Beyond Common Equity: The Influence of Secondary Capital on Bank Risk

Abstract

Banks must adhere to strict rules regarding the quantity of regulatory capital held, but management have some flexibility as to capital composition. In this paper, we examine the sensitivity of bank risk to the quantity and mix of capital other than common equity. Decomposing tier 1 capital into tangible equity and non-core components reveals a heretofore unidentified variation in the risk reduction capacity of each, consistent with regulatory arbitrage. For large banks, a greater quantity of non-core tier 1 capital is found to be positively related to risk. No link between is established between either tier 2 capital or total regulatory capital and bank risk. Finally, the ability of regulatory capital to limit bank risk is found to be impaired when defined relative to risk-weighted assets. Findings are supportive of the Basel III focus on high quality capital.

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

JEL: G21

1. Introduction

This paper seeks to understand a complex and relatively unexplored question, namely, beyond common equity is bank 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. Tier 2 capital is composed of undisclosed and asset revaluation reserves, loan-loss reserves, hybrid capital and subordinated debt. In measuring regulatory capital, each of these is adjusted for asset risk using risk-weighted assets in the denominator. In this study we focus on the influence of non-core tier 1 capital and tier 2 capital on bank risk, a topic which has received little attention. The composition of tier 1 capital has recently been under the spotlight. Under the Basel frameworks, non-cumulative perpetual preference shares were to be the sole non-common equity contributor to tier 1 capital. Recent evidence suggests that banks were able to overcome these stipulations through a

[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.

form of regulatory arbitrage. For example, since 1996 the Federal Reserve Board has permitted U.S. bank holding companies to employ trust preferred securities, a form of cumulative non-perpetual preferred security, to meet tier 1 capital requirements (Boyson et. al. 2016). Pointing towards the weakness of non-core tier 1 capital, Boyson et. al. (2016) provide evidence that banks with more trust preferred securities have greater insolvency risk. In this study, we establish the relationship between the constituents of tier 1 capital and bank risk in detail, providing strong evidence regarding the vital importance of capital quality.

Under Basel I and II, up to 50% of total risk weighted regulatory capital could be held in the form of tier 2 capital. 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; Krisnan et. al., 2005). Furthermore, while general reserves may contribute to tier 2 capital, evidence suggests that reserves have a positive relationship with the risk of bank failure Ng and Roychowdhury (2014). Although Demirg-Kunt et. al. (2013) examine the link between tier 2 capital and bank performance, little attention has been paid to the influence of tier 2 capital on bank risk. We consider this link in detail.

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 scant relationship with market imputed levels of bank risk (Vallascas & Hagendorff, 2013). Furthermore, Mariathasan & Merrouche (2014) find support for risk-weight manipulation, finding a decline in average risk weights after

banks introduce the internal ratings based approach. In light of these important findings, we examine whether the 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 detailed 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, non-core tier 1 capital is inconsistently associated with reduced risk and, in fact, has a positive relationship with risk for large banks. 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. No link between tier 2 capital and realized risk is established, with similar findings for total regulatory capital. Finally, recent doubts raised over the effectiveness of asset risk-weighting are borne out. The relationship between bank capital and risk is further weakened when normalized by risk-weighted assets, as opposed to total unweighted assets. Findings are shown to be consistent for large banks, for accounting measures of risk, for banks with distinct ex-ante capital levels and for a wide range of specification tests.

Our contribution places the paper amongst the literature examining the benefits of holding further capital and that highlighting the potential for regulatory arbitrage. Although various studies highlight the importance of high-quality equity capital on bank performance, little attention has been paid to the components which comprise total regulatory capital. Closest to this paper is Demirg-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 risk rather than performance and illustrates the relevance of capital elements throughout the cycle. In contrast to Berger & Bouman (2012) and many previous studies, our focus on the contributing components of regulatory capital rather than just tier 1 capital or total

regulatory capital sheds light on the individual contributors to the aggregate capital picture. Relative to these studies, our findings illustrate the inconsistent risk reduction benefits of various types of capital other than tangible equity.

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, Boyson et. al. (2016). Moreover, this links to studies detailing the potential for risk-shifting, whereby equity holders decrease the size of their stake but liability holders bear the majority of the risk (Hovakimian and Kane, 2000; John et. al, 1991). 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 the literature examining the potential for misrepresentation of risk weighted assets (Mariathasan & Merrouche (2014), Acharya et. al. (2013), Vallascas & 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.

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 high quality common equity and non-core tier 1 capital. Banks will be required to hold a minimum 4.5% of risk weighted assets in common equity, while the remainding 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 aligned with the loss reduction capacity of such capital outlined here. 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.

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 intermediation volumes 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 are 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 the composition of their capital they might be able to reduce the amount of equity capital held, while maintaining a constant level of regulatory capital (Boyson *et al.*, 2014). Second, they might choose to arbitrage risk weights associated with the regulatory capital denominator, using, for instance, asset-back 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.

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 risking, 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 increased 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.

In addition to equity capital, established regulatory frameworks such as the Basel Accord 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 assets (Gorton and Santomero, 1990). Blum (2002) and Levonian (2001) also 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.

Considering the somewhat disparate conclusions from the theoretical literature, we also look to the empirical literature for guidance on the relationship between banking risk and and various forms of regulatory capital. Considering accounting measures of risk, conflicting evidence exists regarding the adjustment in risk taking found for increased capital (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). Moreover, there is strong evidence that increased capital reduces the probability 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.

[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.

[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).

A related empirical literature considers the ability of debt markets, in particular subordinated debt, to limit bank risk taking. The main focus in this literature has been the relationship between the price of subordinated debt and ex-post risk but evidence for the effectiveness of market discipline on bank risk-taking is somewhat mixed. Various studies provide evidence 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 credit spreads as risk indicators, the association between the quantity of such debt held and risk has received 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 the 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 no link 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.

The quantity and quality of capital held by banks can be measured in a variety of ways, governed predominantly by rules established in the Basel Accords on banking supervision (See, for example, Demirgüç-Kunt *et al.* (2013)). "Tier 1" regulatory capital primarily

consists of equity capital and disclosed reserves, and may include elements of non-redeemable preferred stock. "Tier 2" regulatory capital includes subordinated debt, hybrid securities and undisclosed reserves among others. Under Basel II rules, the total capital (Tier 1 plus Tier 2) must be greater than 8% of risk weighted assets, while Tier 2 capital is limited to 100% of Tier 1 Capital. As banks may hold assets of varying quality, risk weighting calibrates the size of the assets to account for market, operational and credit risk (under Basel II). Previous discussions of capital and bank risk taking have largely focussed on equity and subordinated debt in isolation, but regulatory requirements aggregate the multitude of underlying components in order to set capital requirements. While Demirgüç-Kunt *et al.* (2013) investigate the importance of regulatory capital on bank performance, the relationship of the various components with risk has received little attention.

3. Empirical Model and Data

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

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

where subscript i corresponds to individual banks, j to countries and t to the year of measurement. In our main specifications, $\sigma_{i,j,t}$ is the annualized volatility of monthly bank returns at time t, C^k 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 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 is 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 permits us to uncover the relationship between market risk and capital during both crisis periods and normal times.[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 was 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 period of highest equity market volatility $2007 - 2011$ encompassing the global financial crisis and subsequent European sovereign debt crisis period.

Furthermore, we examine the relationship between capital and risk according to bank size. Large banks are particularly problematic from a regulatory perspective, as prospective losses in the event of failure may be extensive. Moreover, the danger of contagion to other banks leads us to analyse banks with total assets greater than \$50 billion.[7] We also perform sensitivity analysis examining banks with total assets less than \$25 billion and under \$10 billion.

All explanatory variables are windsorised at the 1% and 99% levels, to remove the influence of outliers or reporting errors. Selection bias is reduced by including banks which were taken over, nationalised or filed for bankruptcy.

[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 institution 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).

[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.

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). An additional complication with the use of accounting measures of risk in a study considering bank capital relates to the fact that many of the standard accounting risk measures are implicitly incorporated within bank capital. For example, the commonly applied z-score metric, capturing insolvency risk, contains the ratio of equity capital to assets in the numerator. Moreover, loan loss reserves, often chosen to represent credit risk, may reduce equity capital and can be added back to total regulatory capital up to a maximum of 1.25% of total risk weighted assets (Ng and Roychowdhury, 2014). Any model trying to relate elements of bank capital to such accounting measures of risk will suffer from endogeneity problems. In this paper, the primary focus is on market-based measures of risk, as this permits us to disentangle the relationship of ex-ante capital and ex-post risk, and helps to mitigate such endogenity concerns. In later analysis, some accounting measures of risk are further considered, to validate the consistency of results.

Throughout this study, equity market derived risk measures are employed as the principal dependent variable capturing individual bank risk (Beltratti and Stulz, 2012; Demirgüç-Kunt and Huizinga, 2010). In particular, total bank risk is measured as the annualised volatility of daily stock returns. Further sensitivity tests examine systematic risk and idiosyncratic risk, and also test total risk measured as the annualised volatility of monthly stock returns. The study of equity market 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.

To determine the consistency of results, we further consider two accounting related measures of risk, chosen so as to limit the possibility of introducing endogeneity.[8] The first, non-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 applied is the standard deviation of return on assets, $\sigma(ROA)$.[9] To calculate $\sigma(ROA)$, data from the three most recent years is used. This measure of accounting risk has been considered previously by 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 the relationship between an assortment of capital adequacy metrics and bank 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 A1.

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

[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, which means that a distress measure tells us little about cross-sectional bank risk during 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, we focus on forward-looking market based measures of risk in this study.

[9] A logical alternative to this would be the Z-score measure. However, for reasons previously given, this may result in endogenity problems.

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, it contains elements 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.*, 2014). 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.[10]

TCE is the major component of tier 1 capital. Beyond the TCE element, the remainder of tier 1 capital is composed primarily of perpetual preferred stocks (including related surplus) and trust preferred securities. As these security forms 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.[11]

Tier 2 or supplementary capital is also held by banks, as a buffer for prospective losses

[10]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).

[11]Similar to the case of common equity tier 1 capital, banks in our 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 be subordinated to deposits, general creditors and subordinated debt and perpetual, and 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.

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 little research has been done on 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). However, many of these studies focus on the ability of subordinated debt to provide market discipline, through signals implied from market prices of such securities. In contrast, we consider the relationship between 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, is comprised of both tier 1 and tier 2 capital, thus representing 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). The exposure measure is specified to capture the aggregate unweighted bank risk exposure, consisting primarily of on-balance sheet assets, off-balance sheet assets and derivative exposures.[12] To capture overall bank exposure, in this paper we calibrate each of the capital metrics using both

[12]As with core-tier 1 capital and additional tier 1 capital, banks do not report sufficient data to calculate this metric over the period examined. However, the tangible assets metric described proxies for the total exposure over the bank over this period.

regulatory risk-weighted assets and unweighted balance sheet 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.[13] First, bank profitability or earnings quality is 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 the net interest income to total assets variable, 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.

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

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 the sources of funds counted as capital, whether such sources are verified and whether risk elements are considered in the calculation of capital (Ongena *et al.*, 2013). Capital stringency consists of eight survey questions in total and can take values 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 can take values between 0 and 9, with larger values signalling a 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 the ability to own non-financial firms. Finally, in a more concentrated banking system, the value of the bank franchise 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 the total assets of the banking sector 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 table A1. 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 2002 through 2014. For the main dependent variable of interest, volatility of daily bank returns for each year, the average cross sectional level over all years is 41.543%. However, this value is positively skewed by a small number of banks with highly volatile returns, evidenced by a median volatility of 29.432% over the period. Average annual volatility masks somewhat the considerable time variation over the period 2002 through 2014. The trend in volatility was consistent over the period 2002 to 2007, averaging 26.4%. Volatility was elevated during the period surrounding the global financial crisis, averaging 69.6% in 2008, 82.75% in 2009, 56.92% in 2010, 54.8% in 2011 and 43.7% in 2012. This phase, the 'high volatility period', is later examined in isolation. From this point onwards, the level of equity volatility reverts to levels typical prior to the crisis, averaging 30.6% from 2013 to 2014.

[Table 1 about here.]

The main 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 8.268% of tangible assets and 11.990% 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 0.888% of tangible assets and 1.238% of risk weighted assets. However, moderate average levels of NCT1 capital mask considerable cross-sectional variation. The standard deviation of NCT1 to tangible assets is 1.72% and the 25^{th} and 75^{th} percentiles are 0% and 1.749% 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 9.19% of tangible assets and 13.196% of risk weighted assets. Furthermore, levels of tier 1 capital

normalized by tangible assets are found to display cross-sectional variation, from 7.24% at the 25^{th} percentile to 10.285% at the 75^{th} percentile. The 25% 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.[14]

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 1.217%, while denominated by risk weighted assets the mean value is 1.724%. Finally, total regulatory capital (also known as the capital adequacy ratio) is, on average, 10.080% of tangible and 14.899% of risk weighted assets.

Considering the control variables examined, several points are worth noting. The average return on equity is 5.359%, while the median value is substantially higher at 8.537%. Considerable variation is evident in the ratio of liquid assets to customer and short term deposits, where the mean value of 13.618% is much greater than the median and closer to the 75^{th} percentile value of 14.888%. This indicates a propensity of certain banks to maintain a liquidity ratio much larger than normal. Finally, the ratio of net interest income to total assets has an average value of 3.005% and displays little variation.

Correlations between variables of interest are detailed in Table 2. Considering first the relationships between volatility and each of the capital adequacy metrics, the expected negative relationship is evident in most cases. The major exception is NCT1 which has a positive and significant relationship with risk. Tier 2 capital has a negative relationship with future risk but this is insignificant when denominated by tangible assets. When denominated by tangible assets, tangible equity has a correlation of -0.178 with risk, tier 1 capital has a correlation of -0.108 and total regulatory capital a correlation of -0.098.

[Table 2 about here.]

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

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. Tier 1 capital and total regulatory capital, which subsume tangible equity, are found to have a high level of correlation with the latter (> 0.76). Furthermore, high but not perfect correlations are evident between variables having the same numerator when denominated by both tangible assets and risk weighted assets. For example, the correlation between tier 2 capital when denominated by tangible assets and risk weighted assets is 0.76. Finally, the maximum correlation between the capital variables examined simultaneously in the models to follow is -0.414, helping to alleviate any concerns regarding collinearity and associated interpretation.

Finally, we consider correlations between variables reported in previous studies as controlling for bank risk. A number of these variables are highly correlated with risk. For example, the cost to income ratio has a correlation of 0.325, return on equity a correlation of -0.475, and capital stringency a correlation of 0.121. The cost to income ratio and return on equity are further found to have a cross-correlation of -0.537, 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 risk of -0.061, but is strongly related to net interest income (-0.499), concentration (-0.460) and activity restrictions (-0.397).

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).[15] This method

[15]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.

