On the composition of capital buffers: US evidence

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A thesis submitted in partial fulfilment of the requirements for the degree of

Bachelor of Commerce (Honours), 2017

Department of Banking and Finance

Faculty of Business and Economics

Monash University

October, 2017

Acknowledgements

There are two people without whom this thesis would not have been possible, my supervisors, Barry Williams and Shrimal Perera. There has been nothing more humbling than to walk out of our weekly discussions realising how much more I still have to learn about (1) banking and, (2) life in general. The effort you both showed this year, went far beyond that which you signed up for. That effort you so generously showed me is something that I have tried my hardest to justify, hopefully the finished product reflects that. Barry, you are probably one of the most knowledgeable people I know. At the same time, you are remarkably modest and unbelievably kind. Shrimal, my first impression of you from the orientation day eight months ago has been sustained throughout the year – a genuine passion for teaching and inspiring those around you. Shrimal, you have an exceptional gift for communicating the most complicated messages in an understandable, and simple manner. Not only are you both outstanding academics, but you're each outstanding people. It has been a privilege working with the both of you.

I am also indebted to the Banking and Finance faculty at Monash University for the privilege of completing an Honours year. I extend a personal thanks to the dedicated teaching staff I have had during the year: Philip Gray, Cameron Truong, and Daniel Chai.

Special thanks to the Australian Prudential Regulatory Authority and the Reserve Bank of Australia. I think the greatest reward for any academic paper written is, for it to have practical implications. In banking that is best achieved by making a contribution to the regulatory environment. Receiving the Brian Gray Scholarship and the support that accompanies it, from two of the world's most respected macroprudential supervisory bodies is more flattering than the word properly conveys. I hope that in return there is an idea, a theme, or a finding contained in this thesis that lends itself to regulatory environment.

To my Honours friends, with whom I have experienced this journey. I thank you for your generosity. Your collective and individual brilliance kept me motivated to better myself each day of the year. To my friends and family, your support and frankness kept me sane and grounded throughout the year.

Finally, to my mum, I know it is unlikely that you will read this entire thesis. But if there is one page you do read, I hope it is this one. What you have personally sacrificed to raise Naomi and I, is beyond measurable. Each of the struggles you have overcome in life inspires me to make the most of the opportunities that I have been gifted as a result. I dedicate this work and any future success in life that I may have to you.

Statement of Authorship

Except where reference is made in the text of the Research Thesis, this thesis contains no material published elsewhere or extracted in whole or in part from a thesis or report presented by me for another degree or diploma.

No other person's work has been used without due acknowledgement in the main text of the thesis.

This thesis has not been submitted for the award of any other degree or diploma in any other tertiary institution.

Signature………………................................ Date: 25 October 2017

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Abbreviations

AMA	–	Advanced measurement approach for operational risk
BCBS	–	Basel Committee on Banking Supervision
BHC	–	Bank Holding Company
CAMELS	–	Capital Adequacy Assets Management Capability Earnings Liquidity Sensitivity System
CCB	–	Capital Conservation Buffer
CCyB	–	Counter-Cyclical Capital Buffer
CET1	–	Common Equity Tier 1
FDIC	–	Federal Deposition Insurance Corporation
FDICIA	–	Federal Deposit Insurance Corporation Improvement Act (1991)
FE	–	Two-way fixed effects panel model
FHC	–	Financial Holding Company
GFC	–	Global Financial Crisis
GMM	–	Generalised Method of Moments
IRB	–	Internal ratings-based system for credit risk
PCA	–	Prompt Corrective Action
POLS	–	Pooled Ordinary Least Squares model
RQ1	–	Research Question 1
RQ2	–	Research Question 2
SLHC	–	Savings and Loan Holding Company
TARP	–	Troubled Asset Relief Program
TBTF	–	Too Big to Fail

