II minimum level of 4%, suggesting that substantial capital buffers existed over the period studied.[13]

Tier 2 capital comprises undisclosed and revaluation reserves, general provisions, hybrid debt securities and subordinated debt, and contributes a small portion of total regulatory capital. Tier 2 capital denominated by tangible assets averages 1.23%, while denominated by risk-weighted assets has mean 1.755%. Total regulatory capital (also known as the capital adequacy ratio) is, on average, 9.786% of tangible and 14.436% of risk-weighted assets.

Considering the control variables examined, several points are worth noting. The average return on equity is 5.585%, while the median value is substantially higher at 8.931%. Sub-

[13]The Basel III accord mandates a minimum tier 1 risk-weighted capital ratio of 6%, greater than that required under Basel II.

stantial variation in the ratio of liquid assets to customer and short term deposits is evident, where the mean value of 13.519% is also much greater than the median and closer to the 75^{th} percentile value of 14.406%. This indicates a propensity of certain banks to maintain a liquidity ratio much higher than others. Finally, the ratio of net interest income to total assets has an average value of 2.982% and displays little variation.

Correlations between variables of interest are detailed in Table 2. Considering first the relationships between distance to default and each of the capital adequacy metrics, the expected positive relationship is evident in the cases of tangible equity, tier 1 capital and total regulatory capital. In other words, greater quantities of capital is associated with a reduction in insolvency risk. When denominated by tangible assets, tangible equity has a correlation of 0.208 with risk, tier 1 capital has a correlation of 0.169 and total regulatory capital a correlation of 0.138. In sharp contrast, NCT1 and tier 2 capital are found to have negative and significant relationships with insolvency risk. This provides some early indication that the relationship between capital and insolvency is not straightforward. Moreover, we find evidence that correlations between distance to default are weakened when capital is denominated by risk-weighted assets.

[Table 2 about here.]

Cross correlations between different forms of capital are considered next. Tangible equity, whether denominated by tangible or risk-weighted assets, has a negative relationship with tier 2 capital and with NCT1 capital, perhaps suggesting that these act as substitutes. Tier 1 capital and total regulatory capital, which subsume tangible equity, are found to have a high level of correlation with the latter (> 0.745). Furthermore, high but imperfect correlations are evident between variables having the same numerator when denominated by tangible assets and risk-weighted assets. For example, correlation between tier 2 capital when denominated by tangible assets and risk-weighted assets is 0.847. Finally, the maximum correlation between capital variables examined simultaneously in the models to follow is -0.492, helping to alleviate any concerns regarding collinearity and associated interpretation.

We also consider correlations between variables reported in previous studies as controlling for bank risk. All of these variables are highly correlated with risk. For example, the cost to income ratio has a correlation of −0.123, return on equity a correlation of 0.165, and net interest income a correlation of 0.128. The cost to income ratio and return on equity are further found to have a cross-correlation of −0.543, indicating that less efficiency is associated with less profitability. The ratio of liquid assets to customer and short term deposits has a low negative correlation with insolvency risk of −0.064, but is strongly related to net interest income (−0.497), concentration (−0.529) and activity restrictions (−0.445).

4. Empirical Results

Equation 1 suffers from potential identification issues, primarily the potential endogeneity of capital metrics in risk equations and the persistence of bank risk. The latter issue is addressed through estimation of a dynamic panel model, accounting for risk persistence. To this end, we follow Beck *et al.* (2000) and Levine *et al.* (2000) and estimate equation 1 using the two-step system GMM approach proposed by Blundell and Bond (1998).[14] This method provides a number of benefits; first, it accounts for the dynamics in the dependent variable. Second, it is robust to the presence of unit roots. Finally, it allows for the possibility of potential endogenity between the risk variable and some of the right hand side variables through application of appropriate instruments.

The dynamic panel model helps to reduce potential bias due to a persistence of risk. The coefficient δ on lagged risk may be interpreted as the speed of convergence to equilibrium. A value near 1 is suggestive of a slow speed of adjustment, while a value close to 0 suggests a high speed of adjustment. Between these two extremes the value of δ indicates that risk will persist but ultimately converge to the average level.

In the empirical analysis, we allow for the possibility that capital variables, in addition to

[14]The two step GMM approach tends to bias the estimated standard errors downwards in small samples (Blundell and Bond, 1998). For this reason, we employ the Windmeijer (2005) procedure to adjust the standard errors.

variables controlling for earnings quality, operational efficiency, diversification and liquidity may be endogenous. Potential endogeneity is controlled for in a number of ways. First, we use the forward-looking market-derived distance to default as a dependent variable. Second, all right hand side variables are lagged relative to the dependent variable, mitigating the potential for concurrent managerial decisions on capital and risk. Finally, we instrument each of the capital metrics and other control variables described, by exploiting lag differences of bank characteristics in the level equation and lags of characteristics as instruments in the difference equation.[15] Regulatory variables and bank size are treated as predetermined, while country and year variables are strictly exogenous. We verify that the instruments are valid in a number of ways. First, using a Hansen J-test of overidentifying restrictions. Second, applying a two-stage least squares (2SLS) approach, we test for weak instruments using the Stock and Yogo (2005) weak instrument test and the Cragg-Donald Wald F-statistic. The Sargan test for overidentified restrictions further examines the joint significance of the set of endogenous variables. Further details of the 2SLS analysis are presented in Section 4.8.

4.1. Baseline Model

In this section, we examine the relationship between bank distance to default and the variety of capital adequacy metrics described, both on an individual basis and simultaneously. To this end, equation 1 is estimated for each of the range of capital metrics. Table 3 details our baseline model, examining the relationship between bank distance to default and the level of regulatory capital reported in the previous year over the period $2002-2014$. In each model we relate the distance to default at time t to capital adequacy at time $t-1$, while

[15] An extensive literature review revealed limited instrumental variables correlated with capital but not with bank risk. For example, the effective tax rate and proportion of the population over 65 were both previously tested as potential instruments (Berger and Bouwman, 2013). In our analysis, however, neither of these variables were found to act as a strong instrument, potentially a consequence of the multi-national nature of our sample. Moreover, none of the other potential instruments tested were found to act as strong instruments for capital. An additional complication is the requirement for multiple instrumental variables when considering the differing capital metrics simultaneously. In contrast to the instrumental variables proposed in Berger and Bouwman (2013), lagged differences in capital are demonstrated to act as strong instruments for capital levels. In Section 4.8, a series of two-stage least squares (2SLS) instrumental variable regressions provides strong support for the validity of the instruments used in this paper.

controlling for a range of other characteristics. In untabulated results, time and country dummies are included to account for omitted effects at country and time level.

[Table 3 about here.]

A number of noteworthy results are apparent. First, higher quantities of tangible equity to tangible assets are associated with reduced bank risk. Second, NCT1, the component of tier 1 capital outside of tangible equity, is not linked with distance to default. Third, tangible equity, tier 1 or total regulatory capital are not found to be significant when denominated by risk-weighted assets. Finally, no link between tier 2 capital and distance to default is established.

Results for the control variables are largely as expected. Return on average equity has a positive relationship with risk, suggesting that more profitable banks are perceived to have less risk, potentially a consequence of greater retained earnings. Only capital stringency is opposite to expectations, having a negative relationship with distance to default.

Tangible equity is the purest form of capital held by a bank, consisting of total equity excluding goodwill, other intangibles and deferred tax assets. Our finding that tangible equity divided by tangible assets is associated with a reduction in insolvency risk echoes that of Demirgüç-Kunt *et al.* (2013), where this metric was found to be consistently associated with stock performance for crisis and non-crisis periods. Moreover, the finding that tangible equity is not significantly associated with risk when normalized by risk-weighted assets echoes the findings of Mariathasan and Merrouche (2014) and Vallascas and Hagendorff (2013), who show that risk weighting of assets does not necessarily correspond to true asset risk. Acharya *et al.* (2013) also report that banks used securitization to reduce balance sheet risks but obtained little risk transfer, a form of regulatory arbitrage. In our results, risk weighting of bank assets impedes the link between greater levels of high quality bank capital and a reduction in risk on the whole. No association between NCT1, a contributor to tier 1 capital, and insolvency risk is found in the baseline case. This notwithstanding, the risk reduction capacity of tier 1 capital is found to be unimpaired. This is only the case when tangible assets is used as denominator, as, again, risk-weighting of assets obscures the link between capital and risk.

The quantity of tier 2 capital held by a bank is not found to be linked with solvency risk. While direct regulatory arbitrage is not possible between tier 1 and tier 2 capital, a bank might increase the level of tier 2 capital held to meet the total capital ratio requirement of 8% under Basel II.[16] Previous research has demonstrated that subordinated debt, a component of tier 2 capital, has mixed risk reduction capacity. Camara *et al.* (2013) find little relationship between an increase in subordinated debt and accounting risk, while various studies have shown conflicting evidence for the ability of subordinated debt to provide market discipline (Goyal, 2005; Krishnan *et al.*, 2005; Sironi, 2003).

Our baseline model indicates that greater quantities of higher quality capital is associated with a reduction in bank risk but raises a variety of questions about lower quality capital. In particular, throughout the remainder of this paper, we attempt to isolate the circumstances under which capital other than the highest quality tangible equity is associated with a reduction in bank solvency risk.

4.2. Large Banks

Large banks have been found to have distinct features, perhaps resulting from their too-big-to-fail status (Beltratti and Stulz, 2012; Berger and Bouwman, 2013). In table 4, we detail the relationship between various forms of capital and risk for banks with total assets greater than \$50 billion over the period $2002 - 2014$.[17]

[Table 4 about here.]

Relative to results for banks of all sizes, some important distinctions are evident for large banks. Tangible equity to tangible assets has a positive, albeit weakly significant relationship

[16] Basel III proposes to keep this ratio static, but to increase the requirement to hold a larger proportion of tier 1 capital relative to tier 2.

[17] We later reconsider our findings for banks with assets less than \$50 billion, Section 4.8.

with bank risk. When denominated by risk-weighted assets, this relationship is no longer evident. In fact, for the most systemically important large banks, risk-weighted capital does not have a significant negative relationship with risk for any of the capital metrics considered. The finding that risk-weighted capital is not associated with risk reduction is of particular concern, in light of the importance of risk weighting in capital regulation and the systemic dangers associated with large banks.

Considering tier 1 capital, we now observe a negative, although insignificant, relationship with risk in sharp contrast to the baseline results detailed earlier for banks of all size. Although theory would suggest that tier 1 capital should promote a reduction in bank risk-taking, we find no evidence for this. While the tangible equity component of tier 1 capital has a positive relationship with distance to default, NCT1 is now found to have a negative, although insignificant, relationship with risk for large banks. This, in turn, expunges the relationship between tier 1 capital and risk previously found for all banks. Large banks are more likely to have the ability to perform regulatory capital arbitrage through non-equity issuance such as trust preferred securities, previously shown to be associated with increased bank risk (Boyson *et al.*, 2016). Our findings build upon this, showing that the potential for regulatory arbitrage to impinge upon the capacity of tier 1 capital to reduce bank risk taking, especially for larger banks.

No significance association is found between tier 2 capital and risk, consistent with our baseline results. Finally, no relationship between total regulatory capital and risk is found for large banks, again contrasting with our baseline findings. Our findings suggest that for the largest, most systemically important banks, only tangible equity is associated with the reduction of bank insolvency risk. By shifting to lower quality forms of regulatory capital, large banks are able to meet regulatory capital requirements but such capital does not necessarily contribute to risk reduction.

4.3. Bank Income Diversification

The link between bank income diversification and risk has been considered in detail (Stiroh, 2006; DeYoung and Torna, 2013). Banks with increased non-interest income have been shown to have more risk, but this can depend upon the sources of non-interest income (DeYoung and Torna, 2013). While previous research has indicated that the business model of banks, captured through the proportion of non-interest income, relates to insolvency risk, we examine whether this is, in turn, linked to the forms of capital chosen by banks.

Results, detailed in Table 5, help to clarify some of the findings highlighted earlier and those of the extant literature. For banks with non-interest income to total assets less than the median, results are identical to those shown for the baseline regression. In other words, for banks less diversified than the median, tangible equity, tier 1 capital and total regulatory capital are associated with reduced risk. While NCT1 is not associated with a reduction in risk, this does not impact the risk reduction capacity of tier 1 capital. Tier 2 capital, as highlighted previously, is not associated with bank distance to default.

[Table 5 about here.]

A striking alteration in findings is observed for banks with greater than median non-interest income. While consistent results are evident for tangible equity, findings for the remaining components of capital are noteworthy. While tangible equity is associated with a greater distance to default, NCT1 is found to be significantly associated with greater risk. Moreover, while tangible equity makes up the majority proportion of tier 1 capital, we find that the the risk reduction capacity of tier 1 capital is hindered by the NCT1 component. Both tier 2 and total regulatory capital are not found to be associated with risk. These findings for NCT1 and tier 1 capital may help to reconcile previous findings on bank diversification and risk, where diversification does not lead to reduced risk and may be associated with banks having lower capital levels (Demsetz and Strahan, 1997).

The capacity of elements of NCT1, such as perpetual preferred stock and trust preferred securities to successfully reduce bank risk has previously been in the spotlight. Camara *et al.*

(2013) find a positive relationship between an increase in hybrid securities and increasing risk weighted assets, but no relationship with accounting measures of risk. Boyson *et al.* (2016) demonstrate that banks adopting trust preferred securities (an element of NCT1) are riskier than banks with equivalent levels of regulatory capital, relating their findings to regulatory arbitrage. In the context of results detailed here, this would suggest that banks who shift their focus from the highest quality tangible equity to lower quality securities decrease the risk reducing potential of tier 1 capital. In effect, regulatory arbitrage between forms of capital damages the ability of tier 1 capital, a key pillar of the Basel framework, to impede risk taking. However, it is worth highlighting that Basel III seeks to refocus the allowable components of tier 1 capital towards high quality capital.

These findings also extend and help to clarify the results of Demirgüç-Kunt *et al.* (2013), where the link between bank stock performance and tier 1 capital is found to be inconsistent. Our findings confirm that tangible equity, in addition to improving stock performance, is also associated with a reduction in bank risk. Furthermore, our decomposition into components of tier 1 capital demonstrates that the deficiencies of tier 1 capital highlighted by Demirgüç-Kunt *et al.* (2013), results from the lower risk reduction capacity of NCT1 capital.

4.4. Risk by Level of Capitalization

Banks with sufficient levels of capitalization may choose to increase portfolio risk to ensure adequate returns (Calem and Rob, 1999). Moreover, banks with insufficient levels of capital may have little to lose in the event of default and choose to take high levels of risk in an attempt to gamble for redemption (Calem and Rob, 1999; Rochet, 1992). We now examine whether the relationship between capital and risk is differentiated for banks with distinct levels of capital. To this end, we consider banks with below and above median tangible equity and total regulatory capital, and assess their relationship with risk.

Table 6 details the relationship between capital levels and risk conditional on the level of tangible equity to tangible assets over the period 2002 to 2014.[18] For banks having tangible equity less than the median, tangible equity is associated with a reduction in risk, while NCT1 is linked with greater risk. In this case, however, the opposing relationship for NCT1 is insufficient to eliminate the ability of tier 1 capital to reduce risk. Tier 2 capital and total regulatory capital are not associated with insolvency risk. For banks with tangible equity greater than the median level, only NCT1, when considered in isolation, is found to be significantly associated with an increase in risk. Throughout the plethora of analyses described, this is the only case detailed where tangible equity is not associated with reduced risk. While not suggesting, in the sense of Calem and Rob (1999), that banks with surplus capital increase risk, this finding indicates that there may be limits beyond which greater high quality capital is not associated with a reduction in risk.

[Table 6 about here.]

While various theoretical arguments provide guidance regarding the expected relationship between equity capital and risk, few studies have considered the relationship conditional on total regulatory capital. In Table 7, we examine the link between risk and each form of capital for banks with a level of total regulatory capital above and below the median level. Findings can be clearly distinguished from those in Table 6.

[Table 7 about here.]