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 variables controlling for earnings quality, operational efficiency, diversification and liquidity may be endogenous. Potential endogeneity is controlled for in a number of ways. First, the focus on a market derived dependent variable ensures that there is no direct correspondence between dependent and capital variables. In contrast, the selection of many accounting-based metrics such as loan-loss reserves or Z-score may have potentially induced an endogenous relationship due to their direct association with many of the elements of capital considered. 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.[16] Regulatory variables and bank size are treated as predetermined, while

[16] 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 instrument 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 instrumental variable regressions provides strong evidence for the validity of the instruments used in this paper.

country and year variables are strictly endogenous. 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. See section 4.8 for further details of the 2SLS approach.

4.1. Baseline Model

In this section, we examine the relationship between bank risk and the variety of capital adequacy metrics described, both on an individual basis and simultaneously. To this end, equation 1 is estimated a number of times for each of the range of capital metrics. Table 3 details our baseline model, examining the relationship between bank total equity risk (volatility) and the level of regulatory capital reported in the previous year during the period $2002-2014$. In each model we relate the level of risk (volatility) at time t to capital adequacy at time $t-1$, while controlling for a range of other characteristics. In untabulated results, we include time and country dummies 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, among all other capital metrics examined, only total regulatory capital to tangible assets has a significant relationship with risk. Third, neither tangible equity or total regulatory capital are found to be significant when denominated by risk weighted assets. Finally, while tangible equity normalized by tangible assets is associated with reduced risk, tier 1 capital is not. This is a consequence of the NCT1 component of tier 1 capital having an insignificant relationship with risk.

Results for the control variables are largely as expected. The cost to income ratio has a positive and significant relationship with risk, indicating that less efficient banks are riskier.

Return on average equity has a negative relationship with risk, suggesting that more profitable banks are perceived to have less risk, potentially a consequence of greater retained earnings. Only bank concentration is opposite to expectations, having a positive relationship with risk.

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 reduced risk is in keeping with that of Demirgüç-Kunt *et al.* (2013), where this metric was found to be consistently associated with stock outperformance for crisis and non-crisis periods. Moreover, the finding that tangible equity is not significant associated with risk when normalized by risk weighted assets is supported by 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 seems to impede the link between greater levels of high quality bank capital and a reduction in risk on the whole.

While tangible equity makes up the majority proportion of tier 1 capital, our findings suggest that the former is related to risk, while the latter is not. This suggests that the risk reduction capacity of tier 1 capital is hindered by the NCT1 component, comprising elements of tier 1 capital not contributing to tangible equity. 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 weight assets, but no relationship with accounting measures of risk. Boyson *et al.* (2014) 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. Applying this to our results would suggest that banks who shift their focus from the highest quality tangible equity to

lower quality securities are decreasing 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.

A similar argument could be applied to tier 2 capital, for which we find no significant relationship with 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.[17] 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 articles have shown conflicting evidence for the ability of subordinated debt to provide market discipline.

4.2. Large Banks

Previous research has demonstrated considerable diversity in the drivers of risk and performance for banks of varying size (Beltratti and Stulz, 2012; Berger and Bouwman, 2013). Large banks, in particular, have been found to have distinct features, perhaps a result of their too-big-to-fail status. 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 $2002 - 2014$.[18]

[Table 4 about here.]

Findings are in keeping with those described for banks of all sizes. Tangible equity to tangible assets has a negative and significant relationship with total bank risk. When denominated by risk weighted assets, this relationship is no longer evident. In fact, for the

[17] 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.

[18] We later examine the robustness of these findings for cohorts of banks with assets greater than \$25 billion and greater than \$10 billion, Section 4.8.

most systemically important large banks, risk weighted capital does not have a significant negative relationship with risk for any metric. 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 witness a positive, although insignificant, relationship with risk. 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 negative relationship with risk, NCT1 is now found to be positively and significantly related to risk for large 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.*, 2014). These findings build on this, showing that regulatory arbitrate has the potential to mitigate the capacity of tier 1 capital to reduce bank risk taking, especially for larger banks. Furthermore, the positive relationship between NCT1 and risk is found to hold, even when denominated by risk weighted assets.

No significance is found between tier 2 capital and risk, consistent with our baseline results. Finally, total regulatory capital has a positive, but insignificant, relationship with risk. This positive relationship is driven by a combination of NCT1 and tier 2 capital, again mitigating the ability of tangible equity to reduce risk. Our findings suggest that for the largest, most systemically important banks, only tangible equity denominated by tangible assets is associated with the reduction of total bank 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. High Volatility Periods

We next consider the relationship between risk and capital during the period $2007-2011$, the period during which equity market volatility was most elevated. Results, outlined in table 5, are supportive of most forms of high quality capital in reducing bank risk during periods

of market stress.

[Table 5 about here.]

Findings can be summarized as follows. First, tangible equity, tier 1 capital and total regulatory capital are all associated with reduced risk, whether denominated by tangible assets or risk weighted assets. Second, NCT1 is also significantly associated with reduced risk, in contrast to previous findings over the entire interval $2002 - 2014$. Finally, the level of tier 2 capital held by banks is not found to be associated with a reduction in risk, a result consistent throughout our analysis.

These results suggest that higher quality capital is effective in reducing bank risk at the most critical points. This finding is in agreement with Berger and Bouwman (2013), where both equity capital and tier 1 capital are found to be associated with an increased chance of survival during bank crises. In contrast to results detailed for the longer interval $2002-2014$, NCT1 has a significant negative relationship with risk, while risk weighting of assets also results in a significant relationship. While dependence on lower quality tier 1 capital does not reduce bank risk taking on the whole, during times of heightened volatility banks with greater levels of tier 1 capital experience lower levels of volatility.

This evidence for a phase change in the relationship between NCT1 and risk may be a consequence of the bailout mechanisms adopted in many jurisdictions. In order to increase the quantity of tier 1 capital held by banks, many banks were supported by government entities through the purchase of preferred securities. Such securities do not count as tangible equity, but rather come under the NCT1 component of tier 1 capital. While privately held NCT1 is found to be associated with an increase in risk in many cases, issuance of sovereign-held preferred securities provided strong loss absorption, reducing ex-post risk.

4.4. Accounting Measures of Risk

The analysis detailed above focusses on equity related measures of risk, for two primary reasons. First, many accounting-based measures of banking risk are intrinsically related to

banking capital, adding to potential endogeneity problems. Second, equity related measures of risk are forward looking and less likely to be impacted by managerial discretion.

Accounting based measures of risk are commonly employed in banking studies, and here, we consider whether the results detailed are consistent for two such measures. 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.[19] Furthermore, we consider the standard deviation of return on assets over a rolling three year window. Results, detailed in table 6, are from the period 2002 through 2014, and focus on capital metrics denominated by tangible assets.

[Table 6 about here.]

Findings are broadly supportive of those detailed for equity volatility. Tangible equity to tangible assets has the expected sign for both measures and is found to be significantly related to the standard deviation of ROA. For both metrics, NCT1 and aggregate tier 1 capital are not significantly related to risk. Moreover, as detailed previously, tier 2 capital is not found to be associated with a reduction in banking risk. Finally, total regulatory capital, while displaying the expected sign, is not found to be significantly related to risk. While high quality regulatory capital may help to reduce risk, a shift to lower quality forms of regulatory capital has the effect of impairing risk reduction benefits.

4.5. 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

[19] As there is a direct relationship between loan loss provisions, loan loss reserves and capital, these are not considered here, due to endogenity.

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 7 details the relationship between capital levels and risk conditional on the level of tangible equity to tangible assets over the period 2002 to 2014.[20] For banks with tangible equity less than the median value, no capital metric is found to be significantly related to risk. For banks having tangible equity levels greater than the median value, high quality capital is associated with reduced risk. In particular, tangible equity and tier 1 capital both have a negative association with risk, even though NCT1 is insignificant. Similar to results detailed for banks of all sizes, tier 2 capital is not found to be significantly related to risk. This notwithstanding, total regulatory capital is strongly associated with reduced risk for banks with tangible equity levels greater than the median.

[Table 7 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 8, 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 are consistent with those delineated by tangible equity.

For banks with below median levels of total regulatory capital, no measure of capital has a significant negative relationship with risk. Only NCT1 capital is found to have a significant positive relationship with risk when considered in isolation. Considering banks with total regulatory capital greater than the median level, all forms of capital with the exception of tier 2 are found to have risk reduction capacity. In sharp contrast to banks with below median total regulatory capital, NCT1 capital is found to have a strong, significant negative

[20]Note: In both table 7 and table 8, we only consider tangible assets as denominator for brevity, as strongest links with risk have been detailed for unweighted assets.

relationship with risk. Moreover, tier 1 capital and total regulatory capital are significantly associated with risk reduction.

[Table 8 about here.]

Delineating between banks with below and above median quantities of capital, contrasting results are found. For banks with low core capital and low aggregate capital, no significant relationship between capital and risk reduction is evident. Although this does not suggest that low capitalization banks are taking larger risks and thus gambling for redemption, it does highlight difficulties in ensuring that such banks do not take excessive risks. In contrast, capital is very effective in reducing risk for better capitalized banks. While tier 2 capital is not found to be significantly associated with risk for capital levels either below or above the median level, the coefficients are found to be in agreement. For low capital levels, measured by either the level of tangible equity or total regulatory capital, tier 2 capital is consistently found to have a negative coefficient. In contrast, for high levels of capital, the coefficient on tier 2 capital is found to be positive.

4.6. Changes in Capital

While recent research has focussed on the relationship between capital levels and future performance, there is strong evidence that changes in capital are contemporaneously associated with an adjustment in risk taking (Jokipii and Milne, 2011; Lindquist, 2004). The focus in this paper is different, instead considering the ability of greater quantities of capital of differing quality to prevent future risk taking. Building on this, we now consider whether changes in bank regulatory capital components over year t are associated with lower bank risk in year $t + 1$ over the period 2002 through 2014. Results are detailed in table 9.

[Table 9 about here.]

Results for changes in capital are broadly in line with those detailed earlier for capital levels. An increase in the level of tangible equity to tangible assets is associated with a

reduction in future risk. In contrast, an increase in tangible equity to risk weighted assets does not result in a reduction in risk. An increase in tier 1 capital is not associated with reduced risk, presumably a consequence of the insignificant relationship found for changes in NCT1. As previously detailed for levels of tier 2 capital, increases in such capital are not found to be associated with a reduction in risk. Finally, changes in total regulatory capital are associated with reduced risk when denominated by tangible assets but not by risk weighted assets.

4.7. Basel II Introduction

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.[21] For this reason, we split banks into a number of cohorts in table 10.

[Table 10 about here.]

First, we examine the relationship between risk and capital 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. Results closely follow those reported previously. Tangible equity to tangible assets has a significant negative relationship with risk, while tier 1 capital is not significantly associated with risk. Tangible equity to risk weighted assets is not found to be significantly related to risk. Finally total regulatory capital is insignificant for either denominator.

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. Re-

[21] 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.

sults are in stark contrast to those highlighted to date. None of the capital metrics considered are found to be significantly associated with reduced risk. NCT1 capital has a significant positive relationship with risk when denominated by tangible assets, in keeping with findings detailed for large banks earlier. Moreover, when denominated by risk weighted capital, no capital metric is significant, in keeping with previous findings for 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.[22] Tangible equity to tangible assets has the expected sign and is significant. NCT1, tier 1 capital and total regulatory capital are significant when denominated by risk weighted assets, in keeping with later findings for small and medium US banks. Moreover, findings for NCT1 are in keeping with those detailed during the high volatility period, during which the US government purchased preferred securities in many banks under the TARP framework. In summary, our findings are supportive of earlier results, with tangible equity to tangible assets primarily associated with reduced risk.

4.8. Sensitivity Tests

In this section, we test the robustness of results for: (i) an alternative methodology (ii) alternative measures of market risk (iii) an alternative measurement interval for the dependent variable (iv) differing bank sizes, both large and small (v) orthogonalized capital metrics, to ensure no impact on results from collinearity.

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, second and third 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 11, are consistent with those previously

[22]These are categorized as banks with total assets less than $250 billion or foreign exposures less than $10 billion.

detailed for all banks and large banks. Tangible equity is consistently associated with a reduction in risk, while tier 1 capital is significant for all banks but not for large banks. In agreement with previous findings, the level of NCT1 has a positive and highly significant relationship with risk for large banks. To confirm strong inference, we further test 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 11 about here.]

To this point, the definition of bank risk has been restricted to equity volatility. We now test the sensitivity of our results to alternate risk definitions. Risk is, in turn, defined as systematic risk and idiosyncratic equity risk in table 12, while capital metrics are denominated by tangible assets.[23] Findings for systematic risk are in keeping with those for total risk (volatility). High quality capital, in particular tangible equity, is associated with reduced risk, while lower quality forms of capital such as NCT1 capital and tier 2 capital are not significantly related to risk. Aggregate tier 1 capital and total regulatory capital are found to be associated with reducing systemic risk. Considering the relationship between idiosyncratic risk and capital, all forms of capital expect tier 2 have a negative relationship with risk but are insignificant. Tier 2 capital has a positive association with risk but is also insignificant.

[23]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.

[Table 12 about here.]

The sensitivity of results to the measurement interval used in estimating the dependent variable is now examined for all banks and for large banks. Calculating total volatility using monthly returns, table 13 details results which are consistent with previous findings using daily returns in deriving the dependent variable. Tangible equity is associated with reduced risk for both small and large banks, while NCT1 is found to have a positive association with risk. Aggregate tier 1 capital does not have a significant relationship with risk for large banks or the entire sample of banks. Moreover, tier 2 capital and total regulatory capital are not found to have a significant association with risk. These results suggest that findings previously detailed are not a consequence of the measurement interval used to calculate banking risk.

[Table 13 about here.]

In previous analysis, large banks were defined as those with total assets greater than \$50 billion or more. In table 14 we test the sensitivity of our results for large banks to different size thresholds. Results are found to be broadly consistent with those for banks with size greater than \$50 billion. Reducing the size threshold from \$50 billion to \$25 billion increases the number of observations from 876 to $1,176$. Tangible equity retains the significant negative relationship previously detailed, while NCT1 capital has a strong positive relationship with risk. Tier 1 capital has a positive but insignificant relationship with risk. While high quality tangible equity reduces bank risk, aggregation with lower forms of capital results in total regulatory capital having a positive and significant relationship with risk. Expanding the dataset to include banks with size greater than \$10 billion, consistent results are found for tangible equity and NCT1 capital. Moreover, tier 2 capital is shown to have a significant positive relationship with risk when considered in isolation. In summary, these findings point to the importance of high quality tangible capital in reducing risk for large systemically important banks.

[Table 14 about here.]