Abstract

By composing an unbalanced panel of US Bank Holding Company data from Quarter 1 2001 – Quarter 4 2016, with 78,963 bank-quarter observations, this thesis examines what determines capital buffer quality. Key among the findings of this thesis is that banks in the post Global Financial Crisis (GFC) era have adjusted their capital buffer quality far quicker than previously. The post-GFC speed adjustment is 30.01% faster than during the GFC, and 37.41% faster than pre-GFC. This suggests that building capital buffer quality is a fundamental and growing priority of banks, consistent with Basel III's emphasis on capital quality. It is also found that poorly-capitalised banks face difficulty in re-establishing their buffer quality, counter to the predictions of the capital buffer theory. This implies the need for regulators to intervene early, before 'at risk' banks become poorly capitalised and beyond recall. Banks are observed to have engaged in a moral hazard behaviour by shrinking their capital buffer quality at times when they grow their credit risk. It is also suggested that banks may be aggressively buying market share by writing loans of similar credit risk but at lower returns to capital quality. Additionally, it is found that operationally complex banks signal their viability by holding higher quality capital buffers. Furthermore, no evidence is shown indicating that banks trade-off capital buffer quality with liquid asset investments. There is some evidence to indicate that, consistent with the 'precautionary motive', banks with higher liquid asset investments grow their buffer quality. This may serve as evidence of banks adjusting to the new liquidity requirements mandated under Basel III. Further investigation of the *quantity* of capital buffers dispels the finding of prior work that capital buffer size is influenced inversely by bank size. This serves as further evidence that there are more specific organisational characteristics than mere bank size itself which determine both the quantity and quality of capital buffers.

The implications of this study are significant from a policy perspective. Most notably, capital buffer quality is central to regulator's current mandate under Basel III. Thus, a study evaluating (1) what determines capital buffer quality at large banks, and (2) how banks' responsiveness to capital buffer quality has varied over time is of substantial relevance in shaping future policy. This thesis enlightens bank managers' strategic decision making – namely with respect to capital buffer quality. The findings indicate that bank managers must be alert to both differences in credit risk and the operational complexity of its peers before drawing conclusion on peer's buffer quality. Furthermore, the findings of this thesis offer a platform for bank's shareholders to query the motivations of management if their bank's buffer quality moves inversely with that of their peers in respect of changes to credit risk and operational complexity.

Chapter 1 Introduction

1.1 Introductory points

This thesis examines how capital buffer quality varies across US Bank Holding Companies (BHC) from Quarter 1 2001 to Quarter 4 2016.[1] This is investigated via two research questions (1) What bank characteristics influence the capital buffer quality of large banks? and (2) Do large banks trade-off capital buffer quality with asset liquidity?

The remainder of Chapter 1 is organised as follows: Section 1.2 discusses the background and research motivations. Section 1.3 introduces the objectives and research questions of this study. Section 1.4 explains the academic contributions made. While Section 1.5 describes potential policy implications. Section 1.6 explains how the remainder of this thesis is organised.

1.2 Background and research motivation

Since Merton (1977) first raised the moral hazard introduced by deposit insurance, the thrust of banking regulation, has been on capital adequacy. This regulatory emphasis is most clearly embodied in the Basel Accords.[2] In turn, the literature has evolved over the years to study several aspects of bank capital holdings.[3] Despite the growth in the literature covering bank capital holdings, the *composition* of bank capital (alternatively capital quality) is an area that remains understudied.

The capital used by a bank to finance its operations can be broadly distilled into two regulatory classifications: Tier 1 and Tier 2 regulatory capital.[4] Tier 1 capital – largely composed of shareholder funds and retained earnings – is recognised as superior in terms of its loss-absorbent

[1] The level of regulatory capital a bank holds above the minimum regulatory requirement (Barrios & Blanco, 2003; Marcus, 1983).

[2] The Basel Accords is the preeminent global regulatory framework adopted by many national banking, regulators including those of the US.

[3] See, for instance, Santos (2001), Palia and Porter (2003) and Tanda (2015) for reviews of the literature on capital regulation and contemporary banking theories.

[4] Under Basel II's framework, at the discretion of national authorities, banks could issue a third category of regulatory capital, Tier 3 capital (BCBS, 2006). Tier 3 capital consisted of short-term subordinated debt and was limited to 250% of a bank's Tier 1 capital required for market risk. Tier 3 was intended to play a secondary role (to Tier 1 capital) in covering market risk. Tier 3 capital instruments have been gradually phased out under Basel III.

characteristics (BCBS, 2011).[5] On the other hand, Tier 2 capital (subordinated debt instruments and general provisions) has inferior loss-absorbent qualities but is less costly to raise.[6] Therefore, a bank, in designing its optimal mix of Tier 1 and Tier 2 capital, must trade-off cost considerations with loss-absorbency. Empirical evidence exists to indicate that banks actively manage this mix (Ediz, Michael, & Perraudin, 1998).