First, regardless of the amount of total regulatory capital held, a greater quantity of tangible equity is associated with a reduction in risk. For the remaining components of capital, however, we witness a strong divergence. Tier 1 capital is associated with a reduction in insolvency risk for banks with low regulatory capital but not associated with risk for banks with large quantities of regulatory capital. The latter is, similar to findings detailed earlier

[18]Note: In both table 6 and table 7, we only consider tangible assets as denominator for brevity, as strongest links with risk have been detailed for unweighted assets.

for banks with more diversified income, a consequence of a significant negative relationship between NCT1 and distance to default.

To this point, no evidence of an association between tier 2 capital and risk has been presented. Conditional upon the quantity of total regulatory capital held, we find a significant but opposing relationship between such capital and risk. For banks holding total regulatory capital less than the median, greater tier 2 capital is associated with a reduction in risk. In contrast, for banks having greater than median total regulatory capital, we find that holding greater quantities of tier 2 capital is linked with a reduction in distance to default. These opposing relationships may help untangle the insignificance of tier 2 capital when all banks are considered together.

The combined impact of tier 1 and tier 2 capital permeate total regulatory capital. Capital from tiers 1 and 2 are both significantly associated with risk, leading to a significant relationship for total regulatory capital for banks having below median regulatory capital. In contrast, when banks hold more than median total regulatory capital, we find no evidence of a relationship with risk.

In light of these findings for limited risk reduction for banks with high total regulatory capital, the prospect of increased regulatory capital for all banks under the Basel III framework should be highlighted. On the one hand, Basel III will increase the quantities of tangible equity held by banks. On the other hand, while Basel III regulations will decrease the relative importance of NCT1 and tier 2 capital, these will still contribute to the overall mix of capital held by banks. In tandem with our finding of no link with risk for banks holding large quantities of tangible equity, this may highlight serious limitations for the incoming framework.

4.5. Financial Crisis

We next consider the relationship between risk and capital during the period $2008-2011$, during which aggregate bank insolvency was most elevated. Results, outlined in table 8, are largely in keeping with those over the extended period $2002-2014$. Tangible equity and tier 1 capital, when considered in isolation and denominated by tangible assets, are associated with a reduction in risk. Tier 2 and total regulatory capital are not associated with risk. Finally, when denominated by risk-weighted assets none of the elements of capital are associated with risk. Considering the remaining control variables, return on equity is associated with reduced risk, while, curiously, a larger cost to income ratio is associated with reduced risk. The latter finding is contrary to that observed for banks with low capital or low interest income over the whole period under examination.

[Table 8 about here.]

4.6. Introduction of Basel II

The introduction of the Basel II accord and, in particular, the ability of banks to pursue an internal ratings-based system in the determination of risk-weighted assets has been shown to influence the reported risk levels of bank's portfolios (Mariathasan and Merrouche, 2014). However, the speed of introduction of the Basel II accord has differed substantially in the US and elsewhere.[19] For this reason, we split banks into a number of cohorts in table 9.

[Table 9 about here.]

First, we examine the risk and capital relationship for all banks prior to the introduction of Basel II. This includes European banks from 2002 through 2007 and US banks from 2002 through 2008. We find no evidence of any links between any facet of capital and risk. In other words, differences in the quantities of both higher and lower quality capital held were not associated with cross-sectional variation in bank distance to default.

Next, banks operating under the Basel II framework are considered. This includes all European and Canadian banks from 2008 onwards, and the largest US banks from 2009. Only

[19] In Europe banks formally adopted the Basel II agreement in 2006, and had to comply with Basel II by January 2008. In the US federal agencies agreed regulations concerning Basel II in 2007, but regulations were not effective until April 2008. In contrast to Europe, US regulations only adopted parts of the Basel II accord and these elements were applied to only a small proportion of banks. Banks with total assets greater than $250 billion or foreign exposures greater than $10 billion were required to comply with Basel II.

tangible equity, when denominated by tangible assets, is found to be associated with an improvement in distance to default. Crucially, this relationship disappears when denominated by risk-weighted assets, providing further support for previous findings regarding banks operating under the Basel II internal ratings-based system (Mariathasan and Merrouche, 2014; Vallascas and Hagendorff, 2013).

Finally, we document the relationship between risk and capital for US banks not operating under the Basel II accord from 2008 onwards.[20] Tangible equity to tangible assets has the expected sign and is significant. NCT1 is significantly associated with a reduction in distance to default, culminating in limited evidence for a relationship between tier 1 capital and risk. Tier 2 capital and total regulatory capital are not associated with risk. Moreover, when denominated by risk-weighted assets, all evident sensitivity of risk to capital is eliminated.

In summary, the period after the introduction of the Basel II rules on capital is associated with greater sensitivity of tangible equity to risk, but only when denominated by tangible assets. This period, however, also encompasses the global financial crisis, making it difficult to decompose the singular effect of Basel II on the capital-risk nexus.

4.7. Alternative Measures of Risk

The findings detailed have highlighted the importance of tangible equity in reducing bank insolvency risk, while uncovering the inconsistent risk reduction properties of low quality capital. We now test the sensitivity of our results to alternate risk definitions. First, we assess the relationship between various forms of bank capital and total bank risk, measured as the annualized volatility of daily stock returns. Findings, detailed in Table 10, are in keeping with those outlined for distance to default. Tangible equity when denominated by tangible assets, but not by risk-weighted assets, is associated with reduced volatility. Although NCT1 is not significantly associated with risk, tier 1 capital has a negative and significant relationship with volatility. This finding does not carry over to total regulatory

[20] Categorized as banks with total assets less than $250 billion or foreign exposures less than $10 billion.

capital, which is also not associated with risk. As found for distance to default, capital is not associated with risk when adjusted by risk-weighted assets.

[Table 10 about here.]

Risk is, in turn, defined as systematic risk and idiosyncratic equity risk in table 11, while capital metrics are denominated by tangible assets.[21] Considering systematic risk first, none of the capital measures are associated with a reduction in risk. In fact, banks holding greater quantities of NCT1 are found to have larger systematic risk exposures.

[Table 11 about here.]

Contrasting findings are highlighted for idiosyncratic risk. Each of tangible equity, NCT1, tier 1 and total regulatory capital are associated with a reduction in idiosyncratic risk. The disparity between findings for NCT1 for systematic and idiosyncratic risk is of particular note. Banks with greater quantities of NCT1 are linked with greater systematic or market risk exposures but lower idiosyncratic risk exposures. This divergence may help to explain the inconsistent links between NCT1 and risk detailed earlier, when the latter is represented by total risk (volatility) or insolvency risk (distance to default).

We next consider whether results detailed are consistent for two commonly employed accounting measures of banking risk. First, we consider the level of non-performing loans to gross loans as a proxy for credit risk. However, findings should be interpreted carefully, as banks may ultimately have to make provisions for non-performing loans, which will contribute to the level of capital through an allowance for loan loss reserves.[22] Furthermore, we consider the standard deviation of return on assets over a rolling three year window. Results,

[21] In order to calculate systematic risk and idiosyncratic risk, a market model is estimated for each bank, $R_{it} = \alpha_i + \beta_i R_{M,t} + \epsilon_{i,t}$. The equity market beta β_i is applied as the proxy for systematic risk. The market index is chosen as the MSCI Europe index in the case of Europe, the S&P 500 for US banks and the S&P/TSX index for Canadian banks. The standard deviation of the residual from the market model is used as an estimate of idiosyncratic risk for each bank.

[22] As there is a direct correspondence between loan loss provisions, loan loss reserves and capital, these are not considered here.

detailed in table 12, are from the period 2002 through 2014, and focus on capital metrics denominated by tangible assets.

[Table 12 about here.]

Considering non-performing loans first, we find that all forms of capital are associated with reduced credit risk. Tier 2 capital, only previously found to be related to risk when considered conditional upon the quantity of total regulatory capital held, is found to be associated with reduced credit risk. Findings for the standard deviation of ROA are in keeping with those detailed for distance to default. Tangible equity, tier 1 capital and total regulatory capital are associated with a reduction in risk.

With the exception of systematic risk, tier 1 capital and its predominant contributor, tangible equity, are consistently associated with reduced risk when examined for all banks over the period $2002-2014$. While the latter provides consistent results across the majority of analyses considered, the risk reduction capacity of tier 1 capital has been shown to be impeded for large banks and for banks having considerable revenues from non-interest income. Both tier 2 capital and total regulatory capital have an inconsistent relationship with risk, casting doubt over their ability to reduce bank risk.

4.8. Robustness

In this section, we demonstrate the robustness of our findings to differing bank size, for orthogonal capital metrics and to an alternative estimation methodology, two-stage least-squares regression.

To test the sensitivity of results to the methodology employed and the validity of instruments, a two-stage least squares (2SLS) regression is adopted. In the first stage, third and fourth order lagged differences of each capital metric are employed as instruments for the capital metric level under investigation. Results from the 2SLS regression, detailed in Table 13, are consistent with benchmark findings detailed in Table 3. Tangible equity and tier 1 capital are associated with a reduction in risk, when denominated by tangible assets.

Tier 2 capital is not associated with a reduction in risk. Confirming our earlier results, no significant relationships between risk and capital are found when the latter is denominated by risk-weighted assets. To confirm strong inference, we further test the potential for weak identification of the instrumental variables. The Anderson Canonical Correlation Lagrange Multiplier test is highly significant for each of the regressions, suggesting the model is not underidentified. The Cragg-Donald Wald F-Statistic tests the strength of the first stage regression and the F-statistic is compared with the Stock and Yogo (2005) critical values. For each model, the F-statistic confirms strong instruments. Finally, the Sargan test for overidentifying restrictions examined the joint significance of the set of endogenous variables in the system of equations. Large p-values across all models indicate valid instruments.

[Table 13 about here.]

In Table 4, the risk reduction capacity of various capital metrics for banks with total assets greater than $50 billion was considered. In Table 14, we consider banks excluding these large systemically important banks. Consistent with earlier analysis, a greater quantity of tangible equity is associated with improved distance to default. Tier 1 capital is also associated with a reduction in risk, while NCT1 is negatively associated with distance to default, indicating increased risk. Total regulatory capital is also found to be associated with reduced risk. Consistent results are documented for banks with assets under $50 and $25 million.

[Table 14 about here.]

Combining different forms of capital with a common denominator in a single model may be subject to problems of interpretation due to multicollinearity. To ensure that findings are not influenced by collinearity, principal component analysis (PCA) is used to create orthogonal capital factors representing each capital metric. PCA is a statistical technique that allows reduction of a large set of correlated variables to a smaller group of representative factors with reduced redundancy.[23] Results, detailed in Table 15, are largely consistent with the baseline findings previously outlined. When denominated by tangible assets, tangible equity is alone associated with reduced risk. NCT1 is not linked with reduced risk. This notwithstanding, tier 1 capital is associated with increased distance to default. When denominated by risk-weighted assets, orthogonalized tier 2 capital is associated with an increase in risk. These results once again highlight the importance of high quality tangible equity in reducing bank risk and the narrow links between risk weighting of assets and actual risk.

[Table 15 about here.]

5. Conclusions

Prudential regulation requires banks to hold capital as a buffer in the event of losses and as a means to mitigate risk shifting by shareholders. Under capital regulation, a large menu of securities are permitted to contribute to regulatory capital. While previous studies have predominantly concentrated on the relationship between bank risk and either tier 1 capital or equity capital, we further develop an understanding of the relationship for components of regulatory capital other than equity. This places the work amongst the literature examining the benefits of greater quantities of bank capital and that highlighting the potential for regulatory arbitrage between forms of capital.

The empirical results described in the paper suggest a number of novel findings. While tangible equity is confirmed as the most consistent form of capital in reducing bank insolvency risk, lower quality capital is not reliably associated with risk reduction. This notwithstanding, we provide evidence that any relationship with insolvency risk is eliminated for banks holding greater than median tangible equity. Tier 1 capital is found to be inconsistently associated with insolvency risk, a consequence of weak, and occasionally negative, links between

[23] Given a set of factors, F_t of dimension $N \times T$, PCA decomposes the correlation matrix as $\Sigma_F = A\Lambda A'$ where Λ is the diagonal matrix of the eigenvalues of the correlation matrix and A the matrix of the associated orthogonal eigenvector components. The principal components can then be computed as $P = A'_F$. The associated eigenvalues measure the variance of each principal component. The proportion of variance captured by the j^{th} principal component is $\mu = \Lambda_j / \sum_m \Lambda_m$, where Λ_j is the j^{th} diagonal element of Λ.

NCT1 and risk. Tier 2 capital is only found to reduce risk for banks holding below median quantities of total regulatory capital. The diffuse relationships between the components of capital and insolvency risk further obfuscates the links between total regulatory capital and insolvency risk. Finally, the relationship between risk and capital is found to be weakened when normalized by risk-weighted assets, as opposed to tangible assets.

Taken collectively, our findings suggest that management may be able to shift between capital of differing quality but still meet minimum capital requirements. Such risk shifting is associated, in particular, with impaired risk reduction properties for tier 1 capital. Furthermore, our finding that risk weighting of assets weakens the relationship between risk and capital is supportive of recent research which argues that risk-weighting of assets is not fit-for-purpose. Our results link to various papers, but particularly those proposing the potential of risk-shifting incentives for equity investors, and the potential of regulatory arbitrage amongst banks constrained by capital requirements. In the context of weak or negligible risk reduction properties for capital other than tangible equity, substitute forms of capital need particular attention.

The findings in the paper contribute to the debate regarding the optimal quantity and quality of capital required to reduce future bank risk. In particular, our findings are generally supportive of the inclusion of the core tier 1 capital ratio as a pillar of the Basel III framework. This is with the important caveat that the risk reduction properties of tangible equity are eliminated for banks holding considerable tangible equity, perhaps pointing to a weakness in the framework. Moreover, Basel III outlines plans to limit the use of non-core tier 1 capital which contains instruments such as trust preferred securities, and is shown in this article to have limited risk reduction properties. Finally, given the variation in the marginal contribution of tier 2 capital to overall bank risk demonstrated, a strong focus on core equity capital may help in limiting the complexity of capital regulation and in mitigating future banking risk and associated economic susceptibility.

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Table 1: **Summary Statistics: Capital Ratios and Control Variables**
Summary Statistics calculated over the period 2001 to 2014. All variables are as defined in table A.1. TA is tangible assets and RWA is risk weighted assets. In each case, descriptive statistics relating to mean, standard deviation, minimum, maximum, 25^{th} percentile, 50^{th} percentile, 75^{th} percentile and number of observations are displayed.

	Mean	**Standard Deviation**	**Number of Observations**	**25th Percentile**	**50th Percentile**	**75th Percentile**
Distance to Default	3.992	5.244	8,710	2.285	3.702	5.484
Volatility	41.386	44.589	8,114	21.405	29.306	45.722
Tangible Equity to TA	7.753	3.541	8,710	5.830	7.500	9.300
NCT1 to TA	0.999	1.620	8,710	0.000	0.608	1.902
Tier 1 Capital to TA	8.735	3.212	8,710	7.145	8.641	10.111
Tier 2 Capital to TA	1.230	0.992	8,710	0.743	0.934	1.409
Total Regulatory Capital to TA	9.786	3.326	8,710	8.283	9.809	11.255
Tangible Equity to RWA	11.340	5.733	8,710	8.078	10.468	13.166
NCT1 to RWA	1.378	2.379	8,710	0.000	0.942	2.659
Tier 1 Capital to RWA	12.703	4.912	8,710	10.037	11.926	14.239
T2 Capital to RWA	1.755	1.308	8,710	1.098	1.257	2.145
Total Regulatory Capital to RWA	14.436	4.799	8,710	11.826	13.523	15.875
Cost to Income Ratio	69.595	31.654	8,710	57.573	65.465	74.133
Return on Average Equity	5.585	23.059	8,710	4.544	8.931	12.779
Liquid Assets to Customer ST	13.519	19.369	8,710	3.686	6.742	14.406
Net Interest Income to Total Assets	2.982	1.000	8,710	2.499	3.110	3.578
Total Assets (Natural Logarithm)	21.772	2.174	8,710	20.261	21.173	22.862
Concentration	38.638	18.050	8,396	28.000	32.690	35.410
Capital Stringency	4.690	1.561	8,396	3.000	5.000	6.000
Market Discipline	5.295	0.601	8,710	5.000	5.000	6.000
Activity Restrictions	7.896	1.262	8,396	8.000	8.000	9.000

Table 2: **Correlation Matrix between Variables (2002 – 2014)**

Pearson correlation coefficients between all variables are reported for the period 2002 − 2014. Volatility is measured at time t and all other variables are measured at time $t-1$. *, ** and *** indicate statistical significance at the 10%, 5% and 1% level respectively.