Previous studies have outlined the potential for divergent behaviour when the risk reducing properties of bank capital are considered for small, medium and large banks (Berger and Bouwman, 2013; Demirgüç-Kunt *et al.*, 2013). In table 15, the relationships between differing forms of capital and risk for banks with total assets less than $25 billion and less than $10 billion are considered. Common with the previously outlined findings for large banks and banks of all sizes, tangible equity is found to have a negative and significant relationship with risk when denominated by tangible assets. Tier 1 capital is also found to have a significant relationship with risk, driven by a negative relationship for both component elements. This finding is in sharp contrast to large banks, where tier 1 capital is not found to be significantly related to risk, and may be partially explained by access to capital. Large banks have the ability to issue instruments considered to be a component of NCT1, such as perpetual preferred stock and trust preferred securities while smaller banks may not have access to the same menu of securities. This means that small banks may not be able to take advantage of regulatory arbitrage in the same way that large banks might be able to. Finally, tier 2 capital, whilst negative, is not found to be significant, in common with previous results outlined.

[Table 15 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.[24] Results, detailed in Table 16, are consistent with those

[24]Given a set of factors, F_t of dimension $N \times T$, PCA decomposes the correlation matrix as:

$$\Sigma_F = A\Lambda A' \tag{2}$$

previously outlined. When all banks are considered, tangible equity to tangible assets is alone associated with reduced risk. Aggregate tier 1 capital and tier 2 capital are not associated with a reduction in risk, whether denominated by tangible assets or risk weighted assets. These results once again highlight the importance of high quality tangible equity in reducing bank risk and the limited association between risk weighting of assets and actual risk.

[Table 16 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. In this paper, the relationship between multiple bank capital metrics and risk are considered in detail.

The empirical results described in the paper suggest a number of novel findings. First, unweighted tangible equity is the most consistent form of capital in reducing bank risk. This is in keeping with the push for higher quality capital in the recent Basel III framework. Second, tier 1 capital is inconsistently associated with reduced risk. This finding resonates with the focus by investors on tangibility of capital during the global financial crisis and is found to be a consequence of non-core components of tier 1 capital, consistent with regulatory arbitrage. Next, tier 2 capital is not found to be associated with a reduction in risk for any specification examined. Finally, the association between risk and capital is found to be strongest when examined relative to unweighted assets, as distinct to risk weighted assets. This findings is in keeping with recent evidence highlighting the insufficiencies of asset risk

where Λ is the diagonal matrix of the eigenvalues of the correlation matrix and A is the matrix of the associated orthogonal eigenvector components. The principal components can then be computed as

$$P = A_F^{'} \tag{3}$$

and the associated eigenvalues measure the variance of each principal component. The proportion of variance captured by the j^{th} principal component can be measured as $\mu = \Lambda_j / \sum_m \Lambda_m$, where Λ_j is the j^{th} diagonal element of the matrix Λ.

weighting. Results are shown to be robust for a large variety of specifications, including large banks, for alternative measures of risk, to the level of ex-ante capital held by the institution, amongst others.

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 supportive of the inclusion of the core tier 1 capital ratio as a pillar of the Basel III framework. Moreover, the Basel III framework has outlined plans to limit the use of NCT1 capital, contains instruments such as trust preferred securities, 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 A1. 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
Volatility	41.543	44.379	8,611	21.409	29.432	46.157
Tangible Equity to TA	8.268	4.814	10,714	5.950	7.730	9.600
NCT1 to TA	0.888	1.720	10,714	0.000	0.372	1.749
Tier 1 Capital to TA	9.190	5.118	10,714	7.240	8.719	10.285
Tier 2 Capital to TA	1.217	1.700	10,714	0.737	0.927	1.285
Total Regulatory Capital to TA	10.080	3.861	10,714	8.363	9.866	11.389
Tangible Equity to RWA	11.990	7.038	10,714	8.264	10.717	13.577
NCT1 to RWA	1.238	2.268	10,714	0.000	0.568	2.496
Tier 1 Capital to RWA	13.196	6.268	10,714	10.059	11.992	14.598
Tier 2 Capital to RWA	1.724	1.692	10,714	1.081	1.255	1.955
Total Regulatory Capital to RWA	14.899	6.166	10,714	11.807	13.552	16.094
Cost to Income Ratio	70.910	26.899	10,714	58.128	66.302	75.880
Return on Average Equity	5.359	16.923	10,714	3.898	8.537	12.468
Liquid Assets to Customer ST	13.618	18.117	10,714	3.899	7.105	14.888
Net Interest Income to Total Assets	3.005	1.008	10,714	2.514	3.127	3.614
Total Assets (Natural Logarithm)	21.509	2.255	10,714	20.043	20.920	22.657
Concentration	37.839	17.629	10,394	28.000	32.694	35.406
Capital Stringency	4.656	1.556	10,394	3	5	6
Market Discipline	5.277	0.579	10,714	5	5	6
Activity Restrictions	7.935	1.214	10,394	8	8	9

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.

		(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
Volatility	**(1)**	1.000										
Tangible Equity to Tangible Assets	**(2)**	-0.178***	1.000									
NCT1 to Tangible Assets	**(3)**	0.194***	-0.363***	1.000								
T1 Capital to Tangible Assets	**(4)**	-0.108***	0.905***	-0.024**	1.000							
T2 Capital to Tangible Assets	**(5)**	-0.001	0.004	0.004	0.0209	1.000						
Total Regulatory Capital to Tangible Assets	**(6)**	-0.089***	0.817***	0.024**	0.837***	0.116***	1.000					
Tangible Equity to RW Assets	**(7)**	-0.221***	0.854***	-0.432***	0.726***	-0.098***	0.625***	1.000				
NCT1 to RW Assets	**(8)**	0.187***	-0.376***	0.918***	-0.062***	0.001	-0.029***	-0.414***	1.000			
T1 Capital to RW Assets	**(9)**	-0.170***	0.796***	-0.116***	0.777***	-0.116***	0.680***	0.934***	-0.084***	1.000		
T2 Capital to RW Assets	**(10)**	-0.038***	-0.107***	-0.024**	-0.095***	0.760***	-0.021**	-0.081***	0.034***	-0.091***	1.000	
Total Regulatory Capital to RW Assets	**(11)**	-0.173***	0.762***	-0.107***	0.752***	0.026***	0.684***	0.900***	-0.070***	0.967***	0.094***	1.000

		(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Volatility	**(1)**	1.000									
Cost to Income Ratio	**(2)**	0.325***	1.000								
Return on Equity	**(3)**	-0.475***	-0.537***	1.000							
Liquid Assets To Customer ST	**(4)**	-0.061***	0.137***	-0.033***	1.000						
Net Interest Income to Total Assets	**(5)**	-0.012	-0.127***	0.131***	-0.499***	1.000					
Total Assets (ln)	**(6)**	-0.095***	-0.260***	0.075***	0.330***	-0.527***	1.000				
Concentration	**(7)**	-0.028***	-0.073***	-0.047***	0.460***	-0.476***	0.481***	1.000			
Capital Stringency	**(8)**	0.121***	0.051***	-0.094***	-0.093***	0.027***	0.007	0.037***	1.000		
Market Discipline	**(9)**	-0.079***	-0.014	-0.016*	0.283***	-0.256***	0.315***	0.448***	0.334***	1.000	
Activity Restrictions	**(10)**	0.028**	0.053***	0.041***	-0.397***	0.46***	-0.468***	-0.656***	0.237***	-0.166***	1.000

Table 3: **Individual regressions all banks 2002-2014 - Banking risk and capital adequacy**

Bank risk 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 A1. 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	-6.229**					-5.030*		-1.728					-2.145	
	(-2.17)					(-1.68)		(-1.01)					(-1.09)	
NCT1		-1.422				-4.084			-3.833				-4.518**	
		(-0.39)				(-1.07)			(-1.51)				(-1.96)	
Tier 1 Capital			-5.334		-4.432					-3.086		-1.974		
			(-1.53)		(-1.42)					(-1.43)		(-1.04)		
Tier 2 Capital				0.990	-0.658	-0.927					0.990	-1.389	-1.458	
				(0.26)	(-0.13)	(-0.17)					(0.26)	(-0.43)	(-0.44)	
Total Regulatory Capital							-5.440*							-2.485
							(-1.66)							(-1.16)
Volatility lagged	0.455***	0.555***	0.484***	0.527***	0.489***	0.504***	0.525***	0.456***	0.560***	0.463***	0.527***	0.485***	0.489***	0.467***
	(5.89)	(6.24)	(6.00)	(6.56)	(6.04)	(6.35)	(6.34)	(6.19)	(6.91)	(6.10)	(6.56)	(6.28)	(6.61)	(6.00)
Cost to Income Ratio	0.007**	0.009***	0.009***	0.007**	0.009***	0.008**	0.010***	0.007**	0.010***	0.007**	0.007**	0.007**	0.008**	0.008**
	(2.28)	(2.75)	(2.64)	(2.35)	(2.85)	(2.40)	(3.09)	(2.28)	(2.93)	(2.19)	(2.35)	(2.50)	(2.50)	(2.53)
Return on Average Equity	-0.006**	-0.005**	-0.005*	-0.006**	-0.005*	-0.005	-0.003	-0.007***	-0.004	-0.006**	-0.006**	-0.006**	-0.005**	-0.006**
	(-2.10)	(-2.14)	(-1.69)	(-2.44)	(-1.77)	(-1.61)	(-0.93)	(-2.79)	(-1.62)	(-2.15)	(-2.44)	(-2.24)	(-1.98)	(-2.22)
Liquid Assets to Total Assets	-0.001	0.001	-0.001	0.001	-0.001	0.001	-0.003	-0.002	-0.001	-0.001	0.001	0.000	0.000	-0.001
	(-0.09)	(0.18)	(-0.14)	(0.22)	(-0.14)	(0.11)	(-0.55)	(-0.41)	(-0.09)	(-0.26)	(0.22)	(0.01)	(-0.07)	(-0.26)
Net Interest Income to Total Assets	5.125	1.270	5.078	1.696	3.680	6.276	5.012	0.182	1.920	0.300	1.696	-0.604	1.393	-0.159
	(1.12)	(0.32)	(1.02)	(0.41)	(0.76)	(1.42)	(1.04)	(0.05)	(0.49)	(0.08)	(0.41)	(-0.16)	(0.33)	(-0.04)
Total Assets (ln)	0.003	0.020*	0.011	0.014	0.012	0.019	0.016	0.000	0.026**	0.002	0.014	0.006	0.016	0.007
	(0.23)	(1.92)	(0.90)	(1.48)	(1.00)	(1.43)	(1.52)	(-0.01)	(2.52)	(0.14)	(1.48)	(0.59)	(1.26)	(0.64)
Concentration	0.002**	0.002	0.002	0.001	0.002*	0.002*	0.002	0.002*	0.002*	0.002*	0.001	0.001*	0.002**	0.001
	(2.01)	(1.51)	(1.50)	(1.26)	(1.73)	(1.90)	(1.63)	(1.75)	(1.67)	(1.73)	(1.26)	(1.72)	(2.22)	(1.53)
Capital Stringency	0.006	0.001	0.004	-0.001	0.001	0.004	0.006	0.000	-0.001	-0.003	-0.001	-0.002	-0.003	0.000
	(0.98)	(0.17)	(0.61)	(-0.11)	(0.15)	(0.56)	(0.86)	(0.02)	(-0.08)	(-0.45)	(-0.11)	(-0.33)	(-0.35)	(-0.04)
Market Discipline	-0.005	-0.012	-0.020	0.000	-0.010	-0.016	-0.024	0.006	-0.021	-0.003	0.000	0.007	-0.011	-0.005
	(-0.23)	(-0.58)	(-0.83)	(-0.01)	(-0.44)	(-0.66)	(-1.17)	(0.26)	(-0.94)	(-0.14)	(-0.01)	(0.31)	(-0.47)	(-0.23)
Activity Restrictions	-0.002	0.006	-0.007	0.008	-0.006	-0.010	-0.009	0.008	0.003	-0.002	0.008	0.002	-0.009	0.002
	(-0.13)	(0.41)	(-0.33)	(0.53)	(-0.38)	(-0.66)	(-0.45)	(0.50)	(0.18)	(-0.14)	(0.53)	(0.10)	(-0.51)	(0.14)
Constant	-0.022	-0.613	-0.182	-0.464	-0.246	-0.404	-0.281	0.117	-0.729*	0.265	-0.464	0.036	-0.184	0.104
	(-0.04)	(-1.36)	(-0.29)	(-1.08)	(-0.46)	(-0.68)	(-0.53)	(0.22)	(-1.66)	(0.40)	(-1.08)	(0.06)	(-0.27)	(0.16)
Number Observations	5,930	5,930	5,930	5,930	5,930	5,930	5,855	5,930	5,930	5,930	5,930	5,930	5,930	5,930
Wald Test	2,864.63	2,303.03	1,966.04	2,568.63	2,256.85	2,311.87	2,779.47	2,495.49	2,173.14	2,203.61	2,568.63	2,460.81	2,290.81	2,068.79
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	0.500	0.395	0.436	0.339	0.379	0.452	0.385	0.610	0.538	0.669	0.339	0.501	0.640	0.602
Hansen Test	0.277	0.113	0.236	0.224	0.253	0.245	0.296	0.266	0.155	0.324	0.224	0.234	0.286	0.286

Table 4: **Individual regressions large banks 2002-2014 - Banking risk and capital adequacy**

Bank risk is modelled as a function of a variety of capital adequacy metrics during the period $2002-2014$ for banks with 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:

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

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 A1. 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	-4.731**					-1.168		-1.052					0.074	
	(-2.13)					(-0.32)		(-0.83)					(0.04)	
NCT1		6.607**				4.731			4.241*				3.652	
		(2.03)				(1.46)			(1.88)				(1.49)	
Tier 1 Capital			1.654		1.598					1.173		1.775		
			(0.64)		(0.60)					(0.48)		(1.04)		
Tier 2 Capital				5.121	-0.569	-0.753					2.769	0.297	3.363	
				(0.81)	(-0.11)	(-0.13)					(1.29)	(0.13)	(1.24)	
Total Regulatory Capital							2.687							1.299
							(1.41)							(1.57)
Volatility lagged	0.546***	0.462***	0.525***	0.491***	0.484***	0.448***	0.522***	0.480***	0.495***	0.517***	0.539***	0.538***	0.430***	0.530***
	(8.36)	(6.49)	(7.23)	(7.88)	(6.60)	(5.56)	(9.15)	(7.58)	(6.79)	(7.54)	(8.30)	(10.06)	(6.82)	(9.80)
Cost to Income Ratio	-0.001	-0.002	-0.001	-0.002	-0.001	-0.001	-0.001	-0.002	-0.002	-0.002	-0.002*	-0.001	-0.003	-0.001
	(-0.74)	(-1.61)	(-0.77)	(-1.07)	(-0.65)	(-0.69)	(-0.36)	(-1.25)	(-1.02)	(-0.85)	(-1.66)	(-0.69)	(-1.36)	(-0.47)
Return on Average Equity	-0.002	-0.002	-0.003**	-0.002*	-0.002	-0.001	-0.003**	-0.002	-0.002*	-0.003*	-0.003*	-0.002*	-0.002	-0.003***
	(-1.18)	(-1.50)	(-2.02)	(-1.75)	(-1.36)	(-0.90)	(-2.28)	(-1.44)	(-1.79)	(-1.69)	(-1.86)	(-1.83)	(-1.21)	(-2.60)
Liquid Assets to Total Assets	-0.002	0.000	-0.002	-0.002	-0.002	-0.002	-0.002	-0.001	-0.001	-0.002	-0.002	-0.003*	-0.005	-0.002
	(-1.44)	(-0.05)	(-1.32)	(-0.92)	(-1.37)	(-1.24)	(-1.22)	(-0.46)	(-0.75)	(-1.27)	(-0.86)	(-1.79)	(-1.54)	(-1.00)
Net Interest Income to Total Assets	-3.509	-7.083	-6.785	-7.942	-8.183*	-5.637	-6.007	-5.577	-6.018	-8.848*	-5.408	-5.367	-5.935	-6.888
	(-0.74)	(-1.61)	(-1.43)	(-1.60)	(-1.77)	(-1.00)	(-1.32)	(-1.30)	(-1.22)	(-1.91)	(-1.04)	(-1.25)	(-1.26)	(-1.41)
Total Assets (ln)	-0.001	0.011	0.017	0.021*	0.016	0.006	0.007	0.003	0.011	0.019	0.014	0.014	0.004	0.006
	(-0.07)	(0.71)	(1.04)	(1.66)	(0.96)	(0.37)	(0.52)	(0.22)	(0.82)	(1.21)	(0.93)	(0.84)	(0.24)	(0.42)
Concentration	0.001	0.001	0.001	0.000	0.000	0.000	0.000	0.001	0.001	0.001	0.000	0.000	0.001	0.000
	(1.13)	(0.49)	(1.06)	(0.34)	(0.32)	(0.29)	(0.46)	(1.00)	(1.10)	(0.86)	(0.42)	(0.50)	(0.82)	(0.02)
Capital Stringency	-0.002	-0.009	-0.007	-0.006	-0.009	-0.009	-0.006	-0.009	-0.004	-0.005	-0.004	-0.006	-0.004	-0.002
	(-0.40)	(-1.16)	(-1.01)	(-0.77)	(-1.01)	(-1.2)	(-0.87)	(-1.08)	(-0.56)	(-0.69)	(-0.55)	(-0.71)	(-0.72)	(-0.22)
Market Discipline	-0.008	0.006	-0.009	-0.015	-0.012	-0.001	-0.005	0.001	-0.004	-0.007	-0.019	-0.008	-0.001	-0.015
	(-0.62)	(0.36)	(-0.79)	(-0.99)	(-1.03)	(-0.07)	(-0.34)	(0.07)	(-0.23)	(-0.56)	(-1.14)	(-0.65)	(-0.06)	(-0.99)
Activity Restrictions	-0.017	-0.001	-0.010	-0.018	-0.015	-0.006	-0.013	-0.018	-0.009	-0.011	-0.018	-0.011	-0.021	-0.021
	(-1.22)	(-0.03)	(-0.62)	(-1.02)	(-1.04)	(-0.38)	(-1.04)	(-1.03)	(-0.63)	(-0.70)	(-0.98)	(-0.57)	(-1.29)	(-1.40)
Constant	0.432	-0.077	-0.114	-0.248	0.078	0.123	0.178	0.682	-0.151	-0.064	0.027	-0.109	0.552	0.330
	(0.93)	(-0.13)	(-0.19)	(-0.45)	(0.14)	(0.19)	(0.40)	(1.25)	(-0.33)	(-0.11)	(0.05)	(-0.20)	(1.03)	(0.68)
Number Observations	876	876	876	876	876	876	876	876	876	876	876	876	876	876
Wald Test	6,502.12	3,980.14	2,646.77	5,772.24	2,696.72	10,323.97	4,342.95	14,441.58	3,353.21	2,832.53	13,217.97	2,447.61	6,189.9	3,781.64
AR1	0.007	0.007	0.006	0.009	0.008	0.007	0.007	0.011	0.002	0.008	0.008	0.002	0.004	0.005
AR2	0.861	0.554	0.83	0.847	0.835	0.646	0.754	0.793	0.565	0.857	0.985	0.927	0.921	0.877
Hansen Test	0.289	0.108	0.132	0.084	0.116	0.125	0.089	0.119	0.115	0.253	0.117	0.103	0.129	0.20

Table 5: **Individual regressions all banks during high volatility period (2007-2010) - Banking risk and capital adequacy**

Bank risk is modelled as a function of a variety of capital adequacy metrics during the period $2007 - 2010$. 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 A1. 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	-3.84**					-4.023**		-3.006***					-2.406**	
	(-2.03)					(-2.38)		(-2.90)					(-2.27)	
NCT1		-5.74**				-9.055***			-5.336**				-7.288***	
		(-2.01)				(-3.90)			(-2.57)				(-3.74)	
Tier 1 Capital			-4.783**		-4.594**					-3.401**		-2.409		
			(-1.97)		(-2.14)					(-2.43)		(-1.55)		
Tier 2 Capital				0.948	1.154	0.868					1.600	1.053	1.238	
				(0.29)	(0.39)	(0.40)					(0.72)	(0.45)	(0.57)	
Total Regulatory Capital							-3.879**							-3.502**
							(-2.14)							(-2.29)
Volatility lagged	0.489***	0.514***	0.473***	0.489***	0.451***	0.468***	0.474***	0.486***	0.489***	0.452***	0.49***	0.462***	0.467***	0.452***
	(4.31)	(4.46)	(3.92)	(4.15)	(4.19)	(4.72)	(3.99)	(4.42)	(4.07)	(4.17)	(3.92)	(4.07)	(4.55)	(3.99)
Cost to Income Ratio	0.008	0.010	0.012*	0.011	0.010*	0.005	0.01	0.007	0.008	0.008	0.010	0.008	0.005	0.009*
	(1.52)	(1.21)	(1.84)	(1.48)	(1.77)	(1.18)	(1.53)	(1.51)	(1.10)	(1.63)	(1.36)	(1.54)	(1.22)	(1.73)
Return on Average Equity	0.001	0.001	0.004	0.002	0.002	-0.003	0.003	0.002	-0.001	0.002	0.002	0.002	-0.002	0.003
	(0.31)	(0.15)	(0.64)	(0.31)	(0.30)	(-0.65)	(0.48)	(0.55)	(-0.17)	(0.48)	(0.39)	(0.41)	(-0.65)	(0.71)
Liquid Assets to Total Assets	-0.006	-0.006	-0.006	-0.005	-0.007	-0.007	-0.005	-0.007	-0.006	-0.007	-0.004	-0.004	-0.006	-0.006
	(-1.27)	(-1.06)	(-1.26)	(-0.91)	(-1.44)	(-1.57)	(-1.07)	(-1.40)	(-1.13)	(-1.36)	(-0.63)	(-0.84)	(-1.25)	(-1.22)
Net Interest Income to Total Assets	-7.493	-15.125	-7.678	-15.662	-7.730	-13.508**	-20.433**	-12.951	-20.026**	-20.081***	-23.440**	-21.319***	-16.581**	-21.542***
	(-0.79)	(-1.50)	(-0.75)	(-1.50)	(-0.88)	(-2.17)	(-2.43)	(-1.39)	(-2.16)	(-2.74)	(-2.50)	(-2.76)	(-2.32)	(-2.86)
Total Assets (ln)	-0.013	0.030	0.003	0.013	0.000	-0.003	-0.008	-0.023	0.023	-0.017	-0.001	-0.016	0.002	-0.009
	(-0.54)	(0.96)	(0.14)	(0.49)	(0.00)	(-0.15)	(-0.43)	(-0.9)	(0.84)	(-0.92)	(-0.07)	(-0.80)	(0.09)	(-0.48)
Concentration	-0.003	-0.002	-0.004	-0.003	-0.003	-0.003	-0.006	-0.003	-0.004	-0.004	-0.004	-0.003	-0.001	-0.005
	(-0.48)	(-0.45)	(-0.63)	(-0.48)	(-0.50)	(-0.58)	(-1.04)	(-0.45)	(-0.59)	(-0.64)	(-0.68)	(-0.41)	(-0.10)	(-0.74)
Capital Stringency	-0.082	-0.104	-0.121*	-0.089	-0.104*	-0.106**	-0.15**	-0.074*	-0.107	-0.113**	-0.116	-0.109*	-0.089*	-0.133***
	(-1.59)	(-1.62)	(-1.96)	(-1.35)	(-1.72)	(-2.03)	(-2.30)	(-1.73)	(-1.55)	(-2.40)	(-1.60)	(-1.92)	(-1.86)	(-2.60)
Market Discipline	0.012	0.018	0.019	0.023	0.012	0.000	0.017	0.025	0.021	0.038	0.043	0.043	0.021	0.035
	(0.28)	(0.36)	(0.38)	(0.52)	(0.27)	(0.01)	(0.32)	(0.59)	(0.40)	(0.85)	(0.81)	(0.92)	(0.54)	(0.74)
Activity Restrictions	0.010	0.021	0.026	0.020	0.016	0.019	0.047	-0.016	0.016	-0.004	0.041	0.006	-0.016	-0.002
	(0.27)	(0.49)	(0.62)	(0.43)	(0.44)	(0.54)	(1.12)	(-0.44)	(0.35)	(-0.11)	(0.82)	(0.14)	(-0.48)	(-0.05)
Constant	0.938	-0.333	0.535	-0.123	0.646	1.283	1.403	1.428	0.232	1.660	0.337	1.188	0.987	1.657
	(0.76)	(-0.24)	(0.40)	(-0.10)	(0.54)	(1.35)	(1.32)	(1.15)	(0.20)	(1.53)	(0.30)	(1.04)	(1.05)	(1.45)
Number Observations	2,598	2,598	2,598	2,598	2,598	2,598	2,598	2,598	2,598	2,598	2,598	2,598	2,598	2,598
Wald Test	345.51	377.93	314.14	365.69	395.02	440.4	335.23	362.21	392.88	360.55	317.78	391.84	461.16	387.03
AR1	0.002	0.009	0.003	0.004	0.001	0.000	0.002	0.002	0.004	0.001	0.005	0.001	0.000	0.001
AR2	0.739	0.899	0.732	0.825	0.665	0.786	0.907	0.675	0.951	0.651	0.935	0.798	0.769	0.616
Hansen Test	0.235	0.285	0.683	0.345	0.398	0.199	0.327	0.243	0.201	0.343	0.279	0.212	0.144	0.522

Table 6: **Individual regressions all banks - Accounting measures of risk and capital adequacy**

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:

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

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 A1. 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	-27.285					-20.167		-9.398**					-6.264	
	(-1.21)					(-1.06)		(-2.38)					(-1.47)	
NCT1		-0.144				-22.092			-12.941				-8.174	
		(0.00)				(-0.79)			(-1.46)				(-1.18)	
Tier 1 Capital			-24.026		-19.715					-7.475		0.814		
			(-1.04)		(-1.01)					(-1.54)		(0.29)		
Tier 2 Capital				25.997	17.242	9.802					5.660	6.864	12.863	
				(0.60)	(0.42)	(0.24)					(0.49)	(0.62)	(1.36)	
Total Regulatory Capital							-14.55							-7.459
							(-0.75)							(-1.64)
Volatility lagged	0.810***	0.792***	0.833***	0.720***	0.758***	0.770***	0.713***	0.543***	0.523***	0.43**	0.546***	0.525***	0.474***	0.507***
	(5.88)	(5.24)	(6.18)	(6.66)	(8.04)	(8.93)	(6.69)	(3.33)	(3.41)	(2.32)	(3.60)	(3.59)	(4.17)	(3.24)
Cost to Income Ratio	-0.009	-0.0049	-0.0094	-0.0027	-0.0064	-0.0041	-0.0051	0.0098***	0.0108***	0.0116***	0.0108***	0.0115***	0.0096***	0.0105***
	(-1.20)	(-0.63)	(-1.33)	(-0.43)	(-0.93)	(-0.60)	(-0.85)	(7.25)	(7.76)	(7.68)	(7.77)	(7.33)	(7.10)	(8.12)
Return on Average Equity	-0.0288***	-0.0391***	-0.0311***	-0.0399***	-0.0332***	-0.0303***	-0.0368***							
	(-2.84)	(-3.46)	(-2.78)	(-3.57)	(-3.17)	(-3.15)	(-3.43)							
Liquid Assets to Total Assets	0.0142	0.0608	0.0032	0.0361	0.0141	-0.0021	0.0448	0.0053*	0.0055**	0.008***	0.005*	0.0065**	0.0057**	0.0077***
	(0.25)	(0.93)	(0.07)	(0.92)	(0.33)	(-0.05)	(1.03)	(1.90)	(2.16)	(2.93)	(1.96)	(2.49)	(2.40)	(2.92)
Net Interest Income to Total Assets	-177.995	-184.305*	-180.461*	-150.239**	-110.773*	-85.547	-119.915*	3.876	-11.258*	-6.951	3.619	-8.200	-6.979	3.908
	(-1.58)	(-1.83)	(-1.75)	(-2.27)	(-1.71)	(-1.34)	(-1.81)	(0.48)	(-1.92)	(-0.95)	(0.47)	(-1.13)	(-0.82)	(0.50)
Total Assets (ln)	-0.141	-0.066	-0.145	-0.084	-0.092	-0.055	-0.106	-0.012	-0.017	0.003	0.011	0.004	-0.032	0.005
	(-1.46)	(-0.79)	(-1.58)	(-0.87)	(-1.01)	(-0.64)	(-1.32)	(-0.44)	(-0.73)	(0.12)	(0.47)	(0.14)	(-1.38)	(0.19)
Concentration	-0.0034	-0.0078	-0.0014	-0.0117	-0.008	-0.0019	-0.0051	0.0007	-0.0014	-0.0007	0.0002	0.0000	-0.0003	-0.0012
	(-0.25)	(-0.53)	(-0.1)	(-0.92)	(-0.63)	(-0.15)	(-0.38)	(0.41)	(-0.75)	(-0.31)	(0.15)	(0.01)	(-0.18)	(-0.73)
Capital Stringency	-0.0588	-0.0678	-0.0850	-0.0835	-0.0856	-0.0669	-0.008	0.0139	0.0001	0.0065	0.0084	0.0031	-0.0038	0.0132
	(-0.67)	(-0.75)	(-0.93)	(-0.96)	(-0.91)	(-0.73)	(-0.09)	(1.52)	(0.01)	(0.59)	(0.93)	(0.28)	(-0.33)	(1.61)
Market Discipline	0.1815	0.1588	0.1528	0.1172	0.1243	0.0408	0.0316	-0.0489	-0.0441	-0.0507	-0.0486	-0.0336	-0.0473	-0.0521
	(0.77)	(0.71)	(0.63)	(0.62)	(0.57)	(0.21)	(0.16)	(-1.14)	(-1.1)	(-0.93)	(-1.19)	(-0.75)	(-1.12)	(-1.41)
Activity Restrictions	-0.964***	-1.017***	-0.905***	-0.908***	-0.869***	-0.851***	-1.04***	-0.073***	-0.06**	-0.081***	-0.07***	-0.074***	-0.063**	-0.077***
	(-3.84)	(-4.20)	(-3.75)	(-4.70)	(-4.12)	(-4.39)	(-4.64)	(-2.60)	(-2.17)	(-2.99)	(-2.71)	(-2.93)	(-2.58)	(-3.01)
Constant	15.721***	12.595**	15.829***	12.614***	14.302***	12.606***	15.477***	1.013	1.213	0.332	0.141	0.158	1.543	0.423
	(2.73)	(2.55)	(2.83)	(2.79)	(3.07)	(2.84)	(3.24)	(0.93)	(1.33)	(0.33)	(0.13)	(0.14)	(1.6)	(0.42)
Number Observations	6,134	6,134	6,134	6,134	6,134	6,134	6,134	6,437	6,437	6,437	6,437	6,437	6,437	6,359
Wald Test	6,103.61	5,344.7	6,030.91	6,691.45	5,161.69	5,612.07	5,986.54	1,325.95	1,619.95	1,239.89	1,455.93	1,255.17	1,276.05	1,611.25
AR1	0.000	0.001	0.000	0.000	0.000	0.000	0.000	0.001	0.000	0.013	0.000	0.001	0.000	0.001
AR2	0.121	0.235	0.148	0.178	0.132	0.150	0.140	0.930	0.134	0.326	0.678	0.428	0.344	0.166
Hansen Test	0.195	0.236	0.140	0.143	0.168	0.293	0.335	0.316	0.077	0.294	0.212	0.217	0.181	0.560