Acharya, Gujral, Kulkarni, and Shin (2011) show that the significant balance sheet expansion undertaken by US banks, in the pre-crisis period 2000-2007, was not suitably financed with shareholder equity (also known as common equity) but rather, short-term debt or debt-like instruments. The authors note that banks persisted with dividends payments during the crisis (therefore depleting capital reserves) while the capital that was raised in that period, largely took the form of hybrid instruments.[7] This combination led to the proportion of common equity in banks' capital falling at the time when it was most needed to absorb losses. This (overlooked) systemic vulnerability contributed to the severity of the crisis.[8]

Regulators face the difficult task of stipulating that a bank set aside an 'appropriate' capital base. On the one hand, they must protect against systemic vulnerabilities materialising by requiring banks to hold higher levels of capital of adequate quality. On the other hand, they must balance the interests of bank shareholders, who desire avoiding that their banks hold unnecessarily high levels of costly capital. The relevance of these competing interests is sustained when deciding the composition of the regulatory minimum (i.e. at the Tier 1 vs Tier 2 capital level). Striking the right balance between cost considerations (in which case Tier 2 capital is superior) and loss-absorbency qualities (in which case Tier 1 capital is preferred) has proven challenging. This trade-off provides motivation for a study on capital quality.

[5] Basel III introduces two further sub-categories of Tier 1 regulatory capital. Common Equity Tier 1 consists largely of ordinary shares and retained earnings. It is regarded as the highest quality regulatory capital available to absorb losses (BCBS, 2011). Additional Tier 1 capital is composed of unsecured perpetual instruments that are subordinated in seniority to bank creditors (including holders of Tier 2 instruments) and may be callable by the issuer after five years (BCBS, 2011, p. 16). Typical instruments that take the form of Additional Tier 1 capital are contingent convertible securities, and other hybrid securities. As between Common Equity Tier 1 and Additional Tier 1 capital, the first is more expensive to raise in capital markets but commensurately more loss-absorbent.

[6] Tier 2 capital is subordinated to depositors and general creditors and must have an ordinal maturity of at least five years (BCBS, 2011).

[7] Government-subsidised capital injections for troubled institutions (under the Troubled Asset Relief Program (TARP)) took the form of preferred equity (Black & Hazelwood, 2013).

[8] Martín-Oliver (2012) similarly finds that Spanish banks favoured issuing cheaper hybrid claims over common equity in the period before the global financial crisis (GFC), contributing to that country's extended recession.

Empirically, it has been demonstrated that banks hold capital above the regulatory minimum (therefore creating 'capital buffers'). However, a key lesson of the GFC is that the size of a bank's capital buffer is of second-order relevance. Banks failed during the crisis despite maintaining sizeable capital buffers (BCBS, 2011).[9] Basel III, the regulatory response to the crisis, elevates the role of capital buffer quality in the supervisory agenda.[10] It is this growing appreciation of capital buffer quality which further motivates this thesis. The GFC also serves as a reminder of the moral hazards rife in banking (most significantly 'Too Big To Fail' (TBTF)). Motivated by the potentially exploitative behaviour of large banks, this study specifically explores the activities of these large institutions.

The crisis also exposed how insufficient liquidity can prompt systemic failure and undermine the global financial system (Hartlage, 2012). This was despite banks' capital holdings, for the most part, adhering to or often exceeding regulatory capital minima (Demirguc-Kunt, Detragiache, & Merrouche, 2013). When uncertainty was at its peak, during the crisis, interbank lending and broader financial markets froze (i.e. funding liquidity). Consequently, the risk of bank failure materialised across those with insufficient cash (and cash equivalents).

In addition to raising capital buffer quality standards, Basel III shifts attention toward asset liquidity.[11] Basel III is drafted to encourage coordinated regulation of a bank's capital and liquidity channels, to properly manage systemic risks. The interplay between these channels is further motivation for this thesis.

[9] Anxiety over banks' soundness during the crisis and the subsequent failure of many institutions is attributable, in part to the quality of bank capital being insufficient to absorb losses. The Basel Committee on Banking Supervision (BCBS), itself acknowledged that the '*depth and severity of the crisis were amplified by…excessive leverage, inadequate and low-quality capital, and insufficient liquidity buffers*' (BCBS, 2010, p. 1).