(i) Capital Metrics Correlations

		(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
Distance to Default	**(1)**	1.000										
Tangible Equity to TA	**(2)**	0.208***	1.000									
NCT1 to TA	**(3)**	-0.115***	-0.417***	1.000								
Tier 1 Capital to TA	**(4)**	0.169***	0.876***	0.052***	1.000							
Tier 2 Capital to TA	**(5)**	-0.075***	-0.102***	0.040***	-0.091***	1.000						
Total Regulatory Capital to TA	**(6)**	0.138***	0.745***	0.091***	0.873***	0.134***	1.000					
Tangible Equity to RWA	**(7)**	0.140***	0.787***	-0.492***	0.601***	-0.255**	0.450***	1.000				
NCT1 to RWA	**(8)**	-0.121***	-0.451***	0.948***	-0.007	0.016	0.026**	-0.492***	1.000			
Tier 1 Capital to RWA	**(9)**	0.105***	0.679***	-0.101***	0.693***	-0.291***	0.532***	0.897***	-0.074***	1.000		
T2 Capital to RWA	**(10)**	-0.102***	-0.253***	-0.004	-0.281***	0.847***	-0.052	-0.196*	0.037***	-0.209***	1.000	
Total Regulatory Capital to RWA	**(11)**	0.084***	0.605***	-0.092***	0.618***	-0.067***	0.533***	0.832***	-0.05***	0.940***	0.068***	1.000

(i) Control Variables Correlations

		(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Distance to Default	**(1)**	1.000									
Cost to Income Ratio	**(2)**	-0.123***	1.000								
Return on Average Equity	**(3)**	0.165***	-0.543***	1.000							
Liquid Assets to Customer ST	**(4)**	-0.064***	0.043***	-0.018	1.000						
Net Interest Income to Total Assets	**(5)**	0.128***	-0.098***	0.123***	-0.497***	1.000					
Total Assets (Natural Logarithm)	**(6)**	-0.099***	-0.188***	0.063***	0.442***	-0.577***	1.000				
Concentration	**(7)**	-0.115***	-0.024**	-0.042***	0.529***	-0.494***	0.429***	1.000			
Capital Stringency	**(8)**	0.028**	0.100***	-0.092***	-0.084***	0.016	-0.025**	0.014	1.000		
Market Discipline	**(9)**	0.018***	0.004*	-0.017*	0.354***	-0.361***	0.355***	0.457***	0.314***	1.000	
Activity Restrictions	**(10)**	0.112***	0.037***	0.030***	-0.445***	0.480***	-0.465***	-0.656***	0.234***	-0.198***	1.000

Table 3: **Banking default risk and capital adequacy - All banks (2002-2014)**
Bank default risk (distance to default) is modelled as a function of a variety of capital adequacy metrics during the period 2002 − 2014. Specifications (i)-(vii) employ tangible assets as denominator, while specifications (viii)-(xiv) use risk weighted assets as denominator. The estimated model is:

$$DD_{i,j,t} = \alpha + \delta DD_{i,j,t-1} + \beta^1 C^k_{i,j,t-1} + \beta^2 X_{i,j,t-1} + \beta^3 d_{j,t} + u_{i,j,t}$$

where DD_t is distance to default at time t, $C_{i,j,t-1}$ is bank capital, $d_{j,t}$ is a matrix of country and time dummy variables (untabulated) and $X_{i,j,t-1}$ is a matrix of bank-level control variables at time $t-1$. Capital metrics and control variables are defined in table A.1. The model is estimated using the two-step GMM approach with robust standard errors and robust z-statistics are given in brackets. The Wald test denotes goodness of fit, AR1 and AR2 are tests for first and second order serial correlation and Hansen is the test for overidentifying restrictions.*, ** and *** indicate statistical significance at the 10%, 5% and 1% level respectively.

	Tangible Assets							RW Assets						
	(i)	(ii)	(iii)	(iv)	(v)	(vi)	(vii)	(viii)	(ix)	(x)	(xi)	(xii)	(xiii)	(xiv)
Tangible Equity	22.398**					18.717*		5.064					6.033	
	(2.56)					(1.83)		(1.37)					(1.41)	
NCT1		-2.200				18.560			-6.047				2.070	
		(-0.16)				(1.54)			(-0.49)				(0.16)	
Tier 1 Capital			25.043***		27.080***					4.061		7.121		
			(2.90)		(3.09)					(1.04)		(1.21)		
Tier 2 Capital				-16.817	-2.459	-9.170					-14.890	66.604	43.280	
				(-1.15)	(-0.17)	(-0.58)					(-0.68)	(1.29)	(1.13)	
Total Regulatory Capital							16.912**							2.274
							(2.21)							(0.59)
Zscore Lagged	0.534	0.577*	0.65**	0.541**	0.532**	0.552**	0.534**	0.576*	0.508	0.577**	0.511*	0.551*	0.524	0.601***
	(1.37)	(1.66)	(2.35)	(2.01)	(2.38)	(2.19)	(2.41)	(1.85)	(1.17)	(2.22)	(1.96)	(1.74)	(1.53)	(2.73)
Cost to Income Ratio	0.004	-0.002	0.010	-0.014	0.002	-0.008	0.001	-0.012	-0.002	-0.009	0.013	-0.011	-0.005	-0.007
	(0.16)	(-0.05)	(0.46)	(-0.44)	(0.10)	(-0.33)	(0.04)	(-0.49)	(-0.05)	(-0.45)	(0.30)	(-0.57)	(-0.37)	(-0.49)
Return on Average Equity	0.031**	0.042**	0.034**	0.034*	0.028**	0.026*	0.035**	0.032**	0.041*	0.035***	0.044*	0.039***	0.039***	0.037***
	(1.98)	(2.05)	(2.32)	(1.86)	(2.28)	(1.73)	(2.50)	(2.40)	(1.90)	(2.72)	(1.82)	(2.78)	(3.31)	(3.20)
Liquid Assets to Total Assets	-0.007	0.002	-0.006	0.003	-0.005	-0.002	-0.002	-0.001	0.002	0.000	0.001	-0.003	-0.003	0.001
	(-1.23)	(0.42)	(-1.16)	(0.68)	(-0.96)	(-0.35)	(-0.41)	(-0.13)	(0.35)	(0.00)	(0.16)	(-0.41)	(-0.48)	(0.25)
Net Interest Income to Total Assets	-20.751	-3.136	-20.893	-6.822	-25.780**	-23.979*	-19.192	-10.433	-3.042	-7.955	4.826	-12.381	-9.097	-6.595
	(-1.29)	(-0.18)	(-1.48)	(-0.41)	(-2.00)	(-1.72)	(-1.51)	(-0.86)	(-0.16)	(-0.72)	(0.23)	(-1.09)	(-1.00)	(-0.75)
Total Assets (ln)	0.064	-0.081	0.058	-0.101	0.033	-0.015	-0.037	-0.075	-0.073	-0.085	0.007	-0.223	-0.142	-0.093
	(0.60)	(-0.68)	(0.64)	(-0.87)	(0.41)	(-0.15)	(-0.45)	(-0.69)	(-0.58)	(-0.95)	(0.05)	(-1.54)	(-1.63)	(-1.41)
Concentration	0.009	0.010	0.007	0.011	0.007	0.01	0.008	0.013*	0.010	0.012	0.008	0.011	0.012*	0.011
	(1.19)	(1.30)	(1.01)	(1.42)	(1.00)	(1.29)	(1.15)	(1.71)	(1.27)	(1.59)	(0.90)	(1.59)	(1.70)	(1.58)
Capital Stringency	-0.141***	-0.157***	-0.150***	-0.140***	-0.150***	-0.135***	-0.163***	-0.138***	-0.157***	-0.146***	-0.117**	-0.195***	-0.176***	-0.152***
	(-2.87)	(-3.26)	(-3.03)	(-2.92)	(-2.91)	(-2.76)	(-3.20)	(-2.79)	(-3.20)	(-2.98)	(-2.35)	(-3.17)	(-3.26)	(-3.10)
Market Discipline	-0.063	-0.042	-0.039	-0.025	-0.017	-0.028	-0.012	-0.055	-0.043	-0.039	-0.056	-0.042	-0.066	-0.042
	(-0.48)	(-0.32)	(-0.29)	(-0.19)	(-0.13)	(-0.22)	(-0.09)	(-0.42)	(-0.32)	(-0.30)	(-0.36)	(-0.27)	(-0.49)	(-0.33)
Activity Restrictions	0.060	-0.007	0.037	0.037	0.103	0.043	0.021	0.061	0.020	0.045	-0.076	0.053	0.024	0.016
	(0.36)	(-0.05)	(0.27)	(0.27)	(0.77)	(0.31)	(0.17)	(0.42)	(0.11)	(0.35)	(-0.38)	(0.35)	(0.16)	(0.13)
Constant	-0.160	5.081	-1.134	6.228	-0.21	2.154	2.395	4.445	5.070	4.641	1.932	7.264*	5.226	4.996
	(-0.04)	(0.97)	(-0.29)	(1.31)	(-0.06)	(0.48)	(0.64)	(0.96)	(0.91)	(1.17)	(0.32)	(1.75)	(1.53)	(1.62)
Number Observations	5,920	5,920	5,920	5,920	5,920	5,920	5,920	5,920	5,920	5,920	5,920	5,920	5,920	5,920
Wald Test	99.99	107.12	91.37	95.78	87.97	94.53	90.87	96.93	97.31	95.53	95.87	64.06	77.79	93.94
AR1	0.053	0.022	0.003	0.003	0.001	0.004	0.001	0.009	0.088	0.002	0.019	0.027	0.029	0.000
AR2	0.362	0.269	0.111	0.202	0.159	0.123	0.164	0.218	0.463	0.153	0.111	0.692	0.373	0.082
Hansen Test	0.840	0.976	0.986	0.927	0.984	0.928	0.992	0.719	0.944	0.819	0.736	0.935	0.847	0.830

Table 4: **Banking default risk and capital adequacy - Large banks (2002-2014)**

Bank default risk (distance to default) is modelled as a function of a variety of capital adequacy metrics during the period 2002 – 2014 for banks with total assets greater than $50 billion. Specifications (i)-(vii) employ tangible assets as denominator, while specifications (viii)-(xiv) use risk weighted assets as denominator. The estimated model is:

$$DD_{i,j,t} = \alpha + \delta DD_{i,j,t-1} + \beta^1 C^k_{i,j,t-1} + \beta^2 X_{i,j,t-1} + \beta^3 d_{j,t} + u_{i,j,t}$$

where DD_t is distance to default at time t, $C_{i,j,t-1}$ is bank capital, $d_{j,t}$ is a matrix of country and time dummy variables (untabulated) and $X_{i,j,t-1}$ is a matrix of bank-level control variables at time $t-1$. Capital metrics and control variables are defined in table A.1. The model is estimated using the two-step GMM approach with robust standard errors and robust z-statistics are given in brackets. The Wald test denotes goodness of fit, AR1 and AR2 are tests for first and second order serial correlation and Hansen is the test for overidentifying restrictions.*, ** and *** indicate statistical significance at the 10%, 5% and 1% level respectively.

	Tangible Assets							RW Assets						
	(i)	(ii)	(iii)	(iv)	(v)	(vi)	(vii)	(viii)	(ix)	(x)	(xi)	(xii)	(xiii)	(xiv)
Tangible Equity	52.449*					35.901		22.681					21.351	
	(1.82)					(1.35)		(1.56)					(-1.26)	
NCT1		-49.989				-78.307*			-22.60				-15.654	
		(-1.22)				(-1.93)			(-1.17)				(-1.10)	
Tier 1 Capital			-27.654		-13.999					13.399		5.643		
			(-1.17)		(-0.35)					(1.59)		(0.65)		
Tier 2 Capital				43.463	12.551	62.01					12.269	22.667	25.85	
				(0.84)	(0.10)	(1.22)					(0.55)	(0.85)	(-1.21)	
Total Regulatory Capital							-16.312							11.835
							(-0.61)							(1.53)
Zscore Lagged	0.609***	0.527***	0.582***	0.649***	0.637*	0.605***	0.568***	0.636***	0.725***	0.581***	0.618***	0.607***	0.521***	0.532***
	(5.87)	(3.60)	(4.40)	(4.58)	(1.73)	(4.05)	(3.41)	(5.49)	(4.23)	(4.57)	(4.33)	(5.06)	(4.50)	(4.21)
Cost to Income Ratio	0.008	-0.009	0.002	-0.001	0.013	0.005	0.006	-0.007	-0.017	-0.009	-0.005	-0.001	-0.006	-0.010
	(0.39)	(-0.41)	(0.11)	(-0.08)	(0.30)	(0.28)	(0.32)	(-0.43)	(-0.73)	(-0.67)	(-0.30)	(-0.09)	(-0.43)	(-0.69)
Return on Average Equity	0.004	0.018	0.026	0.026	0.042	0.005	0.032	0.000	0.013	0.000	0.031	0.025	0.018	0.008
	(0.13)	(0.66)	(0.83)	(0.59)	(0.46)	(0.23)	(0.85)	(0.01)	(0.71)	(0.01)	(0.71)	(0.56)	(0.68)	(0.27)
Liquid Assets to Total Assets	-0.019	-0.047	-0.020	-0.018	-0.011	-0.027	-0.031	-0.040	-0.035	-0.026	-0.018	-0.015	-0.026	-0.023
	(-0.63)	(-1.56)	(-0.74)	(-0.64)	(-0.16)	(-0.89)	(-1.21)	(-1.31)	(-1.00)	(-0.86)	(-0.64)	(-0.55)	(-0.96)	(-0.70)
Net Interest Income to Total Assets	-57.265	-2.269	26.362	-13.695	13.849	-49.469	11.111	-15.902	-26.127	7.854	0.593	-0.637	-2.833	19.070
	(-1.04)	(-0.07)	(0.81)	(-0.27)	(0.12)	(-0.87)	(0.29)	(-0.52)	(-0.62)	(0.19)	(0.01)	(-0.01)	(-0.09)	(0.40)
Total Assets (ln)	0.131	0.204	-0.239	-0.077	-0.200	0.277	-0.101	0.167	0.184	-0.077	-0.207	-0.206	0.077	0.016
	(0.38)	(0.63)	(-0.79)	(-0.24)	(-0.18)	(0.84)	(-0.31)	(0.76)	(0.54)	(-0.24)	(-0.69)	(-0.66)	(0.41)	(0.05)
Concentration	-0.003	-0.027	-0.043	-0.021	-0.02	-0.007	-0.039	-0.010	-0.001	-0.027	-0.021	-0.031	-0.017	-0.030
	(-0.11)	(-1.09)	(-1.20)	(-0.81)	(-0.19)	(-0.33)	(-1.03)	(-0.42)	(-0.03)	(-0.99)	(-0.66)	(-0.75)	(-0.68)	(-1.17)
Capital Stringency	0.028	-0.083	0.114	-0.009	0.014	-0.041	0.132	0.074	0.029	0.028	-0.005	-0.013	-0.066	0.002
	(0.32)	(-0.87)	(0.74)	(-0.08)	(0.03)	(-0.32)	(0.86)	(0.89)	(0.36)	(0.38)	(-0.05)	(-0.12)	(-0.60)	(0.02)
Market Discipline	-0.268	-0.176	-0.314	-0.036	-0.230	-0.410	-0.377	-0.325	-0.140	0.034	-0.083	-0.070	-0.184	0.065
	(-1.03)	(-0.69)	(-1.10)	(-0.11)	(-0.19)	(-1.07)	(-1.18)	(-1.63)	(-0.51)	(0.15)	(-0.33)	(-0.24)	(-0.93)	(0.27)
Activity Restrictions	0.044	0.035	-0.072	0.168	-0.007	-0.002	0.000	0.242	0.017	0.321	0.121	0.150	0.199	0.371
	(0.12)	(0.12)	(-0.21)	(0.55)	(-0.01)	(-0.01)	(0.00)	(0.72)	(0.06)	(1.25)	(0.33)	(0.61)	(0.73)	(1.37)
Constant	-0.526	-0.879**	-0.965***	-0.853***	-0.953	-0.673*	-0.935***	-0.667**	-0.680*	-0.965***	-0.856***	-0.954***	-0.742**	-1.030***
	(-1.53)	(-2.64)	(-3.12)	(-2.75)	(-1.11)	(-1.89)	(-2.73)	(-2.00)	(-1.98)	(-3.02)	(-2.65)	(-2.87)	(-2.24)	(-3.39)
Number Observations	881	881	881	881	881	881	881	881	881	881	881	881	881	881
Wald Test	48.67	104.47	5.50	16.85	0.36	26.59	26.74	104.61	36.01	396.24	26.55	29.5	14.98	95.62
AR1	0.000	0.000	0.000	0.000	0.035	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
AR2	0.669	0.864	0.758	0.719	0.964	0.852	0.898	0.970	0.764	0.902	0.857	0.958	0.641	0.912
Hansen Test	0.491	0.745	0.561	0.722	0.785	0.789	0.680	0.724	0.471	0.573	0.755	0.711	0.878	0.762