Table 7: **Individual regressions all banks by level of tangible equity - Banking risk and capital adequacy**

Bank 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:

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

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 A1. 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	-3.968					-5.294		-7.803***					-6.413***	
	(-1.31)					(-0.97)		(-3.01)					(-2.71)	
NCT1		-2.132				-5.501			0.119				0.159	
		(-0.47)				(-1.13)			(0.02)				(0.04)	
Tier 1 Capital			-6.196		-6.048					-7.808***		-6.398**		
			(-1.19)		(-1.28)					(-2.80)		(-2.46)		
Tier 2 Capital				-1.380	-7.362	-9.614					2.086	1.882	3.005	
				(-0.14)	(-0.88)	(-1.35)					(0.62)	(0.53)	(0.85)	
Total Regulatory Capital							-3.225							-8.323***
							(-0.53)							(-3.09)
Volatility Lagged	0.570***	0.588***	0.612***	0.568***	0.588***	0.595***	0.569***	0.563***	0.582***	0.534***	0.609***	0.537***	0.548***	0.547***
	(13.55)	(11.59)	(12.87)	(11.91)	(12.04)	(11.49)	(10.32)	(3.72)	(3.62)	(3.66)	(3.74)	(3.79)	(4.24)	(3.60)
Cost to Income Ratio	0.007**	0.008***	0.008***	0.009***	0.009***	0.007**	0.010***	-0.003*	-0.002	-0.003	-0.003*	-0.003	-0.002	-0.002
	(2.25)	(2.72)	(3.00)	(3.52)	(3.30)	(2.21)	(4.08)	(-1.92)	(-1.37)	(-1.34)	(-1.68)	(-1.44)	(-1.30)	(-1.08)
Return on Average Equity	-0.005*	-0.006**	-0.003	-0.004	-0.002	-0.004	-0.003	-0.013**	-0.019***	-0.014**	-0.015**	-0.013**	-0.014***	-0.013*
	(-1.73)	(-2.36)	(-0.70)	(-1.49)	(-0.63)	(-1.19)	(-0.66)	(-2.08)	(-3.17)	(-2.40)	(-2.56)	(-2.47)	(-2.93)	(-1.94)
Liquid Assets to Customer ST	0.009*	0.007	0.010**	0.008	0.010*	0.010*	0.008**	-0.011	-0.015*	-0.014	-0.007	-0.009	-0.007	-0.009
	(1.76)	(1.35)	(2.03)	(1.35)	(1.89)	(1.91)	(1.97)	(-1.11)	(-1.67)	(-1.44)	(-1.01)	(-1.40)	(-0.89)	(-0.83)
Net Interest Income to Total Assets	2.749	3.641	6.604	2.970	7.484	8.050	4.591	1.442	-7.376	-0.118	-4.744	-0.444	2.068	0.922
	(0.58)	(0.60)	(1.38)	(0.60)	(1.64)	(1.57)	(0.90)	(0.24)	(-1.38)	(-0.02)	(-0.84)	(-0.08)	(0.36)	(0.15)
Total Assets (ln)	0.004	0.014	0.016	0.011	0.016	0.012	0.015	-0.028	-0.012	-0.022	-0.014	-0.029	-0.020	-0.012
	(0.32)	(1.17)	(1.50)	(0.95)	(1.32)	(0.97)	(1.48)	(-1.38)	(-0.68)	(-1.14)	(-0.82)	(-1.55)	(-0.99)	(-0.59)
Concentration	0.002*	0.002	0.002*	0.001	0.001	0.001	0.001	0.005**	0.006**	0.005*	0.004**	0.004**	0.006***	0.005
	(1.93)	(1.46)	(1.93)	(0.83)	(1.11)	(0.80)	(0.93)	(2.19)	(2.29)	(1.71)	(2.36)	(1.97)	(2.79)	(1.54)
Capital Stringency	0.001	-0.002	-0.002	-0.005	-0.005	-0.003	-0.004	0.013	0.004	0.008	0.010	0.012	0.009	0.004
	(0.09)	(-0.23)	(-0.31)	(-0.59)	(-0.64)	(-0.46)	(-0.45)	(0.84)	(0.22)	(0.43)	(0.60)	(0.52)	(0.53)	(0.23)
Market Discipline	0.041	0.034	0.015	0.020	-0.003	0.002	0.009	0.029	-0.014	0.039	-0.030	-0.003	-0.013	0.009
	(0.80)	(0.75)	(0.35)	(0.48)	(-0.08)	(0.04)	(0.18)	(0.44)	(-0.20)	(0.50)	(-0.43)	(-0.04)	(-0.18)	(0.13)
Activity Restrictions	-0.027	-0.023	-0.041*	-0.030	-0.041**	-0.033	-0.039	0.025	0.040	0.014	0.017	-0.001	0.004	0.004
	(-1.33)	(-1.08)	(-1.78)	(-1.38)	(-1.99)	(-1.57)	(-1.47)	(0.65)	(1.10)	(0.36)	(0.45)	(-0.04)	(0.12)	(0.09)
Constant	-0.128	-0.650	-0.488	-0.580	-0.501	-0.317	-0.670	0.878	0.751	0.902	0.849	1.199*	0.825	0.936
	(-0.26)	(-1.33)	(-0.93)	(-1.47)	(-1.03)	(-0.58)	(-1.37)	(1.17)	(1.08)	(1.25)	(1.35)	(1.76)	(1.19)	(1.27)
Number Observations	2,983	2,983	2,983	2,983	2,983	2,983	2,983	2,353	2,353	2,353	2,353	2,353	2,353	2,353
Wald Test	2,003.49	1,008.23	7,67.42	12,050.85	448.92	2,501.8	1,064.9	1,278.44	1,385.36	1,082.1	1,081.35	1,060.32	1,345.13	1,049.57
AR1	0.221	0.185	0.283	0.241	0.330	0.277	0.393	0.155	0.100	0.196	0.125	0.176	0.147	0.175
AR2	0.139	0.091	0.23	0.129	0.241	0.152	0.213	0.461	0.149	0.484	0.241	0.432	0.358	0.385
Hansen Test	0.340	0.183	0.063	0.376	0.111	0.201	0.124	0.476	0.200	0.300	0.108	0.163	0.348	0.326

Table 8: **Individual regressions all banks by level of total regulatory capital - Banking risk and capital adequacy**

Bank 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:

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

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 A1. 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	-2.839					-3.488		-5.789					-6.443**	
	(-1.05)					(-1.13)		(-1.36)					(-2.33)	
NCT1		5.140*				2.098			-13.968***				-10.662***	
		(1.96)				(0.70)			(-2.93)				(-2.60)	
Tier 1 Capital			-1.585		-1.746					-8.033**		-8.151***		
			(-0.49)		(-0.64)					(-2.20)		(-2.71)		
Tier 2 Capital				-4.701	-3.916	-4.099					2.917	5.093	3.150	
				(-0.91)	(-0.90)	(-0.87)					(1.20)	(0.99)	(0.72)	
Total Regulatory Capital							-2.244							-9.678***
							(-0.87)							(-2.62)
Volatility lagged	0.534***	0.557***	0.588***	0.600***	0.557***	0.497***	0.627***	0.572***	0.644***	0.626***	0.613***	0.615***	0.627***	0.586***
	(5.66)	(5.52)	(6.89)	(6.66)	(6.47)	(5.10)	(7.21)	(5.79)	(7.28)	(6.71)	(5.90)	(7.36)	(7.93)	(6.58)
Cost to Income Ratio	0.005**	0.004**	0.005***	0.005**	0.005**	0.004**	0.005***	0.002	0.003	0.004	0.003	0.002	0.003	0.001
	(2.23)	(2.21)	(2.66)	(2.47)	(2.57)	(2.10)	(2.97)	(0.58)	(0.90)	(0.91)	(1.05)	(0.60)	(0.92)	(0.43)
Return on Average Equity	-0.003	-0.004*	-0.003	-0.004	-0.004	-0.003	-0.003	-0.010*	-0.012**	-0.007	-0.010*	-0.008	-0.007	-0.010*
	(-1.31)	(-1.71)	(-1.57)	(-1.57)	(-1.53)	(-1.32)	(-1.27)	(-1.91)	(-2.38)	(-1.54)	(-1.72)	(-1.65)	(-1.77)	(-1.86)
Liquid Assets to Customer ST	0.001	0.002	0.002	0.002	0.003	0.002	0.001	0.001	-0.004	-0.002	0.006	-0.001	0.000	-0.003
	(0.20)	(0.40)	(0.58)	(0.69)	(0.72)	(0.65)	(0.34)	(0.18)	(-0.47)	(-0.21)	(0.99)	(-0.11)	(-0.07)	(-0.34)
Net Interest Income to Total Assets	-2.111	-3.572	-1.907	-2.187	-1.677	-1.286	-1.806	1.987	-0.463	4.982	-2.202	2.413	2.680	6.529
	(-0.49)	(-0.85)	(-0.44)	(-0.54)	(-0.41)	(-0.31)	(-0.41)	(0.29)	(-0.07)	(0.77)	(-0.45)	(0.44)	(0.49)	(0.99)
Total Assets (ln)	0.000	0.004	0.000	0.004	-0.002	-0.006	0.004	-0.009	0.012	0.001	-0.006	-0.019	-0.010	-0.003
	(0.00)	(0.39)	(-0.02)	(0.35)	(-0.18)	(-0.47)	(0.48)	(-0.41)	(0.43)	(0.05)	(-0.37)	(-0.90)	(-0.51)	(-0.12)
Concentration	0.004*	0.003	0.005*	0.004*	0.005**	0.005**	0.003	0.000	0.004	0.001	0.003	0.001	0.000	-0.001
	(1.73)	(1.36)	(1.87)	(1.68)	(2.05)	(2.16)	(1.27)	(0.13)	(0.96)	(0.26)	(1.09)	(0.17)	(-0.02)	(-0.14)
Capital Stringency	-0.002	-0.002	-0.003	-0.008	-0.005	-0.002	-0.004	0.013	0.008	0.013	0.005	0.002	0.005	0.019
	(-0.21)	(-0.16)	(-0.34)	(-0.83)	(-0.53)	(-0.23)	(-0.40)	(0.94)	(0.75)	(0.84)	(0.55)	(0.13)	(0.38)	(1.37)
Market Discipline	-0.018	-0.009	-0.023	-0.020	-0.026	-0.022	-0.022	0.054	0.208	0.054	0.080	0.025	0.015	0.007
	(-0.87)	(-0.46)	(-0.99)	(-1.00)	(-1.12)	(-1.01)	(-1.02)	(0.70)	(1.37)	(0.42)	(0.88)	(0.37)	(0.22)	(0.06)
Activity Restrictions	-0.013	-0.004	-0.003	-0.001	-0.005	-0.008	-0.007	-0.078	-0.119	-0.074	-0.091	-0.075	-0.069	-0.090
	(-0.53)	(-0.20)	(-0.11)	(-0.06)	(-0.19)	(-0.35)	(-0.30)	(-1.43)	(-1.31)	(-1.47)	(-1.45)	(-1.12)	(-1.22)	(-1.42)
Constant	-0.048	-0.201	-0.157	-0.324	-0.097	0.094	-0.151	1.013	-0.396	0.647	0.345	1.22	1.026	1.251
	(-0.09)	(-0.44)	(-0.31)	(-0.64)	(-0.19)	(0.17)	(-0.32)	(0.89)	(-0.34)	(0.44)	(0.49)	(1.30)	(1.26)	(1.07)
Number Observations	2,773	2,773	2,773	2,773	2,773	2,773	2,734	2,563	2,563	2,563	2,563	2,563	2,563	2,534
Wald Test	1,453.51	24,517.02	4,296.95	25,161.25	1,042.74	6,532.24	83,080.85	8,279.45	1,401.36	2,152.94	244.18	5,326.05	1,484.23	1,777.85
AR1	0.414	0.660	0.410	0.619	0.371	0.348	0.682	0.417	0.385	0.443	0.319	0.465	0.459	0.494
AR2	0.066	0.057	0.074	0.062	0.069	0.040	0.149	0.934	0.965	0.756	0.798	0.868	0.908	0.889
Hansen Test	0.260	0.315	0.231	0.532	0.418	0.485	0.147	0.124	0.126	0.10	0.045	0.099	0.166	0.113

Table 9: **Individual regressions all banks 2002-2014 - Banking risk and changes in capital adequacy**

Bank risk 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 capital denominator. The estimated model is:

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

where $\sigma_{i,j,t}$, total bank risk, is measured as the standard deviation of daily bank returns at time t, $\Delta C_{i,j,t-1}$ is the change in bank capital from $t-2$ to $t-1$, $d_{j,t}$ 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 A1. 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							**Risk Weighted Assets**						
	(i)	(ii)	(iii)	(iv)	(v)	(vi)	(vii)	(viii)	(ix)	(x)	(xi)	(xii)	(xiii)	(xiv)
Δ Tangible Equity	-5.427*					-6.321*		1.428					-0.659	
	(-1.73)					(-1.94)		(0.47)					(-0.21)	
Δ NCT1		-1.435			-4.819	-4.564			-0.009			1.109	-0.143	
		(-0.23)			(-1.26)	(-0.69)			(0.00)			(0.28)	(-0.04)	
Δ Tier 1 Capital			-5.878							0.572				
			(-1.52)							(0.15)				
Δ Tier 2 Capital				-7.108	-0.667	0.629					3.611	6.800	7.484	
				(-0.96)	(-0.10)	(0.10)					(0.55)	(1.06)	(1.26)	
Δ Total Regulatory Capital							-6.003*							2.377
							(-1.75)							(0.61)
Volatility lagged	0.449***	0.464***	0.442***	0.440***	0.438***	0.437***	0.442***	0.451***	0.474***	0.446***	0.478***	0.463***	0.458***	0.447***
	(5.55)	(5.60)	(5.27)	(4.88)	(5.17)	(5.28)	(5.38)	(5.03)	(5.74)	(5.34)	(5.25)	(5.24)	(5.15)	(5.21)
Cost to Income Ratio	0.012	0.011	0.012	0.013	0.012	0.011	0.011	0.012	0.012	0.012	0.012	0.012	0.012*	0.012
	(1.58)	(1.42)	(1.62)	(1.57)	(1.63)	(1.57)	(1.43)	(1.59)	(1.51)	(1.63)	(1.55)	(1.64)	(1.67)	(1.62)
Return on Average Equity	-0.009*	-0.010*	-0.008*	-0.009	-0.008*	-0.008*	-0.008	-0.011**	-0.009*	-0.010**	-0.008	-0.009**	-0.008*	-0.011***
	(-1.67)	(-1.85)	(-1.70)	(-1.62)	(-1.79)	(-1.68)	(-1.63)	(-2.23)	(-1.74)	(-2.27)	(-1.44)	(-1.99)	(-1.79)	(-2.62)
Liquid Assets to Total Assets	-0.0077	-0.0008	-0.0091	0.003	-0.0045	-0.0038	-0.0036	-0.0048	-0.0036	-0.0049	0.0002	-0.0032	-0.0026	-0.0068
	(-0.79)	(-0.09)	(-0.98)	(0.31)	(-0.55)	(-0.54)	(-0.41)	(-0.4)	(-0.37)	(-0.43)	(0.02)	(-0.31)	(-0.28)	(-0.61)
Net Interest Income to Total Assets	-0.761	-9.215	-5.300	-8.090	-8.370	-11.441	-11.67	-3.445	-3.079	-5.095	-4.714	-8.29	-10.345	-3.532
	(-0.07)	(-0.91)	(-0.52)	(-0.75)	(-0.76)	(-1.04)	(-1.08)	(-0.34)	(-0.30)	(-0.52)	(-0.47)	(-0.82)	(-1.02)	(-0.36)
Total Assets (ln)	0.029	0.011	0.024	0.014	0.017	0.012	0.009	0.024	0.022	0.023	0.022	0.019	0.017	0.025
	(1.29)	(0.42)	(1.07)	(0.62)	(0.85)	(0.55)	(0.38)	(1.06)	(0.82)	(0.96)	(0.94)	(0.83)	(0.75)	(1.06)
Concentration	0.002	0.001	0.001	-0.001	0.000	0.000	0.001	0.001	0.001	0.001	0.000	0.000	0.001	0.001
	(1.46)	(0.58)	(0.86)	(-0.40)	(0.29)	(0.10)	(0.62)	(0.85)	(1.05)	(0.73)	(0.09)	(0.06)	(0.43)	(0.62)
Capital Stringency	0.011	0.004	0.005	0.013	0.006	0.004	0.003	0.012	0.008	0.008	0.007	0.007	0.007	0.011
	(1.30)	(0.36)	(0.54)	(1.26)	(0.63)	(0.34)	(0.40)	(1.35)	(0.83)	(0.90)	(0.77)	(0.69)	(0.61)	(1.11)
Market Discipline	-0.074*	-0.078*	-0.074*	-0.065	-0.066	-0.069*	-0.069*	-0.049	-0.076*	-0.055	-0.057	-0.040	-0.038	-0.057
	(-1.87)	(-1.82)	(-1.90)	(-1.40)	(-1.64)	(-1.75)	(-1.73)	(-1.15)	(-1.86)	(-1.35)	(-1.33)	(-0.93)	(-0.92)	(-1.39)
Activity Restrictions	0.004	-0.009	0.006	-0.017	0.002	-0.002	0.001	0.002	-0.007	-0.006	-0.003	-0.002	-0.006	-0.006
	(0.17)	(-0.38)	(0.27)	(-0.66)	(0.10)	(-0.08)	(0.04)	(0.08)	(-0.31)	(-0.26)	(-0.11)	(-0.10)	(-0.23)	(-0.26)
Constant	-0.985	-0.278	-0.632	-0.440	-0.421	-0.084	-0.177	-0.970	-0.797	-0.730	-0.815	-0.646	-0.574	-0.849
	(-1.16)	(-0.29)	(-0.73)	(-0.52)	(-0.54)	(-0.10)	(-0.19)	(-1.11)	(-0.84)	(-0.81)	(-0.94)	(-0.74)	(-0.67)	(-0.96)
Number Observations	5,090	5,090	5,090	5,090	5,090	5,090	5,090	5,090	5,090	5,090	5,090	5,090	5,090	5,090
Wald Test	1,209.01	1,162.60	1,165.86	1,185.59	1,285.71	1,274.47	1,127.08	1,173.05	1,162.15	1,136.39	1,294.09	1,220.35	1,185.43	1,129.84
AR1	0.050	0.102	0.036	0.078	0.036	0.035	0.037	0.038	0.1	0.076	0.079	0.073	0.041	0.055
AR2	0.385	0.538	0.361	0.383	0.412	0.483	0.409	0.711	0.494	0.829	0.514	0.989	0.826	0.95
Hansen Test	0.106	0.145	0.324	0.241	0.298	0.513	0.205	0.333	0.149	0.397	0.264	0.552	0.579	0.451

Table 10: **Individual regressions pre- and post-Basel II - Banking risk and capital adequacy**

Bank 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:

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

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 A1. 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													
	Tangible Assets							**Risk Weighted Assets**						
	(i)	**(ii)**	**(iii)**	**(iv)**	**(v)**	**(vi)**	**(vii)**	**(viii)**	**(ix)**	**(x)**	**(xi)**	**(xii)**	**(xiii)**	**(xiv)**
Tangible Equity	-9.360**					-7.145**		-2.413					-2.300	
	(-2.45)					(-2.18)		(-1.04)					(-1.19)	
NCT1		-0.793			-5.854**	-4.834			-0.233			-1.697	-1.694	
		(-0.26)			(-2.04)	(-1.55)			(-0.10)			(-1.16)	(-0.77)	
Tier 1 Capital			-4.048							-1.068				
			(-1.33)							(-0.80)				
Tier 2 Capital				1.535	1.147	3.089					1.535	-1.100	-1.187	
				(0.37)	(0.32)	(0.88)					(0.37)	(-0.20)	(-0.23)	
Total Regulatory Capital							-4.151							-1.272
							(-1.27)							(-1.02)
Number Observations	2,892	2,892	2,892	2,892	2,892	2,892	2,892	2,892	2,892	2,892	2,892	2,892	2,892	2,892
Wald Test	2,516.80	3,214.53	3,093.15	2,940.45	2,545.31	2,466.10	2,615.09	2,310.15	3,216.87	2,912.41	2,940.45	2,813.23	2,671.90	2,615.09
AR1	0.001	0.001	0.002	0.001	0.001	0.001	0.003	0.002	0.001	0.001	0.001	0.001	0.002	0.003
AR2	0.930	0.100	0.688	0.231	0.904	0.998	0.495	0.457	0.185	0.146	0.231	0.230	0.232	0.495
Hansen Test	0.991	0.790	0.859	0.619	0.860	0.880	0.878	0.909	0.647	0.822	0.619	0.680	0.592	0.878

	Post Basel II 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	-0.610					2.050		-0.034					1.314	
	(-0.33)					(0.95)		(-0.02)					(1.17)	
Tier 1 Non-Tangible Capital		5.935*			1.147	4.808*			0.387			1.430	2.133	
		(1.73)			(0.50)	(1.70)			(0.23)			(1.28)	(1.23)	
Tier 1 Capital			1.047							0.941				
			(0.38)							(0.83)				
Tier 2 Capital				1.996	0.178	-0.460					-1.042	-0.796	-2.669	
				(0.81)	(0.05)	(-0.11)					(-0.69)	(-0.48)	(-1.64)	
Total Regulatory Capital							-0.223							0.658
							(-0.09)							(0.75)
Number Observations	786	786	786	786	786	786	786	786	786	786	786	786	786	786
Wald Test	846.9	921.29	721.85	735.05	794.38	1018.33	735.75	626.29	705.93	602.94	709.76	779.01	1001.76	838.5
AR1	0.026	0.025	0.022	0.019	0.023	0.020	0.037	0.028	0.037	0.028	0.022	0.025	0.017	0.024
AR2	0.334	0.382	0.280	0.233	0.261	0.217	0.296	0.373	0.344	0.322	0.281	0.325	0.319	0.246
Hansen Test	0.252	0.456	0.092	0.130	0.153	0.523	0.049	0.157	0.078	0.083	0.161	0.151	0.279	0.069

	Post Basel II US Banks													
	Tangible Assets							**Risk Weighted Assets**						
	(i)	**(ii)**	**(iii)**	**(iv)**	**(v)**	**(vi)**	**(vii)**	**(viii)**	**(ix)**	**(x)**	**(xi)**	**(xii)**	**(xiii)**	**(xiv)**
Tangible Equity	-19.803*					-12.372		-6.21					-6.626	
	(-1.83)					(-1.34)		(-1.27)					(-1.33)	
Tier 1 Non-Tangible Capital		-5.938			-10.611	-8.345			-8.828			-6.143*	-9.524**	
		(-0.68)			(-1.31)	(-0.96)			(-1.57)			(-1.85)	(-2.40)	
Tier 1 Capital			-13.074							-6.391*				
			(-1.45)							(-1.88)				
Tier 2 Capital				-17.400	-6.664	-9.042					-11.368	-7.247	-5.101	
				(-0.87)	(-0.38)	(-0.61)					(-0.57)	(-0.51)	(-0.45)	
Total Regulatory Capital							-13.522							-7.612**
							(-1.44)							(-2.03)
Number Observations	2,246	2,246	2,246	2,246	2,246	2,246	2,246	2,246	2,246	2,246	2,246	2,246	2,246	2,246
Wald Test	220	321.92	316.71	293.38	384.67	380.29	285.61	285.08	328.6	360.69	302.76	407.83	396.45	326.3
AR1	0.002	0.002	0.001	0.003	0.003	0.001	0.002	0.001	0.004	0.001	0.008	0.002	0.002	0.001
AR2	0.443	0.326	0.275	0.416	0.222	0.230	0.247	0.301	0.398	0.218	0.536	0.301	0.324	0.253
Hansen Test	0.23	0.543	0.093	0.278	0.154	0.269	0.18	0.228	0.452	0.236	0.217	0.233	0.191	0.366

Table 11: **2SLS Instrumental variable regressions all banks 2002-2014 - Banking risk and capital adequacy**

Bank 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:

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

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 A1. 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.

	(i)	(ii)	(iii)	(iv)	(v)	(vi)	(vii)	(viii)	(ix)	(x)
Tangible Equity	-11.967***					-4.538**				
	(-6.93)					(2.01)				
NCT1		-0.227					11.285***			
		(-0.19)					(2.66)			
Tier 1 Capital			-14.84***					2.521		
			(-6.56)					(0.72)		
Tier 2 Capital				-0.928					3.093	
				(-0.30)					(0.52)	
Total Regulatory Capital					-14.122***					2.687
					(-5.93)					(1.12)
Cost to Income Ratio	0.002***	0.001***	-0.001	0.001***	-0.0003	-0.0002	-0.0003	0.0000	0.0000	0.0000
	(3.37)	(2.67)	(-1.49)	(2.76)	(-0.65)	(-0.40)	(-0.53)	(0.04)	(-0.08)	(-0.08)
Return on Average Equity	-0.007***	-0.011***	-0.008***	-0.011***	-0.009***	-0.001	-0.001*	-0.002***	-0.002***	-0.002***
	(-9.66)	(-23.49)	(-10.14)	(-22.68)	(-12.60)	(-0.90)	(-1.72)	(-2.72)	(-3.20)	(-3.55)
Liquid Assets to Total Assets	0.005***	0.002***	0.004***	0.002***	0.003***	-0.0001	-0.0001	-0.001	-0.0007	-0.0009
	(6.5)	(2.97)	(5.49)	(2.85)	(4.46)	(-0.02)	(-0.13)	(-1.46)	(-1.19)	(-1.49)
Net Interest Income to Total Assets	8.971***	3.260***	11.943***	3.088***	13.479***	-1.624	-0.697	-4.146	-3.689	-5.358*
	(4.29)	(3.21)	(4.62)	(2.63)	(4.41)	(-0.56)	(-0.36)	(-1.40)	(-1.24)	(-1.68)
Total Assets (ln)	-0.082***	-0.017***	-0.061***	-0.016**	-0.038***	0.0068	0.0205**	0.0321	0.0223*	0.0356*
	(-7.96)	(-3.43)	(-7.61)	(-2.41)	(-6.58)	(0.38)	(2.07)	(1.45)	(1.69)	(1.89)
Concentration	0.004**	0.003*	0.004**	0.003*	0.004**	-0.025	-0.011	-0.007	-0.007	-0.008
	(2.02)	(1.96)	(2.04)	(1.95)	(2.23)	(-1.04)	(-1.49)	(-0.89)	(-0.89)	(-1.03)
Capital Stringency	0.011	0.016**	0.009	0.017**	0.023**	-0.060***	0.028	-0.033*	-0.035*	-0.030
	(1.30)	(2.00)	(1.05)	(1.99)	(2.48)	(-3.38)	(0.93)	(-1.71)	(-1.84)	(-1.54)
Market Discipline	-0.051**	-0.074***	-0.092***	-0.074***	-0.103***	0.002	0.003*	0.003**	0.003*	0.003**
	(-2.08)	(-3.36)	(-3.70)	(-3.37)	(-3.98)	(1.28)	(1.70)	(1.99)	(1.86)	(1.97)
Activity Restrictions	-0.077***	-0.062***	-0.092***	-0.061***	-0.071***	-0.1103***	-0.033	-0.068***	-0.071***	-0.066***
	(-4.13)	(-3.68)	(-4.68)	(-3.54)	(-3.61)	(-2.25)	(-1.51)	(-3.87)	(-4.22)	(-3.76)
Constant	-0.029	0.046	-0.073*	0.050	-0.016	-0.055	-0.481***	0.083*	0.052	0.072*
	(-0.74)	(1.36)	(-1.72)	(1.39)	(-0.38)	(-1.46)	(-4.50)	(1.79)	(1.09)	(1.80)
Number Observations	4,170	4,170	4,170	4,170	4,170	661	661	661	661	661
Adjusted R^2	0.212	0.250	0.167	0.249	0.119	0.439	0.478	0.453	0.458	0.450
Anderson Canonical Correlation	104.148	527.911	86.655	290.046	71.306	29.980	24.232	19.212	33.176	28.695
(p-value)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
Cragg-Donald Wald F-statistic	52.947	299.606	43.865	154.518	35.96	14.871	11.892	9.355	16.514	14.182
Sargan Statistic	0.069	1.085	1.075	0.570	0.717	0.043	1.702	0.742	0.018	0.129
(p-value)	(0.79)	(0.30)	(0.30)	(0.45)	(0.40)	(0.84)	(0.19)	(0.39)	(0.89)	(0.72)