[10] Of note Basel III requires that banks set aside two regulatory buffers which can only be met with Common Equity Tier 1 capital, the most loss-absorbent capital available to a bank. These two buffers are the Counter-Cyclical Capital Buffer and the Capital Conservation Buffer. Further discussion on these buffers is provided in Chapter 3.

Basel III is also acknowledged as raising the quality of capital by requiring that a greater proportion of Tier 1 regulatory capital compose a bank's total regulatory capital ratio (from 50% under Basel II to 75% under Basel III). Basel III also introduces a Common Equity Tier 1 ratio.

[11] Basel III introduces two quantitative liquidity measures. These include the Liquidity Coverage Ratio (stress test of short-term liquidity) and the Net Stable Funding Ratio (ensures banks hold 'stable funding' based on the liquidity of its assets and off-balance sheet activities over a one year period) (BCBS, 2013; Elliott, 2014).

1.3 Objectives and research questions

The point at which this thesis explores a research gap begins with the existing literature's observation that the quantity of capital buffers varies inversely with bank size. That is, larger banks are found to consistently hold smaller capital buffers.[12] The existing literature supports this finding with broad conclusions usually focusing on larger banks being supported by (1) "Too Big to Fail" (TBTF) incentives, (2) superior capital market reputations and, (3) strong geographic and product diversification. These justifications imply that larger banks face lower costs in accessing capital when needed, and so hold smaller-sized capita buffers at any given time (Berger, DeYoung, Flannery, Lee, & Öztekin, 2008; Francis & Osborne, 2010; Jokipii & Milne, 2008).

The empirical observation that larger banks hold smaller buffers is a misleading generalisation. The existing literature treats large banks as homogenous in drawing this conclusion. However, even among the largest financial institutions, significant variability across the operating activities is to be expected. It is therefore necessary to recognise that large banks are heterogenous. This study is positioned to capitalise upon that heterogeneity across large banks. The desire of this study is to ascertain whether there is something beyond large financial institutions' size which determines their capital buffer quality. Exploring how certain bank-level characteristics' influence of capital buffer quality leads to research question 1:

RQ1 - What bank characteristics influence the capital buffers quality of large banks?

Investments in liquid assets have been increasing at financial institutions (Bates, Kahle, & Stulz, 2009; Bordeleau & Graham, 2010). Evidence exists to indicate that banks have been doing this to mitigate against liquidity risks (Bates et al., 2009). This is despite the lower return characteristics associated with liquid assets. In connecting liquid assets to capital buffers, Jokipii and Milne (2011) suggests that banks with high investments in liquid assets can offset the lowered liquidity risk that follows with holding smaller capital buffers. This indicates that banks trade-off the *quantity* of their capital buffers against their liquid asset investments. However, the literature fails to clarify whether this theme persists across the *quality* of a bank's capital buffer. This motivates research question 2:

[12] See for instance Shrieves and Dahl (1992), Ediz et al. (1998), Rime (2001), Ahmad, Ariff, and Skully (2008), E. Brewer, G. G. Kaufman, and L. D. Wall (2008), Francis and Osborne (2010), Gropp and Heider (2010), Jokipii and Milne (2011).

RQ2 - Do large banks trade–off capital buffer quality with liquid asset investments?

To summarise, this thesis is motivated by combining three concepts: (1) the recent shift in attention toward capital buffer quality (2) the lack of prior work on determinants of capital buffer quality and, (3) a growing regulatory focus upon asset liquidity.[13] The first two concepts are linked by studying the association between three bank-level characteristics of large banks and capital buffer quality. Capital buffer quality is also linked with asset liquidity by considering whether large banks trade-off buffer quality against asset liquidity.[14] The intersection of these concepts is of considerable contemporary policy relevance but, as yet remains under-developed by the existing literature.

1.4 Academic contributions

This thesis advances the existing literature through the following streams. Firstly, this study adds to the growing appreciation of capital quality over capital size. It does this by focusing specifically on capital buffer quality, a field not previously researched by the existing literature. This paper makes a genuine contribution by investigating the bank characteristics that drive capital buffer quality at large banks.