Table 5: **Banking default risk and capital adequacy - By Non-Interest Income (2002-2014)**

Bank default risk (distance to default) is modelled as a function of a variety of capital adequacy metrics during the period 2002 − 2014. Specifications (i)-(vii) examine banks with Non-Interest Income to Total Assets less than the median, while specifications (viii)-(xiv) consider those greater than the median. All specifications employ tangible assets as denominator. The estimated model is:

$$DD_{i,j,t} = \alpha + \delta DD_{i,j,t-1} + \beta^1 C^k_{i,j,t-1} + \beta^2 X_{i,j,t-1} + \beta^3 d_{j,t} + u_{i,j,t}$$

where DD_t is distance to default at time t, $C_{i,j,t-1}$ is bank capital, $d_{j,t}$ is a matrix of country and time dummy variables (untabulated) and $X_{i,j,t-1}$ is a matrix of bank-level control variables at time $t-1$. Capital metrics and control variables are defined in table A.1. The model is estimated using the two-step GMM approach with robust standard errors and robust z-statistics are given in brackets. The Wald test denotes goodness of fit, AR1 and AR2 are tests for first and second order serial correlation and Hansen is the test for overidentifying restrictions.*, ** and *** indicate statistical significance at the 10%, 5% and 1% level respectively.

	Non-Interest Income to Total Assets < Median							**Non-Interest Income to Total Assets > Median**						
	(i)	(ii)	(iii)	(iv)	(v)	(vi)	(vii)	(viii)	(ix)	(x)	(xi)	(xii)	(xiii)	(xiv)
Tangible Equity	11.903**					12.445**		13.815**					11.311*	
	(2.42)					(2.59)		(2.08)					(1.91)	
NCT1		-5.226				10.868			-30.608***				-23.532***	
		(-0.54)				(1.31)			(-4.67)				(-2.81)	
Tier 1 Capital			15.759***		15.43***					6.302		10.827		
			(2.85)		(2.77)					(0.88)		(1.63)		
Tier 2 Capital				20.754	12.029	6.970					-4.259	-3.829	-4.560	
				(1.32)	(0.78)	(0.49)					(-0.23)	(-0.23)	(-0.29)	
Total Regulatory Capital							16.149***							9.862
							(3.43)							(1.62)
Zscore Lagged	0.501***	0.437***	0.467***	0.447***	0.463***	0.495***	0.469***	0.277***	0.239***	0.369***	0.332***	0.295***	0.186***	0.359***
	(6.59)	(6.76)	(6.62)	(6.89)	(6.58)	(7.55)	(6.68)	(3.37)	(2.76)	(4.56)	(3.86)	(4.10)	(2.95)	(4.39)
Cost to Income Ratio	-0.007***	-0.008***	-0.007***	-0.009***	-0.008***	-0.008***	-0.007**	0.003	0.005	0.002	0.003	0.002	0.004	0.002
	(-2.92)	(-2.8)	(-2.62)	(-3.03)	(-3.18)	(-2.94)	(-2.48)	(0.98)	(1.29)	(0.59)	(0.91)	(0.49)	(1.27)	(0.61)
Return on Average Equity	-0.004	-0.001	-0.004	-0.003	-0.003	-0.004	-0.003	0.026***	0.037***	0.03***	0.036***	0.028***	0.027***	0.029***
	(-0.75)	(-0.11)	(-0.60)	(-0.45)	(-0.56)	(-0.70)	(-0.50)	(2.83)	(3.97)	(3.15)	(3.67)	(3.11)	(3.31)	(3.10)
Liquid Assets to Total Assets	-0.01	-0.006	-0.004	-0.006	-0.003	-0.005	0.000	0.000	0.002	0.026	-0.014	-0.001	-0.015	0.015
	(-1.1)	(-0.74)	(-0.45)	(-0.76)	(-0.39)	(-0.57)	(0.04)	(0.01)	(0.09)	(1.28)	(-0.69)	(-0.04)	(-1.02)	(0.72)
Total Assets (ln)	0.018	-0.061	0.002	-0.102	-0.036	-0.033	-0.025	0.124**	0.110**	0.082*	0.034	0.094	0.164**	0.075*
	(0.45)	(-1.44)	(0.06)	(-1.57)	(-0.84)	(-0.72)	(-0.73)	(2.46)	(2.50)	(1.75)	(1.57)	(1.48)	(2.50)	(1.69)
Concentration	0.005	0.003	0.004	0.003	0.004	0.003	0.004	0.068	0.087	0.058	-0.003	0.001	0.013	0.059
	(0.64)	(0.31)	(0.42)	(0.42)	(0.47)	(0.33)	(0.46)	(0.66)	(0.83)	(0.57)	(-0.02)	(0.01)	(0.17)	(0.62)
Capital Stringency	-0.044	-0.062	-0.047	-0.106*	-0.074	-0.082	-0.067	-0.455	-0.461	-0.444	-0.171	-0.214	-0.212	-0.388
	(-0.70)	(-0.99)	(-0.78)	(-1.73)	(-1.27)	(-1.39)	(-1.12)	(-0.91)	(-0.93)	(-0.91)	(-0.37)	(-0.52)	(-0.60)	(-0.84)
Market Discipline	-0.213	-0.224	-0.199	-0.109	-0.137	-0.147	-0.151	-0.816	-0.748	-0.861	-0.708	-0.748	-0.716	-0.827
	(-1.52)	(-1.61)	(-1.42)	(-0.86)	(-1.01)	(-1.05)	(-1.14)	(-0.72)	(-0.74)	(-0.81)	(-0.78)	(-0.89)	(-0.96)	(-0.77)
Activity Restrictions	0.13	0.173	0.171	0.166	0.157	0.142	0.149	0.588	0.79	0.576	0.325	0.282	0.012	0.432
	(1.03)	(1.38)	(1.34)	(1.38)	(1.24)	(1.16)	(1.19)	(0.51)	(0.67)	(0.48)	(0.34)	(0.31)	(0.01)	(0.37)
Constant	2.509	5.782***	2.134	5.825***	2.994	3.549*	2.326	-2.534	-3.965	-0.497	6.528	4.569	4.712	-0.292
	(1.27)	(3.42)	(1.03)	(3.15)	(1.46)	(1.76)	(1.16)	(-0.21)	(-0.32)	(-0.04)	(0.61)	(0.50)	(0.59)	(-0.02)
Number Observations	2,224	2,224	2,224	2,224	2,224	2,224	2,224	2,200	2,200	2,200	2,200	2,200	2,200	2,200
Wald Test	48.30	43.40	49.17	40.74	49.23	45.95	52.77	43.58	41.81	48.78	45.20	45.20	42.34	45.64
AR1	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
AR2	0.889	0.995	0.927	0.816	0.906	0.941	0.822	0.558	0.433	0.368	0.375	0.676	0.871	0.409
Hansen Test	0.119	0.182	0.133	0.175	0.237	0.281	0.265	0.410	0.350	0.626	0.194	0.315	0.514	0.611

Table 6: **Banking risk and capital adequacy - All banks by level of tangible equity**

Bank default (distance to default) risk is modelled as a function of a variety of capital adequacy metrics during the period 2002 − 2014. Banks with 2006 tangible equity less than the median are detailed in specifications (i)-(vii) and those with tangible equity greater than the median are detailed in specifications (viii)-(xiv). All specifications use tangible assets as capital denominator. The estimated model is:

$$DD_{i,j,t} = \alpha + \delta DD_{i,j,t-1} + \beta^1 C^k_{i,j,t-1} + \beta^2 X_{i,j,t-1} + \beta^3 d_{j,t} + u_{i,j,t}$$

where DD_t is distance to default at time t, $C_{i,j,t-1}$ is bank capital, $d_{j,t}$ is a matrix of country and time dummy variables (untabulated) and $X_{i,j,t-1}$ is a matrix of bank-level control variables at time $t-1$. Capital metrics and control variables are defined in table A.1. The model is estimated using the two-step GMM approach with robust standard errors and robust z-statistics are given in brackets. The Wald test denotes goodness of fit, AR1 and AR2 are tests for first and second order serial correlation and Hansen is the test for overidentifying restrictions.*, ** and *** indicate statistical significance at the 10%, 5% and 1% level respectively.

	Low Tangible Equity							High Tangible Equity						
	(i)	(ii)	(iii)	(iv)	(v)	(vi)	(vii)	(viii)	(ix)	(x)	(xi)	(xii)	(xiii)	(xiv)
Tangible Equity	23.820***					20.986***		1.997					1.432	
	(3.58)					(3.70)		(0.47)					(0.35)	
NCT1		-18.650**				-9.199			-28.024*				-20.532	
		(-2.49)				(-1.43)			(-1.78)				(-1.50)	
Tier 1 Capital			14.219**		11.179**					3.755		1.268		
			(2.40)		(2.22)					(0.73)		(0.27)		
Tier 2 Capital				3.946	-10.830	-4.720					-17.528	-17.849	-19.110	
				(0.29)	(-0.73)	(-0.36)					(-1.09)	(-1.13)	(-1.17)	
Total Regulatory Capital							5.940							4.575
							(1.26)							(1.01)
Zscore Lagged	0.616***	0.609***	0.600***	0.597***	0.594***	0.573***	0.633***	0.246***	0.211***	0.224***	0.261***	0.239***	0.222***	0.234***
	(10.23)	(9.79)	(10.13)	(10.39)	(10.65)	(10.75)	(11.07)	(4.24)	(3.48)	(3.64)	(4.81)	(4.77)	(4.70)	(3.98)
Cost to Income Ratio	-0.003*	-0.004*	-0.005*	-0.004*	-0.005*	-0.003*	-0.006**	0.012	0.002	0.006	0.012	0.010	0.009	0.003
	(-1.73)	(-1.75)	(-1.74)	(-1.69)	(-1.90)	(-1.79)	(-2.15)	(1.36)	(0.27)	(0.79)	(1.45)	(1.29)	(1.26)	(0.38)
Return on Average Equity	0.007	0.011*	0.008**	0.009**	0.008**	0.009*	0.007**	0.095***	0.064**	0.081***	0.092***	0.088***	0.086***	0.073***
	(1.56)	(1.72)	(2.20)	(2.25)	(2.07)	(1.95)	(2.46)	(3.55)	(2.25)	(3.25)	(4.09)	(3.77)	(3.75)	(3.04)
Liquid Assets to Total Assets	-54.434**	-7.246	-37.034	3.740	-23.076	-40.271*	-21.065	2.275	-11.851	-21.474	12.472	-5.016	-5.723	-25.881
	(-2.00)	(-0.23)	(-1.19)	(0.14)	(-0.93)	(-1.69)	(-0.80)	(0.09)	(-0.45)	(-0.87)	(0.51)	(-0.22)	(-0.25)	(-1.06)
Net Interest Income to Total Assets	0.004	-0.007	0.001	-0.011	-0.004	-0.003	-0.005	-0.025*	-0.019	-0.025	-0.016	-0.019	-0.021	-0.027*
	(0.48)	(-0.81)	(0.12)	(-1.22)	(-0.46)	(-0.32)	(-0.50)	(-1.71)	(-1.25)	(-1.63)	(-1.05)	(-1.36)	(-1.56)	(-1.85)
Total Assets (ln)	-0.027	0.038	-0.014	0.038	0.014	0.012	-0.002	-0.139**	-0.124*	-0.153**	-0.110*	-0.106*	-0.068	-0.168***
	(-0.64)	(0.76)	(-0.32)	(0.78)	(0.30)	(0.28)	(-0.04)	(-2.08)	(-1.81)	(-2.39)	(-1.65)	(-1.66)	(-0.96)	(-2.74)
Concentration	-0.002	0.003	-0.003	0.000	-0.003	-0.001	-0.002	0.013	0.032	0.015	0.013	0.010	0.013	0.014
	(-0.21)	(0.32)	(-0.28)	(0.02)	(-0.27)	(-0.07)	(-0.17)	(0.55)	(1.22)	(0.64)	(0.48)	(0.41)	(0.51)	(0.55)
Capital Stringency	-0.077	-0.066	-0.105	-0.097	-0.083	-0.070	-0.106*	-0.373***	-0.335***	-0.352***	-0.297**	-0.270**	-0.273**	-0.320***
	(-1.18)	(-0.95)	(-1.63)	(-1.62)	(-1.40)	(-1.20)	(-1.81)	(-3.09)	(-2.72)	(-2.96)	(-2.28)	(-2.26)	(-2.25)	(-2.64)
Market Discipline	-0.337***	-0.399***	-0.326***	-0.332***	-0.337***	-0.411***	-0.360***	0.585	0.637	0.545	0.591	0.711	0.817	0.596
	(-2.76)	(-3.09)	(-2.65)	(-2.74)	(-2.70)	(-3.39)	(-2.82)	(0.85)	(0.99)	(0.77)	(0.83)	(1.04)	(1.15)	(0.83)
Activity Restrictions	0.062	0.028	0.120	0.037	0.078	0.064	0.054	-0.146	0.111	-0.219	-0.090	-0.19	-0.086	-0.247
	(0.45)	(0.19)	(0.86)	(0.26)	(0.54)	(0.45)	(0.43)	(-0.32)	(0.25)	(-0.48)	(-0.20)	(-0.42)	(-0.19)	(-0.57)
Constant	5.147**	5.069**	4.854**	4.358**	4.585**	4.760**	5.376***	4.433	1.689	6.440	3.074	3.809	1.675	6.644
	(2.50)	(2.55)	(2.45)	(2.19)	(2.28)	(2.39)	(3.02)	(0.65)	(0.27)	(0.95)	(0.45)	(0.55)	(0.24)	(0.98)
Number Observations	2,612	2,612	2,612	2,612	2,612	2,612	2,612	2,000	2,000	2,000	2,000	2,000	2,000	2,000
Wald Test	55.29	57.81	57.56	62.49	60.06	55.91	66.71	194.73	211.41	66.71	22.85	256.94	138.38	65.49
AR1	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
AR2	0.252	0.262	0.537	0.645	0.613	0.381	0.550	0.913	0.838	0.952	0.702	0.838	0.892	0.879
Hansen Test	0.176	0.176	0.093	0.100	0.205	0.409	0.179	0.159	0.284	0.136	0.307	0.370	0.467	0.257

Table 7: **Banking risk and capital adequacy - All banks by level of total regulatory capital**

Bank default (distance to default) risk is modelled as a function of a variety of capital adequacy metrics during the period 2002 − 2014. Banks with 2006 total regulatory capital less than the median are detailed in specifications (i)-(vii) and those with total regulatory capital greater than the median are detailed in specifications (viii)-(xiv). All specifications use tangible assets as capital denominator. The estimated model is:

$$DD_{i,j,t} = \alpha + \delta DD_{i,j,t-1} + \beta^1 C^k_{i,j,t-1} + \beta^2 X_{i,j,t-1} + \beta^3 d_{j,t} + u_{i,j,t}$$

where DD_t is distance to default at time t, $C_{i,j,t-1}$ is bank capital, $d_{j,t}$ is a matrix of country and time dummy variables (untabulated) and $X_{i,j,t-1}$ is a matrix of bank-level control variables at time $t-1$. Capital metrics and control variables are defined in table A.1. The model is estimated using the two-step GMM approach with robust standard errors and robust z-statistics are given in brackets. The Wald test denotes goodness of fit, AR1 and AR2 are tests for first and second order serial correlation and Hansen is the test for overidentifying restrictions.*, ** and *** indicate statistical significance at the 10%, 5% and 1% level respectively.