Table 12: **Individual regressions all banks 2002-2014 - Systematic / Idiosyncratic Risk and capital adequacy**

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 A1. 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	-10.583**					-8.103		-4.155					-4.336	
	(-2.05)					(-1.56)		(-1.22)					(-1.25)	
NCT1		-5.505				1.466			-4.133				-5.119	
		(-0.81)				(0.16)			(-1.14)				(-1.21)	
Tier 1 Capital			-11.502***		-10.23**					-4.196		-3.874		
			(-3.25)		(-2.46)					(-1.16)		(-1.19)		
Tier 2 Capital				-10.255	-9.750	-11.559					2.507	2.594	1.989	
				(-1.00)	(-1.31)	(-1.27)					(0.90)	(0.53)	(0.35)	
Total Regulatory Capital							-10.891***							-4.33
							(-2.74)							(-1.44)
Volatility lagged	0.883**	1.211***	0.654**	0.911**	0.496*	0.794***	0.75**	0.471***	0.565***	0.49***	0.53***	0.499***	0.516***	0.515***
	(2.58)	(3.91)	(2.53)	(2.4)	(1.91)	(3.05)	(2.37)	(5.74)	(6.25)	(5.94)	(6.48)	(6.04)	(6.26)	(5.91)
Cost to Income Ratio	0.001	0.000	0.001	0 .000	0.001*	0.001	0.001	0.007**	0.009***	0.009***	0.008**	0.008***	0.008**	0.009***
	(0.89)	(-0.11)	(1.55)	(0.08)	(1.66)	(0.93)	(1.32)	(2.12)	(2.73)	(2.7)	(2.46)	(2.64)	(2.23)	(3.02)
Return on Average Equity	0.005**	0.001	0.005***	0.001	0.004**	0.004	0.005***	-0.004	-0.004	-0.003	-0.004	-0.003	-0.003	-0.002
	(2.40)	(0.70)	(3.43)	(0.55)	(2.32)	(1.61)	(3.10)	(-1.61)	(-1.51)	(-1.14)	(-1.54)	(-1.09)	(-1.16)	(-0.72)
Liquid Assets to Total Assets	-0.017	-0.010	-0.013	-0.008	-0.014	-0.014	-0.020	0.003	0.003	0.002	0.003	0	0.001	0
	(-1.14)	(-0.95)	(-1.20)	(-0.73)	(-1.39)	(-1.23)	(-1.47)	(0.50)	(0.61)	(0.39)	(0.46)	(0.02)	(0.12)	(0.04)
Net Interest Income to Total Assets	8.209	-2.310	12.965**	-2.022	11.372*	5.418	9.765*	4.765	0.202	3.982	2.185	3.23	5.735	3.229
	(1.26)	(-0.55)	(2.39)	(-0.47)	(1.82)	(0.80)	(1.68)	(1.06)	(0.05)	(0.77)	(0.53)	(0.67)	(1.23)	(0.69)
Total Assets (ln)	0.071	0.072	0.078	0.102*	0.103*	0.090	0.031	0.013	0.021**	0.016	0.016	0.014	0.021*	0.017*
	(1.23)	(1.31)	(1.57)	(1.84)	(1.93)	(1.64)	(0.66)	(0.95)	(1.97)	(1.51)	(1.64)	(1.29)	(1.82)	(1.70)
Concentration	0.003**	0.001	0.003***	0.002	0.003**	0.002	0.004**	0.001	0.001	0.001	0.001	0.001	0.001	0.001
	(2.09)	(0.82)	(2.68)	(1.21)	(2.26)	(1.14)	(2.42)	(1.01)	(0.86)	(0.77)	(0.47)	(0.88)	(1.24)	(0.99)
Capital Stringency	-0.002	-0.004	-0.007	0.002	-0.005	-0.004	-0.010	0.003	-0.001	0.000	-0.003	-0.003	-0.001	0.001
	(-0.37)	(-0.81)	(-1.18)	(0.23)	(-0.66)	(-0.54)	(-1.61)	(0.46)	(-0.1)	(0.06)	(-0.42)	(-0.44)	(-0.12)	(0.16)
Market Discipline	-0.042*	-0.029	-0.050**	-0.029	-0.056***	-0.033	-0.044*	-0.004	-0.013	-0.005	0	-0.001	-0.011	-0.021
	(-1.83)	(-1.50)	(-2.53)	(-1.53)	(-2.69)	(-1.57)	(-1.95)	(-0.19)	(-0.57)	(-0.24)	(0.00)	(-0.04)	(-0.46)	(-1.04)
Activity Restrictions	-0.061**	-0.060***	-0.065***	-0.064***	-0.075***	-0.061**	-0.041*	-0.011	-0.014	-0.014	-0.010	-0.013	-0.017	-0.016
	(-2.49)	(-2.81)	(-3.03)	(-2.78)	(-3.32)	(-2.58)	(-1.87)	(-0.69)	(-0.82)	(-0.72)	(-0.6)	(-0.77)	(-0.96)	(-0.85)
Constant	-1.027	-0.703	-1.073	-1.347	-1.390	-1.168	-0.076	-0.379	-0.598	-0.419	-0.55	-0.365	-0.479	-0.273
	(-0.87)	(-0.70)	(-1.02)	(-1.34)	(-1.25)	(-1.08)	(-0.08)	(-0.68)	(-1.26)	(-0.76)	(-1.25)	(-0.74)	(-0.81)	(-0.56)
Number Observations	5,723	5,723	5,723	5,723	5,723	5,723	5,723	5,798	5,798	5,798	5,798	5,798	5,798	5,798
Wald Test	4,006.68	8,397.56	3,460.43	5,429.97	2,789.43	2,869.04	9,561.93	4,331.21	2,588.08	2,480.68	4,626.05	2,704.98	2,643.84	2,627.88
AR1	0.018	0.004	0.015	0.048	0.027	0.007	0.038	0.000	0.000	0.000	0.000	0.000	0.000	0.000
AR2	0.257	0.133	0.509	0.206	0.753	0.232	0.743	0.443	0.348	0.407	0.294	0.359	0.419	0.342
Hansen Test	0.916	0.677	0.557	0.461	0.412	0.508	0.619	0.332	0.299	0.411	0.387	0.454	0.368	0.491

Table 13: **Individual regressions all banks 2002-2014 - Banking risk (Monthly Equity Returns) and capital adequacy**

Bank risk is modelled as a function of a variety of capital adequacy metrics during the period 2002 − 2014. Specifications (i)-(vii) looks at banks of all sizes, while specifications (viii)-(xiv) examine large banks with total assets greater than $50 billion. Tangible assets is used as denominator for each capital metric. 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 monthly 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 A1. 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							Large Banks						
	(i)	(ii)	(iii)	(iv)	(v)	(vi)	(vii)	(viii)	(ix)	(x)	(xi)	(xii)	(xiii)	(xiv)
Tangible Equity	-7.082*					-6.107		-3.97**					-0.024	
	(-1.82)					(-1.26)		(-2.13)					(-0.01)	
NCT1		10.262**			-5.636	1.252			6.069**			0.329	6.623**	
		(2.16)			(-1.01)	(0.22)			(2.31)			(0.17)	(2.02)	
Tier 1 Capital			-6.722							-1.435				
			(-1.21)							(-0.67)				
Tier 2 Capital				2.340	1.079	2.937					0.018	-0.750	-2.206	
				(0.40)	(0.17)	(0.41)					(0.00)	(-0.16)	(-0.42)	
Total Regulatory Capital							-2.743							0.045
							(-0.53)							(0.02)
Volatility lagged	0.201**	0.210***	0.251***	0.284***	0.270***	0.247***	0.28***	0.33***	0.286***	0.310***	0.324***	0.285***	0.249***	0.329***
	(2.58)	(2.88)	(3.41)	(3.89)	(3.73)	(3.33)	(3.82)	(5.58)	(5.13)	(5.13)	(5.75)	(4.46)	(3.67)	(6.26)
Cost to Income Ratio	0.011***	0.010**	0.010**	0.013***	0.011**	0.011***	0.013***	-0.001	-0.001	-0.001	-0.001	-0.001	-0.001	0.000
	(2.63)	(2.22)	(2.15)	(2.82)	(2.47)	(2.74)	(2.66)	(-0.59)	(-0.80)	(-0.73)	(-0.59)	(-0.78)	(-0.71)	(-0.12)
Return on Average Equity	-0.002	-0.006	-0.001	-0.001	0.000	-0.001	0.001	-0.001	-0.001	-0.001	-0.001	-0.002	-0.002	-0.001
	(-0.42)	(-1.38)	(-0.17)	(-0.27)	(-0.11)	(-0.36)	(0.12)	(-0.38)	(-0.91)	(-0.61)	(-0.68)	(-1.00)	(-1.07)	(-0.54)
Liquid Assets to Total Assets	-0.015**	-0.013*	-0.015**	-0.014**	-0.014**	-0.011	-0.018**	-0.001	0.000	-0.002	-0.001	-0.003	-0.003	-0.001
	(-2.05)	(-1.82)	(-2.16)	(-2.30)	(-2.25)	(-1.58)	(-2.21)	(-0.62)	(0.27)	(-1.16)	(-0.91)	(-1.29)	(-1.43)	(-0.56)
Net Interest Income to Total Assets	1.031	-5.075	0.378	-2.892	0.519	1.032	-3.581	-0.050	-1.706	-1.321	-0.992	-1.039	0.350	-2.722
	(0.18)	(-1.12)	(0.06)	(-0.59)	(0.08)	(0.16)	(-0.56)	(-0.01)	(-0.39)	(-0.34)	(-0.20)	(-0.23)	(0.07)	(-0.62)
Total Assets (ln)	-0.009	0.008	-0.002	0.016	0.000	-0.005	0.011	0.014	0.011	0.019	0.028**	0.028**	0.022	0.018
	(-0.61)	(0.69)	(-0.12)	(1.24)	(-0.01)	(-0.38)	(0.78)	(0.82)	(0.91)	(1.22)	(2.09)	(1.99)	(1.38)	(0.84)
Concentration	0.002	0.002	0.002	0.001	0.001	0.001	0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	(1.22)	(1.44)	(1.26)	(1.02)	(1.38)	(1.17)	(1.04)	(0.34)	(0.11)	(0.04)	(-0.31)	(0.02)	(0.18)	(-0.17)
Capital Stringency	0.008	0.009	0.009	0.004	0.005	0.004	0.007	-0.002	-0.002	-0.002	-0.004	-0.005	-0.008	-0.006
	(1.02)	(1.13)	(1.15)	(0.50)	(0.57)	(0.44)	(0.78)	(-0.48)	(-0.32)	(-0.35)	(-0.78)	(-0.83)	(-1.30)	(-1.10)
Market Discipline	-0.032	-0.028	-0.038	-0.025	-0.040	-0.034	-0.024	-0.010	0.005	-0.013	-0.015	-0.012	-0.005	-0.012
	(-1.09)	(-0.94)	(-1.26)	(-0.79)	(-1.36)	(-1.11)	(-0.78)	(-0.73)	(0.31)	(-0.84)	(-0.89)	(-0.80)	(-0.36)	(-0.81)
Activity Restrictions	-0.035*	-0.014	-0.042*	-0.033*	-0.045**	-0.039*	-0.033	-0.037**	-0.021	-0.042***	-0.032**	-0.038**	-0.033	-0.034**
	(-1.73)	(-0.67)	(-1.87)	(-1.69)	(-2.07)	(-1.78)	(-1.41)	(-2.12)	(-1.23)	(-2.73)	(-2.42)	(-2.35)	(-1.60)	(-2.49)
Constant	0.821	0.040	0.732	-0.283	0.523	0.581	0.086	0.124	-0.079	0.218	-0.363	-0.019	0.126	-0.024
	(1.23)	(0.07)	(0.90)	(-0.44)	(0.71)	(0.93)	(0.11)	(0.23)	(-0.15)	(0.35)	(-0.69)	(-0.04)	(0.20)	(-0.04)
Number Observations	5,710	5,710	5,710	5,710	5,710	5,710	5,635	871	871	871	871	871	871	820
Wald Test	1,064.60	1,031.54	1,031.34	1,111.96	1,064.32	986.17	1,135.09	9,726.68	1,133.38	3,705.96	2,806.19	3,640.00	1,620.01	1,573.88
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	0.350	0.943	0.180	0.630	0.314	0.566	0.381	0.755	0.957	0.906	0.918	0.989	0.914	0.835
Hansen Test	0.500	0.324	0.231	0.166	0.268	0.521	0.221	0.331	0.108	0.262	0.210	0.196	0.126	0.257

Table 14: **Individual regressions large banks by differing size 2002-2014 - Banking risk and capital adequacy**