Furthermore, this thesis utilised modelling techniques that reveal the speed at which banks adjust buffer quality (primarily through use of the two-step system GMM econometric technique developed by Arellano and Bond (1991) and enhanced by Blundell and Bond (1998)). This novel contribution enables the investigation as to whether prioritising buffer quality has changed in the minds of bankers over time. Of particular interest is whether banks are more acutely aware of buffer quality in the wake of the post-GFC, Basel III era, when the emphasis on buffer quality has been most pronounced. The speed of adjustment term with respect to buffer quality can also be compared with that calculated by the prior literature in relation to buffer size. This allows for a further examination of the priorities of banks (i.e. do they prioritise capital buffer quality over capital buffer size?).

[13] Capital quality, in this context, refers to the classifications of Tier 1 and Tier 2 regulatory capital. The first of these is broadly considered higher quality and costlier for a bank to raise. Following the GFC and Basel III's introduction, there has been a greater emphasis by regulators on forcing banks to hold higher levels of Tier 1 regulatory capital (particularly Common Equity Tier 1 capital).

[14] The quality of capital buffers is examined by considering the proportion of Tier 1 capital a bank discretionarily holds as a proportion of its total capital buffer.

A further analysis as to how easily banks at extreme measures of capitalisation (i.e. poorly capitalised or well-capitalised) adjust their buffer quality is made possible by interacting adjustment speeds with degrees of capitalisation. In so doing, this thesis can explore whether these interaction terms follow that predicted under theories such as the capital buffer theory.[15] This follows the approach taken with respect to prior work on buffer size but offers results for the first time, with respect to buffer quality.[16]

Three regressive techniques are utilised in this thesis, namely a two-step system GMM estimator (the primary model), Pooled Ordinary Least Squares and a two-way Fixed Effects panel model. While the system GMM is the prevailing method in the existing literature, some studies do rely upon these alternative techniques.[17] By presenting results for all three, this thesis explores whether these studies that utilised alternative techniques to the system GMM are attributing greater statistical significance than what should be reported.

This thesis also reports disaggregated results based upon the regulatory holding company structure of the bank.[18] This is a consideration not previously discussed. Providing disaggregated results based upon regulatory holding company structures allows for an examination as to whether the unique operating emphasises of each regulatory structure dictate what influences capital buffer quality.

Additionally, by preparing separate results for buffer size regressions (see Appendix A.2), this thesis offers a direct comparison with the prior literature. This enables the investigating of the existing literature's suggestion that bank size is determinative of the size of capital buffers.

[15] Capital buffer theory predicts that a bank deliberately maintains a buffer above the regulatory capital minimum (Kleff & Weber, 2008).[15] Consequently, there should be a positive adjustment between regulatory capital holdings and loan portfolio risk. That is, while expanding credit risk, to maintain their target capital buffer, a bank should increase its capital buffer. The theory's prediction implies that poorly capitalised banks lower credit risk, while simultaneously increasing their capital holdings to re-establish a capital buffer. Well-capitalised banks, under the theory, are expected to sustain their buffer by growing (decreasing) credit risk exposures as the buffer increases (decreases) (Jokipii & Milne, 2011).

[16] For prior work considering similar interaction terms but in relation to capital buffer size, see Jokipii and Milne (2011) and Pereira and Saito (2015).

[17] See for instance Francis and Osborne (2012) who use a fixed effects model and Pereira and Saito (2015) who used both a fixed effects model and pooled OLS.

[18] The data sample to this study includes Bank Holding Companies, Financial Holding Companies and Savings and Loan Holding Companies.

As a US-focused study, this research should offer particularly enriching results. The ability to study a heterogenous pool of large banks operating under a homogenous, regulatory structure presents a certain desirability. This heterogeneity across a sizeable sample of 2,885 banks creates greater confidence in empirical testing of banking behaviour, across different bank-level operating activities at different banks.

Finally, there are rich contributions associated with the nature of the sample data. Examining capital buffer quality from Quarter 1 2001 to Quarter 4 2016 implies 64 quarters of observations. During such a period, the US banking industry operated across the extremes of the business cycle. This offers the ability to study how capital buffer quality has varied across a boom (2001 – 2006), recession (2007 – 2009) and, recovery (2010 – 2016). Furthermore, the data set is drawn from regulatory filings made by banks to the Federal Reserve. This requires that the banks in the sample accurately report their activities, and consequently implies an enhanced degree of integrity to the data relied upon in this study.