	Low Total Regulatory Capital							High Total Regulatory Capital						
	(i)	(ii)	(iii)	(iv)	(v)	(vi)	(vii)	(viii)	(ix)	(x)	(xi)	(xii)	(xiii)	(xiv)
Tangible Equity	26.867***					23.835***		11.571**					2.531*	
	(4.39)					(3.70)		(2.47)					(1.76)	
NCT1		-11.827				6.022			-27.616***				-23.657***	
		(-1.38)				(0.64)			(-3.43)				(-3.47)	
Tier 1 Capital			26.431***		23.982***					6.066		4.124		
			(3.42)		(3.24)					(1.28)		(0.94)		
Tier 2 Capital				54.250***	33.028*	21.090*					-34.938**	-29.773*	-31.550**	
				(2.78)	(1.72)	(1.74)					(-2.17)	(-1.90)	(-2.07)	
Total Regulatory Capital							22.246***							1.314
							(3.70)							(0.28)
Zscore Lagged	0.490***	0.528***	0.502***	0.525***	0.507***	0.484***	0.506***	0.230***	0.166**	0.252***	0.238***	0.226***	0.170***	0.240***
	(7.95)	(7.98)	(8.71)	(8.68)	(8.65)	(8.17)	(9.13)	(3.65)	(2.52)	(4.04)	(4.00)	(3.99)	(3.37)	(4.00)
Cost to Income Ratio	-0.005*	-0.01***	-0.006**	-0.008**	-0.005	-0.004	-0.007**	0.005	-0.001	0.008	0.006	0.007	0.002	0.008
	(-1.72)	(-2.78)	(-2.02)	(-2.21)	(-1.47)	(-1.26)	(-2.24)	(1.02)	(-0.28)	(1.60)	(1.11)	(1.46)	(0.50)	(1.56)
Return on Average Equity	0.003*	0.004*	0.002*	0.014***	0.008**	0.009**	0.004*	0.045***	0.023*	0.057***	0.048***	0.051***	0.033***	0.059***
	(1.68)	(1.85)	(1.71)	(2.90)	(2.01)	(2.29)	(1.94)	(3.23)	(1.93)	(4.14)	(3.82)	(4.42)	(3.08)	(4.33)
Liquid Assets to Total Assets	-21.217	-26.650	-4.356	-7.610	8.873	-12.631	-18.688	18.184	20.746	25.378	31.993	26.517	21.789	24.106
	(-0.78)	(-0.94)	(-0.16)	(-0.23)	(0.32)	(-0.52)	(-0.60)	(0.78)	(0.92)	(1.26)	(1.40)	(1.43)	(1.24)	(1.27)
Net Interest Income to Total Assets	0.012	0.001	0.013	0.004	0.011	0.010	0.013	-0.001	-0.002	0.005	0.016	0.004	0.000	0.006
	(1.25)	(0.09)	(1.20)	(0.39)	(1.21)	(1.20)	(1.16)	(-0.06)	(-0.15)	(0.39)	(1.12)	(0.32)	(0.04)	(0.48)
Total Assets (ln)	-0.041	-0.081	-0.036	-0.095	-0.048	-0.052	-0.070	0.077	0.065	0.033	0.113*	0.100	0.160**	0.047
	(-0.65)	(-1.35)	(-0.68)	(-1.44)	(-0.88)	(-0.99)	(-1.16)	(1.42)	(1.32)	(0.76)	(1.80)	(1.65)	(2.46)	(1.27)
Concentration	0.009	0.010	0.009	0.013	0.010	0.008	0.010	0.008	0.009	0.011	0.002	0.003	0.004	0.009
	(0.89)	(1.05)	(0.87)	(1.33)	(1.01)	(0.81)	(0.93)	(0.42)	(0.50)	(0.50)	(0.11)	(0.14)	(0.23)	(0.41)
Capital Stringency	-0.078	-0.111*	-0.063	-0.15**	-0.091	-0.095	-0.099	-0.200*	-0.199*	-0.229*	-0.145	-0.159	-0.139	-0.222*
	(-1.29)	(-1.83)	(-1.02)	(-2.23)	(-1.30)	(-1.38)	(-1.58)	(-1.71)	(-1.72)	(-1.77)	(-1.26)	(-1.41)	(-1.20)	(-1.72)
Market Discipline	-0.304**	-0.286**	-0.282**	-0.224*	-0.241*	-0.260**	-0.266**	0.150	0.091	0.056	0.464	0.463	0.509	0.069
	(-2.52)	(-2.33)	(-2.27)	(-1.75)	(-1.96)	(-2.08)	(-2.11)	(0.26)	(0.20)	(0.09)	(0.78)	(0.78)	(0.90)	(0.11)
Activity Restrictions	0.135	0.185	0.162	0.044	0.112	0.130	0.104	-0.542	-0.404	-0.489	-0.309	-0.291	-0.228	-0.482
	(1.08)	(1.54)	(1.26)	(0.35)	(0.89)	(1.07)	(0.79)	(-1.27)	(-0.78)	(-1.08)	(-0.70)	(-0.67)	(-0.51)	(-1.06)
Constant	3.263	6.108***	2.386	5.95**	2.438	3.294	4.092*	3.866	5.476	4.691	0.681	0.630	-0.228	5.950
	(1.42)	(2.65)	(0.99)	(2.31)	(1.04)	(1.44)	(1.73)	(0.83)	(1.14)	(1.00)	(0.13)	(0.13)	(-0.04)	(1.21)
Number Observations	2,152	2,152	2,152	2,152	2,152	2,152	2,152	2,172	2,172	2,172	2,172	2,172	2,172	2,172
Wald Test	40.54	38.58	40.65	40.83	43.40	43.68	46.12	62.02	55.95	84.26	44.37	72.54	209.32	53.27
AR1	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
AR2	0.832	0.883	0.909	0.983	0.913	0.939	0.916	0.611	0.428	0.67	0.737	0.637	0.608	0.566
Hansen Test	0.367	0.326	0.368	0.345	0.569	0.990	0.356	0.318	0.356	0.576	0.312	0.471	0.701	0.505

Table 8: **Banking risk and capital adequacy - All banks during the financial crisis period (2008-2011)**
Bank default (distance to default) risk is modelled as a function of a variety of capital adequacy metrics during the period 2008 − 2011. Specifications (i)-(vii) employ tangible assets as denominator, while specifications (viii)-(xiv) use risk weighted assets as denominator. The estimated model is:

$$DD_{i,j,t} = \alpha + \delta DD_{i,j,t-1} + \beta^1 C^k_{i,j,t-1} + \beta^2 X_{i,j,t-1} + \beta^3 d_{j,t} + u_{i,j,t}$$

where DD_t is distance to default at time t, $C_{i,j,t-1}$ is bank capital, $d_{j,t}$ is a matrix of country and time dummy variables (untabulated) and $X_{i,j,t-1}$ is a matrix of bank-level control variables at time $t-1$. Capital metrics and control variables are defined in table A.1. The model is estimated using the two-step GMM approach with robust standard errors and robust z-statistics are given in brackets. The Wald test denotes goodness of fit, AR1 and AR2 are tests for first and second order serial correlation and Hansen is the test for overidentifying restrictions.*, ** and *** indicate statistical significance at the 10%, 5% and 1% level respectively.

	Tangible Assets							RW Assets						
	(i)	(ii)	(iii)	(iv)	(v)	(vi)	(vii)	(viii)	(ix)	(x)	(xi)	(xii)	(xiii)	(xiv)
Tangible Equity	29.203**					18.810		5.594					1.080	
	(2.51)					(1.54)		(0.95)					(0.17)	
NCT1		-28.522				-12.397			-17.054				-16.017	
		(-1.33)				(-0.73)			(-1.10)				(-1.02)	
Tier 1 Capital			28.006*		21.590					-0.739		-2.627		
			(1.78)		(1.45)					(-0.11)		(-0.38)		
Tier 2 Capital				-1.062	12.984	24.460					5.023	6.691	26.060	
				(-0.03)	(0.38)	(0.69)					(0.14)	(0.18)	(0.69)	
Total Regulatory Capital							12.783							-0.861
							(1.11)							(-0.13)
Zscore Lagged	0.314**	0.440***	0.324**	0.407***	0.287*	0.272*	0.383**	0.430***	0.455***	0.453***	0.395***	0.427***	0.431***	0.440***
	(2.12)	(2.87)	(1.99)	(2.99)	(1.89)	(1.88)	(2.57)	(2.85)	(3.05)	(2.90)	(2.62)	(2.62)	(2.71)	(2.83)
Cost to Income Ratio	0.031**	0.07**	0.045**	0.071**	0.049**	0.030**	0.058**	0.036*	0.062**	0.050*	0.072**	0.055**	0.042**	0.050**
	(2.06)	(2.23)	(2.33)	(2.44)	(2.55)	(2.21)	(2.51)	(1.95)	(2.27)	(1.95)	(2.53)	(2.16)	(2.28)	(2.13)
Return on Average Equity	0.028**	0.063***	0.039***	0.067***	0.045***	0.031***	0.053***	0.036**	0.058***	0.051**	0.067***	0.056***	0.044***	0.050***
	(2.52)	(2.82)	(2.67)	(3.09)	(3.08)	(2.74)	(3.22)	(2.48)	(2.94)	(2.47)	(3.23)	(2.84)	(3.20)	(2.69)
Liquid Assets to Total Assets	0.018	0.024	0.025	0.022	0.000	-0.03	0.015	-0.044	0.001	-0.038	0.043	-0.024	-0.036	-0.045
	(0.25)	(0.32)	(0.34)	(0.33)	(0.00)	(-0.50)	(0.21)	(-0.84)	(0.01)	(-0.70)	(0.67)	(-0.47)	(-0.70)	(-0.92)
Net Interest Income to Total Assets	8.926	61.790*	24.846	63.563**	24.929	3.589	41.984	21.314	48.235	35.180	69.013**	41.732	26.010	33.066
	(0.41)	(1.72)	(1.00)	(2.05)	(1.13)	(0.17)	(1.58)	(1.03)	(1.64)	(1.28)	(2.32)	(1.59)	(1.31)	(1.29)
Total Assets (ln)	0.268	0.328	0.261	0.253	0.204	0.147	0.238	0.078	0.262	0.093	0.273	0.110	0.123	0.081
	(1.49)	(1.36)	(1.46)	(1.41)	(1.43)	(1.16)	(1.33)	(0.63)	(1.26)	(0.63)	(1.57)	(0.81)	(0.90)	(0.60)
Concentration	0.051	0.041	0.058	0.032	0.006	-0.046	0.040	-0.120	-0.017	-0.107	0.094	-0.061	-0.059	-0.128
	(0.29)	(0.21)	(0.31)	(0.19)	(0.04)	(-0.31)	(0.21)	(-0.90)	(-0.10)	(-0.75)	(0.58)	(-0.43)	(-0.43)	(-0.97)
Capital Stringency	-0.274	-0.549	-0.301	-0.511	-0.296	-0.221	-0.383	-0.158	-0.449	-0.237	-0.562*	-0.308	-0.286	-0.224
	(-1.15)	(-1.51)	(-1.26)	(-1.59)	(-1.34)	(-1.02)	(-1.48)	(-0.73)	(-1.40)	(-0.89)	(-1.77)	(-1.15)	(-1.16)	(-0.87)
Market Discipline	0.232	0.217	0.296	0.220	0.180	-0.049	0.303	-0.656	-0.032	-0.542	0.545	-0.234	-0.193	-0.632
	(0.26)	(0.21)	(0.31)	(0.23)	(0.20)	(-0.06)	(0.3)	(-0.94)	(-0.03)	(-0.69)	(0.60)	(-0.28)	(-0.24)	(-0.85)
Activity Restrictions	0.033	0.143	0.048	0.152	0.138	0.215	0.077	0.504	0.251	0.434	-0.038	0.263	0.259	0.491
	(0.07)	(0.27)	(0.09)	(0.31)	(0.29)	(0.49)	(0.14)	(1.28)	(0.54)	(1.00)	(-0.09)	(0.63)	(0.69)	(1.17)
Constant	-13.406	-15.309	-15.853	-13.473	-9.876	-1.213	-13.968	7.936	-7.644	6.013	-19.914	0.942	0.853	8.294
	(-0.62)	(-0.61)	(-0.69)	(-0.63)	(-0.51)	(-0.07)	(-0.60)	(0.51)	(-0.36)	(0.35)	(-0.98)	(0.05)	(0.05)	(0.52)
Number Observations	2,269	2,269	2,269	2,269	2,269	2,269	2,269	2,269	2,269	2,269	2,269	2,269	2,269	2,269
Wald Test	60.52	17.36	20.87	24.25	28.36	15.04	41.69	52.84	24.02	36.01	30.11	38.2	13.46	28.59
AR1	0.003	0.001	0.003	0.000	0.001	0.005	0.000	0.001	0.000	0.001	0.000	0.001	0.001	0.000
AR2	0.765	0.982	0.746	0.887	0.669	0.749	0.765	0.774	0.851	0.770	0.821	0.827	0.779	0.788
Hansen Test	0.173	0.450	0.307	0.295	0.301	0.203	0.233	0.126	0.338	0.198	0.191	0.158	0.210	0.183

Table 9: **Banking risk and capital adequacy - pre- and post-Basel II**

Bank default (distance to default) risk is modelled as a function of a variety of capital adequacy metrics for all banks prior to the introduction of Basel II, for banks excluding small and medium US banks post-Basel II and for remaining US banks post Basel II. Specifications (i)-(vii) employ tangible assets as denominator, while specifications (viii)-(xiv) use risk weighted assets as denominator. The estimated model is:

$$DD_{i,j,t} = \alpha + \delta DD_{i,j,t-1} + \beta^1 C^k_{i,j,t-1} + \beta^2 X_{i,j,t-1} + \beta^3 d_{j,t} + u_{i,j,t}$$

where DD_t is distance to default at time t, $C_{i,j,t-1}$ is bank capital, $d_{j,t}$ is a matrix of country and time dummy variables (untabulated) and $X_{i,j,t-1}$ is a matrix of bank-level control variables at time $t-1$. Capital metrics and control variables are defined in table A.1. The model is estimated using the two-step GMM approach with robust standard errors and robust z-statistics are given in brackets. The Wald test denotes goodness of fit, AR1 and AR2 are tests for first and second order serial correlation and Hansen is the test for overidentifying restrictions.*, ** and *** indicate statistical significance at the 10%, 5% and 1% level respectively.