Bank risk is modelled as a function of a variety of capital adequacy metrics during the period $2002-2014$ for large banks. Specifications (i)-(vii) consider banks with assets greater than \$25 billion, while specifications (viii)-(xiv) model banks with assets greater than \$10 billion. In each case, tangible assets is used as denominator for capital metrics. 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 A1. 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 > \$25 Billion							**Total Assets > \$10 Billion**						
	(i)	(ii)	(iii)	(iv)	(v)	(vi)	(vii)	(viii)	(ix)	(x)	(xi)	(xii)	(xiii)	(xiv)
Tangible Equity	-3.78*					0.244		-6.57***					-4.607*	
	(-1.69)					(0.12)		(-2.69)					(-1.83)	
NCT1		6.489***				5.347**			6.179**				3.294	
		(2.60)				(2.20)			(2.09)				(1.16)	
Tier 1 Capital			2.58		3.133					-1.238		-1.608		
			(1.37)		(1.46)					(-0.60)		(-0.77)		
Tier 2 Capital				3.013	-0.420	2.055					9.182**	6.907	4.577	
				(0.72)	(-0.10)	(0.53)					(2.14)	(1.38)	(1.08)	
Total Regulatory Capital							2.786*							0.939
							(1.75)							(0.60)
Volatility lagged	0.561***	0.507***	0.560**	0.567***	0.552***	0.507***	0.561***	0.595***	0.568***	0.640***	0.629***	0.636***	0.572***	0.639***
	(7.58)	(5.92)	(8.56)	(7.35)	(6.69)	(5.74)	(8.65)	(8.09)	(7.08)	(8.68)	(8.28)	(8.49)	(7.33)	(9.07)
Cost to Income Ratio	0.001	0.000	0.001	0.000	0.001	0.000	0.001	0.001	0.000	0.001	0.000	0.001	0.001	0.001
	(0.24)	(0.17)	(0.27)	(-0.19)	(0.35)	(0.20)	(0.46)	(0.58)	(-0.03)	(0.55)	(0.19)	(0.47)	(0.41)	(0.58)
Return on Average Equity	-0.004**	-0.004***	-0.005***	-0.004***	-0.005***	-0.004***	-0.005***	-0.005***	-0.006***	-0.006***	-0.006***	-0.005***	-0.005***	-0.006***
	(-2.52)	(-2.73)	(-2.94)	(-3.34)	(-3.07)	(-2.85)	(-3.42)	(-2.69)	(-3.81)	(-3.08)	(-4.07)	(-2.98)	(-3.03)	(-3.69)
Liquid Assets to Total Assets	0.001	0.001	0.000	0.001	0.000	-0.001	0.000	0.004	0.006*	0.004	0.004*	0.003	0.003	0.003
	(0.70)	(0.50)	(-0.13)	(0.48)	(-0.15)	(-0.53)	(-0.20)	(1.55)	(1.95)	(1.42)	(1.65)	(1.26)	(1.25)	(1.42)
Net Interest Income to Total Assets	-13.532*	-18.316*	-16.727**	-19.949**	-19.317**	-17.634**	-17.738**	-22.563***	-37.117***	-28.390***	-29.548***	-27.116***	-27.903***	-30.529***
	(-1.93)	(-1.80)	(-2.11)	(-2.47)	(-2.27)	(-2.33)	(-2.37)	(-2.98)	(-3.61)	(-2.67)	(-2.78)	(-2.67)	(-2.99)	(-3.15)
Total Assets (ln)	-0.013	-0.013	0.009	0.004	0.006	-0.014	0.007	-0.032**	-0.022	-0.014	-0.01	-0.015	-0.031*	-0.012
	(-0.75)	(-1.01)	(0.86)	(0.55)	(0.54)	(-0.95)	(0.84)	(-2.08)	(-1.58)	(-0.85)	(-0.78)	(-1.05)	(-1.96)	(-0.86)
Concentration	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.001	0.000	0.000	0.000	0.001	0.001	0.000
	(0.02)	(-0.16)	(0.00)	(-0.24)	(0.23)	(0.29)	(0.17)	(0.73)	(-0.21)	(0.32)	(0.05)	(0.52)	(0.84)	(-0.02)
Capital Stringency	-0.002	-0.004	-0.002	-0.002	-0.003	-0.004	-0.001	-0.003	-0.003	-0.002	-0.004	-0.003	-0.005	-0.003
	(-0.40)	(-0.64)	(-0.25)	(-0.41)	(-0.52)	(-0.65)	(-0.13)	(-0.56)	(-0.63)	(-0.46)	(-0.66)	(-0.59)	(-0.92)	(-0.56)
Market Discipline	-0.006	0.003	-0.01	-0.009	-0.011	-0.001	-0.007	0.001	0.010	-0.003	0.001	-0.001	0.007	-0.004
	(-0.44)	(0.17)	(-0.83)	(-0.70)	(-0.92)	(-0.07)	(-0.46)	(0.04)	(0.56)	(-0.22)	(0.08)	(-0.08)	(0.39)	(-0.24)
Activity Restrictions	-0.017	-0.003	-0.017	-0.023*	-0.013	-0.005	-0.016	-0.017	-0.010	-0.022	-0.013	-0.021	-0.010	-0.020
	(-1.21)	(-0.21)	(-1.14)	(-1.74)	(-0.96)	(-0.36)	(-1.00)	(-1.43)	(-0.76)	(-1.39)	(-0.86)	(-1.39)	(-0.77)	(-1.45)
Constant	0.623	0.516	0.075	0.231	0.077	0.530	-0.015	1.011**	0.731*	0.648	0.459	0.633*	0.865**	0.542
	(1.34)	(1.47)	(0.19)	(0.82)	(0.21)	(1.28)	(-0.04)	(2.35)	(1.82)	(1.42)	(1.35)	(1.65)	(1.97)	(1.41)
Number Observations	1,197	1,197	1,197	1,197	1,197	1,197	1,197	1,756	1,756	1,756	1,756	1,756	1,756	1756
Wald Test	2,090.16	1,693.36	2,936.63	2,157.57	2,528.17	1,856.21	2,622.59	1,301.76	1,395.66	1,088.88	1,451.46	1,603.31	1,902.69	1,140.26
AR1	0.009	0.012	0.007	0.006	0.008	0.011	0.007	0.001	0.001	0.001	0.001	0.001	0.001	0.001
AR2	0.418	0.203	0.420	0.554	0.421	0.322	0.384	0.428	0.556	0.571	0.577	0.569	0.480	0.601
Hansen Test	0.119	0.121	0.233	0.191	0.221	0.185	0.309	0.125	0.130	0.052	0.059	0.152	0.294	0.155

Table 15: **Individual regressions small and medium sized banks by differing size 2002-2014 - Banking risk and capital adequacy**

Bank risk is modelled as a function of a variety of capital adequacy metrics during the period $2002-2014$ for large banks. Specifications (i)-(vii) consider banks with assets less than \$25 billion, while specifications (viii)-(xiv) model banks with assets less than \$10 billion. In each case, tangible assets is used as denominator for capital metrics. 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 A1. 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 < \$25 Billion							**Total Assets < \$10 Billion**						
	(i)	(ii)	(iii)	(iv)	(v)	(vi)	(vii)	(viii)	(ix)	(x)	(xi)	(xii)	(xiii)	(xiv)
Tangible Equity	-7.625**					-5.428**		-7.925**					-5.691**	
	(-2.34)					(-2.00)		(-2.36)					(-2.11)	
NCT1		-2.361				-5.709			-3.937				-6.626*	
		(-0.73)				(-1.59)			(-1.15)				(-1.87)	
Tier 1 Capital			-7.057**		-5.994**					-7.376**		-6.048**		
			(-2.17)		(-2.10)					(-2.19)		(-2.02)		
Tier 2 Capital				-2.951	-5.362	-6.594					-2.423	-3.693	-4.558	
				(-0.63)	(-0.97)	(-1.14)					(-0.56)	(-0.60)	(-0.77)	
Total Regulatory Capital							-7.44**							-8.151***
							(-2.52)							(-2.65)
Volatility lagged	0.415***	0.509***	0.44***	0.486***	0.446***	0.469***	0.479***	0.425***	0.526***	0.447***	0.505***	0.455***	0.491***	0.481***
	(5.26)	(5.19)	(5.47)	(5.10)	(5.56)	(5.85)	(5.61)	(5.25)	(5.81)	(5.38)	(5.36)	(5.27)	(6.04)	(5.35)
Cost to Income Ratio	0.003	0.005	0.006*	0.003	0.006	0.005	0.005	0.005	0.006	0.007*	0.005	0.006	0.006	0.006
	(1.12)	(1.22)	(1.69)	(1.00)	(1.63)	(1.46)	(1.34)	(1.21)	(1.58)	(1.67)	(1.21)	(1.59)	(1.40)	(1.32)
Return on Average Equity	-0.010***	-0.010**	-0.008**	-0.011***	-0.008**	-0.009**	-0.008*	-0.006*	-0.007*	-0.005	-0.009**	-0.006	-0.006*	-0.005
	(-2.99)	(-2.26)	(-2.32)	(-2.71)	(-2.33)	(-2.55)	(-1.69)	(-1.84)	(-1.95)	(-1.49)	(-2.19)	(-1.62)	(-1.76)	(-0.97)
Liquid Assets to Total Assets	-0.006	-0.003	-0.006	-0.005	-0.006	-0.004	-0.011*	-0.001	-0.001	-0.001	-0.005	-0.002	-0.001	-0.008
	(-0.91)	(-0.45)	(-0.91)	(-0.70)	(-1.09)	(-0.76)	(-1.82)	(-0.11)	(-0.10)	(-0.07)	(-0.74)	(-0.37)	(-0.14)	(-0.94)
Net Interest Income to Total Assets	-0.025	0.009	-0.006	-0.005	-0.005	0.005	-0.007	2.931	0.445	5.742	-2.845	3.792	5.127	3.206
	(-1.27)	(0.60)	(-0.33)	(-0.32)	(-0.29)	(0.28)	(-0.44)	(0.62)	(0.08)	(1.15)	(-0.56)	(0.81)	(1.05)	(0.63)
Total Assets (ln)	0.032	0.041	0.028	-0.017	-0.009	0.010	-0.015	-0.015	0.022	0.008	0.001	0.006	0.016	-0.001
	(0.18)	(0.38)	(0.15)	(-0.15)	(-0.05)	(0.05)	(-0.09)	(-0.60)	(0.98)	(0.37)	(0.06)	(0.30)	(0.71)	(-0.05)
Concentration	0.006***	0.006***	0.006***	0.005*	0.006***	0.006***	0.006***	0.005***	0.005***	0.005***	0.005**	0.005***	0.005***	0.006***
	(2.99)	(2.72)	(3.01)	(1.90)	(3.00)	(3.17)	(3.11)	(2.92)	(2.77)	(2.72)	(2.44)	(2.86)	(2.91)	(2.79)
Capital Stringency	0.004	0.002	0.001	0.000	0.002	0.004	0.002	0.005	0.001	0.002	-0.002	0.002	0.003	0.001
	(0.40)	(0.24)	(0.12)	(-0.01)	(0.17)	(0.48)	(0.17)	(0.47)	(0.09)	(0.24)	(-0.16)	(0.16)	(0.28)	(0.12)
Market Discipline	0.000	-0.017	-0.014	0.006	-0.008	-0.022	-0.013	0.000	-0.017	-0.012	0.007	-0.010	-0.030	-0.003
	(0.01)	(-0.50)	(-0.32)	(0.16)	(-0.17)	(-0.51)	(-0.29)	(-0.01)	(-0.38)	(-0.21)	(0.17)	(-0.17)	(-0.58)	(-0.05)
Activity Restrictions	-0.006	-0.008	-0.016	0.004	-0.015	-0.021	-0.012	-0.027	-0.016	-0.032	-0.009	-0.027	-0.032	-0.026
	(-0.28)	(-0.38)	(-0.64)	(0.20)	(-0.59)	(-0.88)	(-0.53)	(-1.01)	(-0.67)	(-1.10)	(-0.34)	(-0.93)	(-1.19)	(-0.97)
Constant	0.762	-0.197	0.278	0.172	0.243	0.076	0.406	0.553	-0.432	-0.001	0.140	0.059	-0.063	0.325
	(0.99)	(-0.26)	(0.30)	(0.26)	(0.28)	(0.08)	(0.45)	(0.60)	(-0.43)	(0.00)	(0.17)	(0.06)	(-0.06)	(0.29)
Number Observations	5,075	5,075	5,075	5,075	5,075	5,075	5,075	4,715	4,715	4,715	4,715	4,715	4,715	4,715
Wald Test	3,515.21	3,282.54	3,067.14	4,083.47	2,697.27	2,897.26	3,640.45	2,441.93	2,543.90	2,047.48	3,721.38	2,209.28	2,180.55	1,859.59
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	0.376	0.332	0.372	0.338	0.416	0.417	0.419	0.377	0.335	0.358	0.327	0.389	0.391	0.422
Hansen Test	0.494	0.174	0.462	0.244	0.703	0.787	0.523	0.639	0.300	0.585	0.355	0.696	0.798	0.698

Table 16: **Individual regressions all and large banks 2002-2014 - Banking risk and capital adequacy using principal component analysis (PCA)**

Bank risk is modelled as a function of a PCA capital adequacy metrics during the period $2002 - 2014$. Specifications (i)-(iv) details results for all banks, while specifications (v)-(viii) consider large banks. 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, $C_{i,j,t-1}$ 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 A1. 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	-0.253*		-0.108	
	(-1.91)		(-0.89)	
NCT1	-0.031		-0.089*	
	(-0.44)		(-1.95)	
Tier 1 Capital		-0.235		-0.124
		(-1.56)		(-1.11)
Tier 2 Capital	-0.056	-0.014	-0.016	-0.009
	(-0.65)	(-0.17)	(-0.28)	(-0.17)
Volatility lagged	0.482***	0.494***	0.496***	0.491***
	(6.04)	(6.22)	(6.74)	(6.39)
Cost to Income Ratio	0.008**	0.008***	0.008**	0.007**
	(2.54)	(2.81)	(2.35)	(2.39)
Return on Average Equity	-0.005**	-0.005*	-0.005**	-0.006**
	(-2.11)	(-1.87)	(-2.05)	(-2.18)
Liquid Assets to Total Assets	-0.001	-0.003	-0.001	0.000
	(-0.25)	(-0.51)	(-0.21)	(-0.10)
Net Interest Income to Total Assets	6.443	3.320	1.247	0.110
	(1.45)	(0.72)	(0.29)	(0.03)
Total Assets (ln)	0.021	0.010	0.015	0.006
	(1.64)	(0.92)	(1.18)	(0.61)
Concentration	0.002*	0.002*	0.002**	0.002*
	(1.81)	(1.91)	(2.24)	(1.91)
Capital Stringency	0.005	0.000	-0.003	-0.003
	(0.83)	(0.06)	(-0.36)	(-0.38)
Market Discipline	-0.021	-0.012	-0.012	0.007
	(-0.97)	(-0.52)	(-0.53)	(0.29)
Activity Restrictions	-0.011	-0.005	-0.010	-0.002
	(-0.62)	(-0.32)	(-0.62)	(-0.15)
Constant	-0.764	-0.468	-0.455	-0.315
	(-1.47)	(-1.04)	(-0.74)	(-0.67)
Number Observations	5,930	5,930	5,930	5,930
Wald Test	2,226.83	2,208.28	2,161.90	2,379.85
AR1	0.000	0.000	0.000	0.000
AR2	0.521	0.420	0.607	0.467
Hansen Test	0.359	0.285	0.264	0.233

Appendix

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 A1: **Data Description**
Data definitions for capital adequacy metrics and control variables applied in the study. Data is sourced from Bankscope.