1.5 Policy implications

The considerations of this thesis colour the interests of numerous key stakeholders in the banking industry. From a regulator's perspective, studying capital buffer quality is of present and future relevance to their supervisory mandate as drafted into Basel III. The findings will assist their understanding of what operating activities drive capital buffer quality at large banks. By understanding banks' incentives (to actively manage their capital buffer quality), regulators can design frameworks that mould more appropriately to specific bank-level activities. This has downstream benefits for the safety of the funds of depositors and other bank creditors.

Moreover, examining how quickly banks have adjusted their buffer quality through time (i.e. pre-GFC, GFC and post-GFC) enables regulators to understand whether banks are learning to promote the role of buffer quality (by prioritising faster adjustments to buffer quality) over buffer size. This policy implication is heightened by exploring the ease at which poorly-capitalised and well-capitalised banks adjust their buffer quality (i.e. 'extremes analysis'). Taking an extremes analysis will inform regulators as to whether early intervention into 'at-risk' banks (i.e. banks that are not yet considered poorly capitalised, but have experienced a deterioration in their capitalisation levels) is more or less desirable, in light of the ability for poorly capitalised banks to re-establish their buffer.

This thesis also offers bank managers strategic insights. The ability to understand how their peers adjust and target buffer quality is desirable across a particularly large group of banks (the sample to this study is composed of 2,885 banks). This informs which future operating activities they may be best to grow or shrink, to maximise the utility of their costly capital buffers. Enriching their decisions-making in such a way is desirable in a setting of growing supervisory scrutiny.

1.6 Organisation of thesis

The remainder of this thesis is organised as follows. Section 2 reviews the literature and develops the hypotheses. Section 3 discusses the data sample and methodology applied Section 4 presents the empirical results. Finally, Section 5 concludes this thesis.

Chapter 2 Prior Literature and Hypotheses Development

2.1. Introduction

The purpose of this section is to position a study on capital buffer quality in the context of how the existing literature has developed to addresses the association between capital buffers and bank size. Section 2.2 describes the functions of capital buffers in the presence of state safety nets. Section 2.3 explains the determinants of capital buffers which have been found to determine the size of a bank's capital buffer. Section 2.4 proceeds to consider how capital buffers have been found to vary with bank size. Section 2.5 explains why a study on capital buffer quality is a desirable extension to the existing literature's examination of capital buffers and bank size. Sections 2.6 to 2.9 introduce testable hypotheses that enrich a study on capital buffer quality. Section 2.10 summarises the chapter.

2.2. Functions of capital buffers in the presence of state safety nets

A bank's immediate obligation, from a capitalisation perspective, is to satisfy the minimum regulatory capital level. However, empirically it is generally acknowledged that banks target aggregate capital holdings in excess of the regulatory minimum (Ayuso, Pérez, & Saurina, 2004). The explanations as to why banks target capital buffers can be conceptualised from two perspectives (1) the systemic functions and, (2) the bank-specific functions of capital buffers. From the first of these two perspectives, capital buffers enable a bank to absorb unexpected losses while continuing to operate (FDIC, 2016). This ability promotes public confidence and signals a bank's financial health (Berger, Herring, & Szegö, 1995). Additionally, strong capitalisation reduces the probability of tax-payer funded bailouts. From a bank-specific perspective, excess equity offers flexibility, enabling the bank to exploit growth opportunities (Berger et al., 2008; Francis & Osborne, 2010), shield against supervisory intervention, and reduce costly market disciplinary pressures (Berger et al., 1995; Jokipii & Milne, 2008).

The need for sufficient capital is amplified in the presence of deposit insurance and other state safety nets.[19] Deposit insurance is designed to allay the likelihood of bank runs, particularly in times of crisis. An unintended consequence of this explicit state safety net is the creation of risk-

[19] Concessions such as deposit insurance and access to the discount window are considered to lessen bank creditors' exposure to the bank's risk taking and in turn shield banks from market discipline (Berger et al., 1995). Banks, operating under the protection of the state safety net, are theoretically deterred from building costly, higher quality capital buffer.

shifting incentives for bank managers. Merton (1977) models deposit insurance as a put option on the value of a bank's assets, at a strike price equal to the value of its debt. Under this model, a bank maximises the value of the put by increasing asset risk or decreasing its capital-to-asset ratio (Santos, 2001). The banks' put option results in the failure to internalise the costs associated with the riskiness of its investments. The bearer of downside risk is the state (as guarantor of the bank's primary source of financing) and the beneficiary of the upside gains is the bank's shareholders. Merton (1977) concludes that capital is an important regulatory tool to mitigate this moral hazard.