	Pre-Basel II (European and North American Banks)													
	Tangible Assets							**Risk Weighted Assets**						
	(i)	(ii)	(iii)	(iv)	(v)	(vi)	(vii)	(viii)	(ix)	(x)	(xi)	(xii)	(xiii)	(xiv)
Tangible Equity	41.399					20.595		-0.117					-43.668	
	(0.80)					(0.55)		(-0.18)					(-1.28)	
NCT1		-33.626				117.638			0.129				-44.234	
		(-0.41)				(0.99)			(0.10)				(-1.31)	
Tier 1 Capital			33.868		54.028					6.939		-48.039		
			(0.67)		(0.80)					(0.14)		(-1.36)		
Tier 2 Capital				-28.872	5.206	-10.37					-85.239	-58.297	-6.29	
				(-0.28)	(0.07)	(-0.14)					(-0.72)	(-0.49)	(-0.05)	
Total Regulatory Capital							10.281							19.999
							(0.23)							(0.39)
Number Observations	2,924	2,924	2,924	2,924	2,924	2,924	2,924	2,924	2,924	2,924	2,924	2,924	2,924	2,924
Wald Test	2.72	5.17	3.02	3.52	3.22	3.70	4.30	2.86	2.90	3.15	3.13	3.33	5.24	3.16
AR1	0.008	0.014	0.009	0.098	0.015	0.004	0.017	0.003	0.022	0.012	0.108	0.028	0.013	0.01
AR2	0.128	0.121	0.113	0.189	0.121	0.114	0.119	0.12	0.104	0.11	0.252	0.115	0.112	0.108
Hansen Test	0.598	0.717	0.413	0.628	0.301	0.292	0.587	0.426	0.863	0.281	0.623	0.296	0.128	0.453

	Post Basel II (All banks excluding Small & Medium US Banks)													
	Tangible Assets							**Risk Weighted Assets**						
	(i)	(ii)	(iii)	(iv)	(v)	(vi)	(vii)	(viii)	(ix)	(x)	(xi)	(xii)	(xiii)	(xiv)
Tangible Equity	23.484***					22.571*		6.459					-19.657	
	(2.85)					(1.94)		(0.54)					(-0.81)	
NCT1		-90.327				-42.033			-30.532				-30.046	
		(-1.60)				(-1.08)			(-1.11)				(-0.94)	
Tier 1 Capital			7.95		-2.369					-2.054		-19.283		
			(0.34)		(-0.20)					(-0.09)		(-0.84)		
Tier 2 Capital				-12.289	-3.635	-18.290					-14.616	-10.038	-9.890	
				(-0.41)	(-0.12)	(-0.33)					(-0.58)	(-0.34)	(-0.29)	
Total Regulatory Capital							0.907					-19.283		-14.579
							(0.08)					(-0.84)		(-0.65)
Number Observations	1,095	1,095	1,095	1,095	1,095	1,095	1,095	1,095	1,095	1,095	1,095	1,095	1,095	1,095
Wald Test	34.64	19.48	29.89	24.41	26.81	23.46	30.33	30.46	19.25	25.69	26.46	11.58	11.50	22.35
AR1	0.161	0.182	0.106	0.094	0.105	0.128	0.079	0.189	0.239	0.13	0.138	0.066	0.152	0.100
AR2	0.197	0.171	0.188	0.173	0.179	0.201	0.179	0.195	0.191	0.178	0.183	0.16	0.171	0.165
Hansen Test	0.233	0.405	0.182	0.467	0.252	0.942	0.162	0.558	0.132	0.729	0.518	0.652	0.317	0.799

	Post Basel II Small and Medium US Banks													
	Tangible Assets							**Risk Weighted Assets**						
	(i)	(ii)	(iii)	(iv)	(v)	(vi)	(vii)	(viii)	(ix)	(x)	(xi)	(xii)	(xiii)	(xiv)
Tangible Equity	56.896**					42.476		20.319					4.338	
	(2.48)					(1.59)		(1.57)					(0.50)	
NCT1		-38.744*				-30.067			-14.029				-6.145	
		(-1.77)				(-1.26)			(-1.22)				(-0.54)	
Tier 1 Capital			51.521		57.493*					8.336		12.594		
			(1.48)		(1.82)					(0.37)		(0.75)		
Tier 2 Capital				-17.204	37.525	41.590					3.422	29.487	53.48	
				(-0.11)	(0.40)	(0.65)					(0.03)	(0.44)	(0.81)	
Total Regulatory Capital							46.442							11.949
							(1.40)							(0.65)
Number Observations	3,076	3,076	3,076	3,076	3,076	3,076	3,076	3,076	3,076	3,076	3,076	3,076	3,076	3,076
Wald Test	47.06	36.87	32.93	39.03	34.74	44.56	34.20	28.03	26.99	42.09	42.03	41.96	31.30	41.04
AR1	0.086	0.001	0.036	0.000	0.028	0.007	0.030	0.009	0.003	0.003	0.000	0.003	0.001	0.006
AR2	0.532	0.680	0.247	0.603	0.229	0.804	0.388	0.481	0.939	0.424	0.711	0.491	0.518	0.499
Hansen Test	0.363	0.488	0.396	0.388	0.538	0.383	0.522	0.664	0.651	0.293	0.427	0.346	0.693	0.325

Table 10: **Banking volatility risk and capital adequacy - All banks (2002-2014)**

Bank default risk (Stock Market Volatility) is modelled as a function of a variety of capital adequacy metrics during the period 2002 − 2014. Specifications (i)-(vii) employ tangible assets as denominator, while specifications (viii)-(xiv) use risk weighted assets as denominator. The estimated model is:

$$\sigma_{i,j,t} = \alpha + \delta\sigma_{i,j,t-1} + \beta^1 C^k_{i,j,t-1} + \beta^2 X_{i,j,t-1} + \beta^3 d_{j,t} + u_{i,j,t}$$

where $\sigma_{i,j,t}$, total bank risk, is measured as the standard deviation of daily bank returns at time t, $C_{i,j,t-1}$ is bank capital, $d_{j,t}$ is a matrix of country and time dummy variables (untabulated) and $X_{i,j,t-1}$ is a matrix of bank-level control variables at time $t-1$. Capital metrics and control variables are defined in table A.1. The model is estimated using the two-step GMM approach with robust standard errors and robust z-statistics are given in brackets. The Wald test denotes goodness of fit, AR1 and AR2 are tests for first and second order serial correlation and Hansen is the test for overidentifying restrictions.*, ** and *** indicate statistical significance at the 10%, 5% and 1% level respectively.

	Tangible Assets							RW Assets						
	(i)	(ii)	(iii)	(iv)	(v)	(vi)	(vii)	(viii)	(ix)	(x)	(xi)	(xii)	(xiii)	(xiv)
Tangible Equity	-2.054*					-3.391**		-1.443					-0.790	
	(-1.66)					(-2.35)		(-1.43)					(-0.78)	
NCT1		-0.336				-6.312			-2.311				-0.352	
		(-1.18)				(-1.16)			(-1.27)				(-1.27)	
Tier 1 Capital			-2.918**		-2.576**					-2.527		-2.463		
			(-2.23)		(-2.18)					(-1.60)		(-1.21)		
Tier 2 Capital				5.543	2.508	0.650					4.342	0.472	1.3 00	
				(1.62)	(0.86)	(0.17)					(1.61)	(0.17)	(0.51)	
Total Regulatory Capital							-2.139							-2.077
							(-1.49)							(-1.46)
Volatility Lagged	0.441***	0.530***	0.416***	0.517***	0.441***	0.478***	0.524***	0.405**	0.503***	0.348**	0.563***	0.344	0.528***	0.379**
	(2.95)	(4.32)	(3.07)	(3.72)	(3.55)	(3.63)	(3.90)	(2.51)	(3.58)	(2.09)	(4.39)	(1.65)	(4.01)	(2.34)
Cost to Income Ratio	0.000	0.007**	0.000	0.001	0.001	0.003	-0.001	0.000	0.004	0.002	0.000	0.005	0.004**	0.002
	(-0.15)	(2.14)	(0.14)	(0.28)	(0.35)	(1.15)	(-0.16)	(0.04)	(1.14)	(0.73)	(0.11)	(1.61)	(2.21)	(0.51)
Return on Average Equity	-0.010***	-0.004	-0.010***	-0.012***	-0.008**	-0.004	-0.009**	-0.010***	-0.008**	-0.009**	-0.011**	-0.009**	-0.002	-0.010***
	(-2.71)	(-1.04)	(-2.78)	(-2.66)	(-2.29)	(-1.09)	(-2.48)	(-2.69)	(-2.05)	(-2.52)	(-2.44)	(-2.53)	(-0.81)	(-2.69)
Liquid Assets to Total Assets	0.004	0.007	0.006	-0.005	0.005	0.004	0.003	0.003	0.006	0.003	-0.005	-0.001	0.001	0.003
	(1.11)	(1.53)	(1.61)	(-1.07)	(1.27)	(0.94)	(0.83)	(0.92)	(1.42)	(0.78)	(-1.09)	(-0.27)	(0.40)	(0.70)
Net Interest Income to Total Assets	13.195*	8.672	11.543*	25.056**	12.501*	12.956*	9.024	8.359	9.989	5.866	24.866**	16.518	2.726	6.436
	(1.90)	(0.99)	(1.72)	(2.44)	(1.92)	(1.76)	(1.30)	(1.11)	(1.09)	(0.73)	(2.55)	(1.63)	(0.33)	(0.80)
Total Assets (ln)	-0.002	0.037**	-0.004	0.035	-0.003	0.005	-0.001	-0.005	0.027	-0.007	0.031	0.019	0.007	-0.001
	(-0.12)	(2.27)	(-0.25)	(1.44)	(-0.20)	(0.37)	(-0.04)	(-0.24)	(1.44)	(-0.39)	(1.28)	(0.90)	(0.31)	(-0.06)
Concentration	0.002***	0.001	0.002***	0.003***	0.001**	0.002**	0.002***	0.002***	0.002	0.001**	0.003***	0.002***	0.001**	0.002***
	(3.00)	(1.53)	(2.60)	(3.91)	(2.58)	(2.50)	(2.99)	(2.75)	(1.49)	(2.35)	(4.01)	(2.79)	(2.23)	(2.86)
Capital Stringency	0.008	0.003	0.007	0.004	0.005	0.003	0.007	0.004	0.001	0.000	0.003	0.000	0.001	0.004
	(1.45)	(0.51)	(1.39)	(0.61)	(0.87)	(0.63)	(1.32)	(0.71)	(0.21)	(0.04)	(0.49)	(-0.06)	(0.21)	(0.74)
Market Discipline	-0.065**	-0.064*	-0.072***	-0.082**	-0.061**	-0.078**	-0.058**	-0.066**	-0.107**	-0.071***	-0.077**	-0.086**	-0.043	-0.071**
	(-2.35)	(-1.68)	(-2.66)	(-2.30)	(-2.36)	(-2.09)	(-2.01)	(-2.38)	(-2.36)	(-2.64)	(-2.31)	(-2.47)	(-1.60)	(-2.58)
Activity Restrictions	-0.004	-0.003	-0.009	0.015	-0.011	-0.014	-0.004	-0.001	-0.001	-0.005	0.012	0.005	-0.006	-0.004
	(-0.43)	(-0.20)	(-0.93)	(1.12)	(-1.20)	(-1.07)	(-0.36)	(-0.09)	(-0.03)	(-0.46)	(0.96)	(0.39)	(-0.55)	(-0.40)
Constant	0.214	-1.204	0.418	-1.286	0.219	0.118	0.315	0.397	-0.611	0.664	-1.15	-0.313	-0.122	0.487
	(0.29)	(-1.65)	(0.54)	(-1.32)	(0.30)	(0.18)	(0.41)	(0.48)	(-0.69)	(0.76)	(-1.22)	(-0.32)	(-0.15)	(0.61)
Number Observations	6,823	6,823	6,823	6,823	6,823	6,823	6,823	6,823	6,823	6,823	6,823	6,823	6,823	6,823
Wald Test	91.60	44.89	74.73	61.72	70.56	53.34	70.70	88.67	44.89	72.65	68.29	64.40	55.51	73.39
AR1	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
AR2	0.146	0.708	0.156	0.085	0.311	0.681	0.269	0.105	0.609	0.094	0.131	0.105	0.660	0.098
Hansen Test	0.201	0.561	0.162	0.629	0.118	0.344	0.134	0.278	0.317	0.275	0.500	0.498	0.417	0.330

Table 11: **Systematic / Idiosyncratic Risk and capital adequacy - All banks (2002-2014)**

Bank risk is modelled as a function of a variety of capital adequacy metrics during the period 2002 − 2014. Specifications (i)-(vii) employ firm systematic risk as dependent variables, while specifications (viii)-(xiv) use idiosyncratic risk as dependent. In order to calculate systematic risk, a market model is estimated for each bank, $R_{it} = \alpha_i + \beta_i R_{M,t} + \epsilon_{i,t}$. The market index is chosen as the Euro Stoxx 600 in the case of Europe, the S&P 500 for US banks and the S&P/TSX index for Canadian banks. Idiosyncratic risk is estimated as the standard deviation of the residual from the market model. The estimated model is:

$$\Omega_{i,j,t} = \alpha + \delta\Omega_{i,j,t-1} + \beta^1 C^k_{i,j,t-1} + \beta^2 X_{i,j,t-1} + \beta^3 d_{j,t} + u_{i,j,t}$$

where $\Omega_{i,j,t}$ is either systematic risk or idiosyncratic risk, $C_{i,j,t-1}$ is bank capital, $d_{j,t}$ is a matrix of country and time dummy variables (untabulated) and $X_{i,j,t-1}$ is a matrix of bank-level control variables at time $t-1$. Capital metrics and control variables are defined in table A.1. The model is estimated using the two-step GMM approach with robust standard errors and robust z-statistics are given in brackets. The Wald test denotes goodness of fit, AR1 and AR2 are tests for first and second order serial correlation and Hansen is the test for overidentifying restrictions.*, ** and *** indicate statistical significance at the 10%, 5% and 1% level respectively.

	Systematic Risk							Idiosyncratic Risk						
	(i)	(ii)	(iii)	(iv)	(v)	(vi)	(vii)	(viii)	(ix)	(x)	(xi)	(xii)	(xiii)	(xiv)
Tangible Equity	0.371					1.396		-2.304*					-2.152*	
	(0.28)					(0.95)		(-1.86)					(-1.75)	
NCT1		4.014***				5.257***			-2.278*				-3.793**	
		(2.88)				(2.97)			(-1.69)				(-2.09)	
Tier 1 Capital			0.500		1.087					-3.427**		-2.674*		
			(0.35)		(0.71)					(-2.40)		(-1.83)		
Tier 2 Capital				1.305	3.403	2.350					-0.477	-3.062	-2.780	
				(0.36)	(0.87)	(0.51)					(-0.13)	(-0.85)	(-0.76)	
Total Regulatory Capital							0.753							-2.948**
							(0.56)							(-2.34)
Lagged Dependent	0.679	0.906	0.474	0.722	0.661	1.176	1.199	0.622***	0.738***	0.602***	0.796***	0.676***	0.661***	0.618***
	(1.23)	(1.53)	(1.14)	(1.32)	(1.11)	(1.54)	(1.29)	(4.21)	(5.02)	(4.61)	(5.19)	(4.73)	(4.71)	(4.52)
Cost to Income Ratio	0.003	0.006	0.001	0.005	0.002	0.006	0.004	0.002	0.002	0.004	0.000	0.003	0.003	0.004
	(0.83)	(1.40)	(0.30)	(1.03)	(0.43)	(1.33)	(0.81)	(0.57)	(0.58)	(1.02)	(0.07)	(0.62)	(0.71)	(1.04)
Return on Average Equity	0.006	0.009	0.004	0.008	0.006	0.011	0.009	-0.007**	-0.008**	-0.007**	-0.009***	-0.008**	-0.008**	-0.007**
	(1.30)	(1.49)	(1.14)	(1.52)	(1.22)	(1.54)	(1.12)	(-2.35)	(-2.31)	(-2.44)	(-2.83)	(-2.55)	(-2.54)	(-2.33)
Liquid Assets to Total Assets	-0.003	-0.004	-0.004	-0.002	-0.004	-0.006*	-0.005	-0.003	-0.003	-0.002	-0.003	-0.001	-0.002	-0.001
	(-0.95)	(-1.12)	(-1.25)	(-0.60)	(-1.23)	(-1.70)	(-1.54)	(-1.15)	(-1.33)	(-0.74)	(-1.32)	(-0.51)	(-0.90)	(-0.57)
Net Interest Income to Total Assets	0.957	4.584	-0.243	1.815	0.569	5.886	2.234	5.108	6.042	10.388	5.932	8.744	7.916	11.345
	(0.09)	(0.41)	(-0.03)	(0.17)	(0.06)	(0.52)	(0.19)	(0.41)	(0.69)	(0.87)	(0.50)	(0.72)	(0.89)	(0.95)
Total Assets (ln)	0.070	0.044	0.090*	0.062	0.065	0.013	0.005	0.001	0.025	0.009	0.016	0.013	0.020	0.018
	(1.09)	(0.58)	(1.85)	(0.91)	(0.94)	(0.14)	(0.04)	(0.03)	(1.36)	(0.38)	(0.62)	(0.54)	(1.00)	(0.76)
Concentration	0.002**	0.002	0.002**	0.002*	0.002**	0.002	0.002*	0.001**	0.002***	0.001**	0.002***	0.001**	0.002***	0.001**
	(2.00)	(1.49)	(2.32)	(1.75)	(2.30)	(1.61)	(1.67)	(2.35)	(2.91)	(2.18)	(2.63)	(2.46)	(3.00)	(2.10)
Capital Stringency	-0.005	-0.006	-0.005	-0.005	-0.007	-0.008	-0.004	0.008	0.008	0.009	0.007	0.010*	0.010*	0.011*
	(-0.86)	(-1.09)	(-0.94)	(-0.97)	(-1.17)	(-1.21)	(-0.81)	(1.44)	(1.46)	(1.60)	(1.41)	(1.80)	(1.82)	(1.82)
Market Discipline	-0.015	0.003	-0.022	-0.009	-0.015	0.011	-0.001	-0.038	-0.045	-0.049*	-0.033	-0.041	-0.051*	-0.047*
	(-0.49)	(0.08)	(-0.78)	(-0.27)	(-0.49)	(0.28)	(-0.01)	(-1.54)	(-1.62)	(-1.89)	(-1.27)	(-1.60)	(-1.94)	(-1.76)
Activity Restrictions	-0.076***	-0.071***	-0.067***	-0.084***	-0.076***	-0.077***	-0.081***	-0.002	-0.005	-0.006	0.000	-0.007	-0.008	-0.005
	(-3.73)	(-3.10)	(-4.02)	(-3.82)	(-3.91)	(-2.95)	(-2.76)	(-0.24)	(-0.48)	(-0.66)	(-0.01)	(-0.78)	(-0.88)	(-0.50)
Constant	-1.104	-0.972	-1.329	-1.037	-1.011	-0.580	0.000	0.212	-0.521	-0.054	-0.275	-0.059	-0.166	-0.310
	(-0.88)	(-0.64)	(-1.26)	(-0.78)	(-0.79)	(-0.34)	(0.00)	(0.20)	(-0.66)	(-0.05)	(-0.24)	(-0.06)	(-0.21)	(-0.30)
Number Observations	6,759	6,759	6,759	6,759	6,759	6,759	6,759	6,759	6,759	6,759	6,759	6,759	6,759	6,759
Wald Test	435.70	230.59	152.94	321.52	213.75	187.42	263.01	70.04	84.44	62.72	76.11	67.84	63.99	62.31
AR1	0.189	0.116	0.178	0.162	0.242	0.129	0.220	0.000	0.000	0.000	0.000	0.000	0.000	0.000
AR2	0.651	0.378	0.998	0.577	0.736	0.289	0.388	0.794	0.692	0.833	0.689	0.773	0.779	0.813
Hansen Test	0.603	0.759	0.189	0.641	0.290	0.806	0.328	0.193	0.073	0.348	0.140	0.257	0.149	0.327

Table 12: **Accounting measures of risk and capital adequacy - All Banks**

Bank risk is modelled as a function of a variety of capital adequacy metrics during the period 2002 − 2014. Bank risk is defined as non-performing loans to gross loans in specifications (i)-(vii) and as the three year rolling standard deviation of return on assets in specifications (viii)-(xiv). All specifications use tangible assets as denominator. The estimated model is:

$$A_{i,j,t} = \alpha + \delta A_{i,j,t-1} + \beta^1 C^k_{i,j,t-1} + \beta^2 X_{i,j,t-1} + \beta^3 d_{j,t} + u_{i,j,t}$$

where $A_{i,j,t}$, accounting risk, is either non-performing loans to gross loans or a three-year rolling standard deviation of ROA at time t, $C_{i,j,t-1}$ is bank capital, $d_{j,t}$ is a matrix of country and time dummy variables (untabulated) and $X_{i,j,t-1}$ is a matrix of bank-level control variables at time $t-1$. Capital metrics and control variables are defined in table A.1. The model is estimated using the two-step GMM approach with robust standard errors and robust z-statistics are given in brackets. The Wald test denotes goodness of fit, AR1 and AR2 are tests for first and second order serial correlation and Hansen is the test for overidentifying restrictions.*, ** and *** indicate statistical significance at the 10%, 5% and 1% level respectively.

	Non-Performing Loans to Gross Loans							Standard Deviation ROA						
	(i)	(ii)	(iii)	(iv)	(v)	(vi)	(vii)	(viii)	(ix)	(x)	(xi)	(xii)	(xiii)	(xiv)
Tangible Equity	-18.260***					-15.699**		-11.160***					-7.879**	
	(-2.68)					(-2.47)		(-3.48)					(-2.42)	
NCT1		-21.679***				-26.121***			-0.496				-4.834	
		(-2.76)				(-3.06)			(-0.18)				(-1.60)	
Tier 1 Capital			-21.280***		-15.299**					-13.16***		-9.677***		
			(-2.77)		(-2.18)					(-3.55)		(-2.76)		
Tier 2 Capital				-74.711***	-73.692***	-74.070***					-5.193	-7.263	-5.400	
				(-3.17)	(-3.10)	(-3.10)					(-1.03)	(-1.36)	(-1.08)	
Total Regulatory Capital							-23.354***							-11.795***
							(-2.90)							(-3.18)
Lagged Dependent	0.878***	0.959***	0.897***	0.947***	0.905***	0.904***	0.892***	0.594**	1.138***	0.555**	1.278***	0.752***	0.838***	0.578***
	(18.91)	(21.85)	(20.25)	(23.46)	(20.59)	(19.41)	(19.91)	(2.38)	(4.98)	(2.47)	(5.29)	(3.43)	(3.65)	(2.72)
Cost to Income Ratio	0.008***	0.008***	0.008***	0.009***	0.009***	0.009***	0.008***	0.006***	0.006***	0.006***	0.006***	0.006***	0.006***	0.007***
	(3.33)	(3.42)	(3.52)	(3.50)	(3.65)	(3.87)	(3.55)	(6.01)	(6.08)	(6.60)	(5.03)	(6.64)	(6.63)	(7.05)
Liquid Assets to Total Assets	-0.073***	-0.076***	-0.059***	-0.07***	-0.049**	-0.046**	-0.046**	-0.003	0.001	-0.002	0.002	0.001	0.001	-0.001
	(-2.93)	(-3.57)	(-2.71)	(-2.94)	(-2.20)	(-2.10)	(-2.15)	(-0.72)	(0.38)	(-0.52)	(0.57)	(0.19)	(0.35)	(-0.19)
Net Interest Income to Total Assets	4.272	-8.344	9.494	2.576	16.703	18.622*	15.306	13.419***	3.907***	14.964***	4.712***	13.931***	12.809***	15.931***
	(0.44)	(-1.33)	(0.96)	(0.33)	(1.46)	(1.71)	(1.40)	(4.53)	(2.86)	(4.84)	(3.14)	(3.87)	(3.44)	(4.47)
Total Assets (ln)	0.082	0.099***	0.061	0.168***	0.084*	0.106*	0.041	0.034*	0.023***	0.014	0.028***	0.007	0.002	0.007
	(1.39)	(2.92)	(1.30)	(3.40)	(1.76)	(1.96)	(1.07)	(1.93)	(2.87)	(1.03)	(2.79)	(0.59)	(0.17)	(0.79)
Concentration	-0.003	0.005	-0.003	0.002	-0.004	-0.002	-0.004	0.002	0.002	0.002*	0.003*	0.003**	0.002*	0.002
	(-0.40)	(0.69)	(-0.42)	(0.20)	(-0.51)	(-0.25)	(-0.54)	(1.42)	(1.25)	(1.69)	(1.75)	(1.98)	(1.69)	(1.62)
Capital Stringency	-0.230***	-0.204***	-0.220***	-0.124*	-0.118*	-0.117*	-0.184***	-0.004	-0.007	-0.006	-0.007	-0.001	0.000	0.004
	(-3.35)	(-2.98)	(-3.25)	(-1.76)	(-1.73)	(-1.69)	(-2.76)	(-0.50)	(-0.84)	(-0.67)	(-0.74)	(-0.09)	(0.05)	(0.43)
Market Discipline	0.296*	0.258*	0.258*	0.263*	0.27*	0.255	0.244	-0.011	0.032	-0.033	0.015	-0.017	0.013	-0.033
	(1.89)	(1.70)	(1.68)	(1.66)	(1.73)	(1.59)	(1.58)	(-0.30)	(0.94)	(-0.87)	(0.36)	(-0.45)	(0.35)	(-0.87)
Activity Restrictions	-0.323***	-0.297***	-0.383***	-0.324***	-0.454***	-0.467***	-0.420***	-0.050**	-0.059**	-0.077***	-0.048**	-0.070***	-0.067***	-0.060**
	(-2.78)	(-2.79)	(-3.39)	(-2.83)	(-3.93)	(-4.10)	(-3.67)	(-2.03)	(-2.60)	(-2.98)	(-2.04)	(-2.81)	(-2.66)	(-2.30)
Constant	8.537***	2.240	8.519***	1.432	5.415**	4.88**	8.358***	1.802**	-0.845**	1.794**	-0.935**	0.790	0.499	1.100
	(3.64)	(1.43)	(3.78)	(0.81)	(2.55)	(2.22)	(3.83)	(2.16)	(-2.45)	(2.08)	(-2.57)	(1.13)	(0.73)	(1.49)
Number Observations	5,539	5,539	5,539	5,539	5,539	5,539	5,539	5,508	5,508	5,508	5,508	5,508	5,508	5,508
Wald Test	208.81	254.28	222.49	226.38	207.32	198.45	215.21	44.05	89.99	36.79	99.48	43.56	47.45	40.70
AR1	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.069	0.001	0.063	0.001	0.016	0.009	0.047
AR2	0.460	0.538	0.498	0.452	0.428	0.420	0.472	0.543	0.023	0.899	0.012	0.410	0.154	0.783
Hansen Test	0.428	0.410	0.464	0.209	0.122	0.157	0.266	0.819	0.186	0.715	0.720	0.455	0.182	0.497

Table 13: **2SLS Instrumental variable regressions - Banking risk and capital adequacy - All banks (2002-2014)**
Bank default (distance to default) risk is modelled as a function of a variety of capital adequacy metrics during the period $2002-2014$. All specifications use tangible assets as capital denominator. Specifications (i)-(v) include banks of all sizes, while specifications (vi)-(x) examine large banks with total assets greater than $50 billion. The estimated model is:

$$DD_{i,j,t} = \alpha + \delta DD_{i,j,t-1} + \beta^1 C^k_{i,j,t-1} + \beta^2 X_{i,j,t-1} + \beta^3 d_{j,t} + u_{i,j,t}$$

where DD_t is distance to default at time t, $C_{i,j,t-1}$ is bank capital, $d_{j,t}$ is a matrix of country and time dummy variables (untabulated) and $X_{i,j,t-1}$ is a matrix of bank-level control variables at time $t-1$. Capital metrics and control variables are defined in table A.1. The model is estimated using two-stage least squares instrumental variable regression. In the first stage, each capital metric is instrumented using the second and third lagged difference of the variable. The Anderson Canonical Correlation is a test for underidentification, the Cragg-Donald Wald F-statistic also tests for weak instruments while the Sargan statisic tests for overidentifying restrictions. *, ** and *** indicate statistical significance at the 10%, 5% and 1% level respectively.

	Tangible Assets							RW Assets						
	(i)	(ii)	(iii)	(iv)	(v)	(vi)	(vii)	(viii)	(ix)	(x)	(xi)	(xii)	(xiii)	(xiv)
Tangible Equity	43.530***					31.118**		6.659					9.269	
	(4.99)					(2.47)		(0.79)					(1.24)	
NCT1		-60.026***				-28.221*			-52.012				-8.284	
		(-6.26)				(-1.89)			(-1.52)				(-0.27)	
Tier 1 Capital			27.461**		25.934*					7.044		7.513		
			(2.20)		(1.94)					(0.71)		(0.84)		
Tier 2 Capital				-60.912	-28.895	-14.155					1.111	2.623	18.276	
				(-1.53)	(-0.79)	(-0.39)					(0.05)	(0.11)	(0.69)	
Total Regulatory Capital							19.106							13.453
							(1.56)							(1.44)
Cost to Income Ratio	-0.007**	-0.010***	-0.016***	-0.017***	-0.016***	-0.006**	-0.018***	-0.017***	-0.006*	-0.018***	-0.019***	-0.018***	-0.014*	-0.018***
	(-2.19)	(-3.85)	(-5.87)	(-6.94)	(-5.74)	(-2.04)	(-6.82)	(-4.19)	(-1.73)	(-6.34)	(-7.79)	(-6.39)	(-1.95)	(-6.91)
Return on Average Equity	0.011***	0.021***	0.017***	0.021***	0.016***	0.013***	0.02***	0.02***	0.023***	0.020***	0.024***	0.020***	0.019***	0.016***
	(3.01)	(7.51)	(3.89)	(6.84)	(3.86)	(3.39)	(4.98)	(3.37)	(7.47)	(3.06)	(7.81)	(3.23)	(3.64)	(2.74)
Liquid Assets to Total Assets	-54.097***	-5.078	-39.165**	2.646	-0.012**	-0.018***	-32.938*	-10.761	-13.874*	-9.902	-9.144	-0.011	-0.013*	-11.952
	(-4.66)	(-0.70)	(-2.52)	(0.28)	(-2.37)	(-3.80)	(-1.94)	(-1.44)	(-1.71)	(-1.36)	(-1.19)	(-1.2)	(-1.71)	(-1.61)
Net Interest Income to Total Assets	-0.017***	-0.011***	-0.010**	-0.009*	-31.949	-36.673*	-0.007	-0.010	-0.007	-0.010	-0.004	-10.213	-13.974*	-0.015*
	(-3.65)	(-2.64)	(-2.03)	(-1.87)	(-1.56)	(-1.89)	(-1.56)	(-1.17)	(-1.56)	(-1.07)	(-1.00)	(-1.34)	(-1.65)	(-1.74)
Total Assets (ln)	-1.323***	-2.130***	-1.588***	-1.593***	-0.015	0.106*	-1.888***	-1.748***	-2.101***	-1.731***	-2.095***	-0.098	-0.068	-1.53***
	(-3.77)	(-6.80)	(-4.06)	(-3.86)	(-0.25)	(1.89)	(-5.50)	(-3.32)	(-6.45)	(-2.94)	(-5.36)	(-1.25)	(-0.77)	(-3.09)
Concentration	-0.081***	-0.073***	-0.079***	-0.071***	-0.077***	-0.078***	-0.078***	-0.074***	-0.075***	-0.075***	-0.074***	-0.075***	-0.075***	-0.075***
	(-4.94)	(-4.51)	(-4.72)	(-4.27)	(-4.58)	(-4.75)	(-4.66)	(-4.63)	(-4.42)	(-4.58)	(-4.47)	(-4.59)	(-4.71)	(-4.64)
Capital Stringency	-0.222***	-0.246***	-0.228***	-0.187***	-0.202***	-0.216***	-0.258***	-0.222***	-0.249***	-0.220***	-0.246***	-0.222***	-0.239***	-0.216***
	(-3.63)	(-4.08)	(-3.68)	(-2.73)	(-2.93)	(-3.19)	(-4.16)	(-3.37)	(-3.96)	(-3.17)	(-3.53)	(-2.97)	(-3.25)	(-3.43)
Market Discipline	0.020	-0.158	0.059	-0.037	0.052	-0.055	0.044	-0.040	-0.186	-0.023	-0.034	-0.024	-0.084	-0.026
	(0.12)	(-0.94)	(0.33)	(-0.22)	(0.29)	(-0.32)	(0.25)	(-0.24)	(-0.92)	(-0.14)	(-0.20)	(-0.14)	(-0.44)	(-0.15)
Activity Restrictions	0.307**	0.270**	0.334***	0.417***	0.379***	0.310**	0.296**	0.388**	0.302**	0.391**	0.319**	0.393**	0.395***	0.445***
	(2.45)	(2.17)	(2.64)	(3.05)	(2.76)	(2.26)	(2.33)	(2.59)	(2.33)	(2.46)	(2.49)	(2.55)	(2.69)	(2.95)
Constant	7.733***	13.711***	11.64***	13.344***	10.711***	8.484***	13.618***	13.123***	13.073***	13.329***	15.838***	13.280***	12.445***	11.669***
	(2.8)	(6.10)	(3.95)	(5.11)	(3.68)	(3.03)	(5.12)	(3.26)	(4.48)	(3.24)	(6.33)	(3.35)	(3.57)	(3.23)
Number Observations	3,673	3,673	3,673	3,673	3,673	3,696	3,673	3,673	3,673	3,673	3,673	3,673	3,696	3,673
Ajdusted R2	0.299	0.314	0.287	0.285	0.293	0.320	0.286	0.326	0.258	0.313	0.289	0.314	0.342	0.319
Anderson Canonical Correlation	132.851	314.952	87.978	118.771	56.036	59.220	79.166	43.488	10.950	47.083	84.839	56.989	13.450	51.445
(p-value)	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.027	0.000	0.000	0.000	0.036	0.000
Cragg-Donald Wald F-statistic	34.103	85.232	22.301	40.501	9.381	7.438	20.018	10.888	2.717	15.738	21.487	11.455	11.668	12.909
Sargan Statistic	5.084	3.612	5.746	0.571	6.327	9.014	2.871	3.463	1.365	2.808	4.107	2.960	8.767	5.940
(p-value)	0.166	0.307	0.125	0.752	0.176	0.109	0.412	0.326	0.714	0.246	0.250	0.398	0.119	0.115

Table 14: **Banking risk and capital adequacy - banks by differing size (2002-2014)**

Bank default (distance to default) risk is modelled as a function of a variety of capital adequacy metrics during the period $2002-2014$ for banks of differing sizes. Specifications (i)-(vii) consider banks with assets less than $50 billion, while specifications (viii)-(xiv) model banks with assets less than $25 billion. In each case, tangible assets is used as denominator for capital metrics. The estimated model is:

$$DD_{i,j,t} = \alpha + \delta DD_{i,j,t-1} + \beta^1 C^k_{i,j,t-1} + \beta^2 X_{i,j,t-1} + \beta^3 d_{j,t} + u_{i,j,t}$$

where DD_t is distance to default at time t, $C_{i,j,t-1}$ is bank capital, $d_{j,t}$ is a matrix of country and time dummy variables (untabulated) and $X_{i,j,t-1}$ is a matrix of bank-level control variables at time $t-1$. Capital metrics and control variables are defined in table A.1. The model is estimated using the two-step GMM approach with robust standard errors and robust z-statistics are given in brackets. The Wald test denotes goodness of fit, AR1 and AR2 are tests for first and second order serial correlation and Hansen is the test for overidentifying restrictions.*, ** and *** indicate statistical significance at the 10%, 5% and 1% level respectively.

	Total Assets < $50 Billion							Total Assets < $25 Billion						
	(i)	(ii)	(iii)	(iv)	(v)	(vi)	(vii)	(viii)	(ix)	(x)	(xi)	(xii)	(xiii)	(xiv)
Tangible Equity	24.715***					19.535*		25.904***					25.163**	
	(2.84)					(1.94)		(3.05)					(2.58)	
NCT1		-24.807**				0.868			-21.889				1.923	
		(-1.98)				(0.07)			(-1.64)				(0.16)	
Tier 1 Capital			19.977**		14.144					21.437**		18.449*		
			(2.35)		(1.43)					(2.49)		(1.95)		
Tier 2 Capital				-17.689	-23.842	-9.760					-26.904	-33.551	-19.060	
				(-0.70)	(-0.76)	(-0.33)					(-0.94)	(-1.13)	(-0.69)	
Total Regulatory Capital							15.027**							15.65**
							(1.99)							(2.19)
Zscore Lagged	0.301**	0.241	0.366	0.342**	0.160	0.208	0.432***	0.300**	0.260*	0.369	0.338**	0.162	0.247	0.412***
	(2.08)	(1.51)	(1.41)	(2.15)	(0.65)	(1.05)	(2.88)	(2.16)	(1.68)	(1.60)	(2.10)	(0.71)	(1.23)	(2.94)
Cost to Income Ratio	-0.009	-0.005	-0.013	-0.025	-0.03	-0.021	-0.005	-0.004	-0.012	-0.007	-0.027	-0.020	-0.006	-0.008
	(-0.54)	(-0.27)	(-0.63)	(-1.14)	(-1.12)	(-0.9)	(-0.31)	(-0.24)	(-0.64)	(-0.41)	(-1.43)	(-0.92)	(-0.25)	(-0.52)
Return on Average Equity	0.008	0.018	0.012	0.010	0.004	0.006	0.015	0.012	0.018	0.017	0.008	0.007	0.012	0.014
	(0.77)	(1.27)	(0.95)	(0.72)	(0.30)	(0.47)	(1.26)	(1.05)	(1.18)	(1.21)	(0.62)	(0.55)	(0.86)	(1.22)
Liquid Assets to Total Assets	-0.006	-0.014	0.001	-0.021	-0.036	-0.029	-0.002	-0.023	-0.028	-0.026	-0.037	-0.065	-0.060	-0.012
	(-0.23)	(-0.52)	(0.03)	(-0.79)	(-0.96)	(-0.81)	(-0.07)	(-0.61)	(-0.62)	(-0.51)	(-0.86)	(-1.57)	(-1.33)	(-0.34)
Net Interest Income to Total Assets	-19.854	13.040	-32.150	9.628	-22.840	-17.615	-1.509	-25.477	2.671	-42.253	5.992	-29.448	-19.995	-7.902
	(-0.78)	(0.62)	(-1.10)	(0.41)	(-0.78)	(-0.64)	(-0.07)	(-1.05)	(0.12)	(-1.63)	(0.26)	(-1.07)	(-0.79)	(-0.35)
Total Assets (ln)	0.007	-0.107	-0.065	-0.251**	-0.179	-0.094	-0.091	0.018	-0.166	0.003	-0.319***	-0.142	-0.039	-0.111
	(0.05)	(-0.97)	(-0.51)	(-2.38)	(-1.24)	(-0.66)	(-0.87)	(0.11)	(-1.13)	(0.02)	(-2.85)	(-0.9)	(-0.22)	(-0.84)
Concentration	0.020	0.036	0.021	0.023	0.029	0.013	0.018	0.019	0.017	0.019	0.014	0.026	0.004	0.010
	(0.66)	(1.08)	(0.52)	(0.65)	(0.75)	(0.39)	(0.50)	(0.57)	(0.49)	(0.45)	(0.38)	(0.67)	(0.11)	(0.29)
Capital Stringency	-0.278*	-0.336*	-0.401*	-0.262	-0.203	-0.178	-0.29	-0.253	-0.275	-0.239	-0.199	-0.147	-0.109	-0.189
	(-1.85)	(-1.81)	(-1.7)	(-1.45)	(-0.90)	(-0.86)	(-1.64)	(-1.6)	(-1.47)	(-1.10)	(-1.05)	(-0.70)	(-0.54)	(-1.08)
Market Discipline	-0.403	-0.721	-1.018	-0.341	0.020	-0.146	-0.490	-0.036	-0.205	0.361	0.109	0.865	0.511	0.180
	(-0.55)	(-0.79)	(-0.75)	(-0.46)	(0.02)	(-0.14)	(-0.60)	(-0.04)	(-0.20)	(0.23)	(0.13)	(0.70)	(0.43)	(0.21)
Activity Restrictions	0.168	0.317	0.165	0.241	0.757	0.461	0.055	0.324	0.435	0.825	0.335	1.193*	0.627	0.213
	(0.42)	(0.76)	(0.20)	(0.52)	(1.05)	(0.76)	(0.13)	(0.77)	(0.97)	(0.95)	(0.65)	(1.73)	(1.10)	(0.47)
Constant	-0.741***	-0.804***	-0.734***	-0.882***	-0.998***	-1.563	-0.772***	-0.443	6.169	-3.910	8.489	-0.863***	-0.625*	1.302
	(-3.67)	(-3.99)	(-3.23)	(-4.22)	(-2.61)	(-1.34)	(-3.50)	(-0.05)	(0.61)	(-0.21)	(1.05)	(-4.05)	(-1.86)	(0.14)
Number Observations	5,092	5,092	5,092	5,092	5,092	5,092	5,092	4,883	4,883	4,883	4,883	4,883	4,883	4,883
Wald Test	64.93	60.00	73.32	54.5	53.85	19.32	68.94	59.35	57.94	74.46	50.40	19.01	15.88	72.41
AR1	0.000	0.001	0.015	0.000	0.030	0.006	0.000	0.000	0.000	0.007	0.000	0.025	0.006	0.000
AR2	0.311	0.642	0.464	0.288	0.982	0.782	0.115	0.279	0.543	0.398	0.293	0.973	0.682	0.128
Hansen Test	0.165	0.104	0.473	0.158	0.344	0.272	0.234	0.107	0.047	0.444	0.149	0.409	0.192	0.135

Table 15: **Banking risk and capital adequacy using principal component analysis (PCA) - All and large banks (2002-2014)**

Bank default (Distance to default) risk is modelled as a function of orthogonal capital adequacy metrics extracted from a principal component analysis during the period 2002−2014. Specifications (i)-(ii) details results for all banks, while specifications (iii)-(iv) consider large banks. The estimated model is:

$$DD_{i,j,t} = \alpha + \delta DD_{i,j,t-1} + \beta^1 C^k_{i,j,t-1} + \beta^2 X_{i,j,t-1} + \beta^3 d_{j,t} + u_{i,j,t}$$

where DD_t is distance to default at time t, $C_{i,j,t-1}$ are PCA bank capital metrics, $d_{j,t}$ is a matrix of country and time dummy variables (untabulated) and $X_{i,j,t-1}$ is a matrix of bank-level control variables at time $t-1$. Capital metric factors are orthogonal and created using a varimax rotation on factors from a principal component analysis. The PCA capital factors are interpreted using the largest contributing factor components. Capital metrics and control variables are defined in table A.1. The model is estimated using the two-step GMM approach with robust standard errors and robust z-statistics are given in brackets. The Wald test denotes goodness of fit, AR1 and AR2 are tests for first and second order serial correlation and Hansen is the test for overidentifying restrictions.*, ** and *** indicate statistical significance at the 10%, 5% and 1% level respectively.

	All Banks			
	Tangible Assets		**Risk Weighted Assets**	
	(i)	(ii)	(iii)	(iv)
Tangible Equity	1.320***		63.183	
	(2.90)		(1.38)	
NCT1	0.109		-4.81	
	(0.68)		(-0.10)	
Tier 1 Capital		1.495***		68.823
		(3.22)		(1.25)
Tier 2 Capital	-0.167	-0.136	-0.837*	-0.791**
	(-0.67)	(-0.52)	(-1.70)	(-2.17)
Zscore Lagged	0.534**	0.424*	0.548	0.494*
	(2.21)	(1.86)	(1.60)	(1.85)
Cost to Income Ratio	-0.01	-0.013	-0.011	-0.016
	(-0.73)	(-0.89)	(-0.61)	(-0.80)
Return on Average Equity	0.023**	0.022*	0.032**	0.033**
	(2.02)	(1.85)	(2.50)	(2.42)
Liquid Assets to Total Assets	-0.005	-0.005	-0.003	-0.003
	(-1.14)	(-1.16)	(-0.52)	(-0.40)
Net Interest Income to Total Assets	-27.613**	-31.659**	-6.386	-8.877
	(-1.99)	(-2.16)	(-0.61)	(-0.77)
Total Assets (ln)	0.008	-0.004	-0.022	-0.046
	(0.12)	(-0.06)	(-0.32)	(-0.55)
Concentration	0.009	0.009	0.014	0.014
	(1.14)	(1.11)	(1.48)	(1.44)
Capital Stringency	-0.125***	-0.135**	-0.091*	-0.092
	(-2.64)	(-2.59)	(-1.74)	(-1.64)
Market Discipline	-0.074	-0.042	-0.063	-0.039
	(-0.56)	(-0.31)	(-0.47)	(-0.27)
Activity Restrictions	0.088	0.146	0.094	0.111
	(0.62)	(0.99)	(0.48)	(0.65)
Constant	3.941	4.367	4.549	5.168
	(1.35)	(1.51)	(1.38)	(1.47)
Number Observations	5,951	5,951	5,951	5,951
Wald Test	82.10	78.65	71.19	64.41
AR1	0.006	0.012	0.029	0.009
AR2	0.191	0.362	0.262	0.228
Hansen Test	0.898	0.891	0.726	0.756

Appendix A. Data Definitions

Capital Adequacy Metrics

Variable	Definition
Tangible Equity to Tangible Assets	Total equity (common stock and retained earnings) minus goodwill, other intangibles and deferred tax assets / Total assets minus goodwill, other intangibles and deferred tax assets
Non-Core Tier 1 to Tangible Assets	(Tier 1 capital - Tangible Equity) / Total assets minus goodwill, other intangibles and deferred tax assets
Tier 1 Capital to Tangible Assets	Total Equity capital (common stock, disclosed reserves and retained earnings), qualifying perpetual preferred stock (including related surplus), senior perpetual preferred stock, trust preferred securities, related interest in equity of consolidated subsidiaries less goodwill and other intangible assets/ Total assets minus goodwill, other intangibles and deferred tax assets
Tier 2 Capital to Tangible Assets	Supplementary bank capital inclusive of undisclosed reserves, revaluation reserves, general provisions, hybrid debt securities, subordinated term debt / Total assets minus goodwill, other intangibles and deferred tax assets
Total Regulatory Capital to Tangible Assets	(Tier 1 Capital + Tier 2 Capital) / Total assets minus goodwill, other intangibles and deferred tax assets
Tangible Equity to Risk Weighted Assets	Total equity (common stock and retained earnings) minus goodwill, other intangibles and deferred tax assets / Reported risk weighted assets
Non-Core Tier 1 to Risk Weighted Assets	(Tier 1 capital - Tangible Equity) / Reported risk weighted assets
Tier 1 Capital to Risk Weighted Assets	Total Equity capital (common stock, disclosed reserves and retained earnings), qualifying perpetual preferred stock (including related surplus), senior perpetual preferred stock, trust preferred securities, related interest in equity of consolidated subsidiaries less goodwill and other intangible assets / Reported risk weighted assets
Tier 2 Capital to Risk Weighted Assets	Supplementary bank capital inclusive of undisclosed reserves, revaluation reserves, general provisions, hybrid debt securities, subordinated term debt / Reported risk weighted assets
Total Regulatory Capital to Risk Weighted Assets	(Tier 1 Capital + Tier 2 Capital) / Reported risk weighted assets

Control Variables

Variable	Definition
Loan Loss Provisions to Total Loans	Loan impairment charge / Total loans
Return on Average Equity	Net Income / Equity
Cost to Income Ratio	Overheads / Other operating income plus net interest revenue
Liquid Assets to Customer and Short Term Deposits	Liquid Assets (including trading securities, loans and advances to banks, reverse repos and cash collateral, cash and due from banks) / Customer deposits plus deposits from banks plus repos and cash collateral plus other deposits and short term borrowings
Net Interest Income to Total Assets	(Total Interest and Dividend Income - Total Interest Expense) / Total Assets
Total Assets (Ln)	Natural logarithm of total bank assets as per balance sheet

Table A.1: **Data Description**
Data definitions for capital adequacy metrics and control variables applied in the study. Data is sourced from Bankscope.

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