2.3. Determinants of capital buffers

Traditional corporate finance theories, such as the pecking order theory, offer explanations as to why banks should favour debt and debt-like instruments over costlier equity financing (Myers & Majluf, 1984). Under such theories, a bank should minimalise its buffer size and rely upon cheaper debt funding. Despite this, it is empirically observed that banks target capital buffers (Milne, 2004a). Therefore, although cost considerations are relevant, the decision to hold a capital buffer is likely to be influenced by other considerations.

The regulatory capital minimum is the instrument which defines the capital buffer. The existing literature observes that the intensity of supervisory pressure is influential in explaining the long-term capital buffer targeted by a bank (Ediz et al., 1998; Francis & Osborne, 2010; Milne, 2004a). This is important in the context of the US-based BHCs examined in this thesis, who under the US Federal Deposit Insurance Corporation Improvement Act (FDICIA) are subject to 'Prompt Corrective Action' (PCA).[20] Empirically, it has been found that a bank with inferior capitalisation responds not only by making the largest proportionate increase in its capital holdings, but makes such adjustments the quickest vis-à-vis better capitalised peers (Aggarwal & Jacques, 1998; Ediz et al., 1998).[21]

[20] Section 131 of FDICIA prescribes prompt corrective action (PCA) to be used by the Federal Deposit Insurance Corporation as a means of early intervention into troubled banks. PCA establishes zones of bank capitalisation from 'well-capitalised to poorly-capitalised'. As a bank's capitalisation becomes further distressed, each zone corresponds with escalating degrees of discretionary regulatory interference with a bank's operations (Aggarwal & Jacques, 2001; FDICIA, 1991).

[21] In a cross-country examination of this phenomenon, Brewer et al. (2008) find evidence that the magnitude of the buffer is largest in countries where regulatory scrutiny is higher, such as the US.

A bank may consider the costs to shareholders of foreclosure (i.e. loss of its 'franchise value' or 'charter value').[22] A bank with high franchise value may desire larger capital buffers to absorb losses and avoid insolvency (Demsetz et al., 1996). Likewise, a bank exposed to market discipline is incentivised to signal its ongoing soundness by holding larger buffers (P. Jackson et al., 1999; Jokipii & Milne, 2008).

The observation that banks hold capital buffers reflects the imperfections of capital markets. Were equity markets perfect, a bank's optimal buffer would be zero, given the opportunity cost of holding idle capital (García-Suaza, Gómez-González, Pabón, & Tenjo-Galarza, 2012).[23] A bank may hold a capital buffer in light of the difficulty in raising capital cheaply when needed, especially in light of the likely negative signalling effects associated with a capital raising (Myers & Majluf, 1984).

The existing literature also documents how the business cycle influences the capital buffer maintained by a bank. Negative relationships between the buffer and economic cycle (such that a bank grows its buffer during economic downswings, and depletes its buffer during upswings) have broadly been observed in the existing literature (Ayuso et al., 2004; Francis & Osborne, 2010; Jokipii & Milne, 2008; Lindquist, 2004). Basel III introduces a pair of business cycle-dependent capital buffer requirements which are directed at reducing this behaviour among banks.[24]

2.4. How bank size influences capital buffers

A pattern has emerged across the existing literature in observing that the quantity of capital buffers falls as bank size increases. Several reason have been advanced explaining this relationship. Jayaratne and Morgan (2000) indicate that smaller banks are met with investor scepticism when issuing equity and must overcome significant market frictions. Therefore, the transaction costs and

[22] Franchise value is the value of the bank's future profits that would be lost if it were to be (Demsetz, Saidenberg, & Strahan, 1996; Jokipii & Milne, 2011).

[23] It is worth acknowledging the potential that banks' have an internal capital target that differs from the minimum capital ratio set by the regulator (Jokipii & Milne, 2008). How banks assess risk may rely upon different modelling assumptions and therefore reflect their own risk-return preference.

[24] The combination of these two buffers is intended to (1) address procyclicality in capital positions of banks, and (2) mitigate the damage caused by the accumulation of systemic risks (BCBS, 2013). The phasing in of the first of these buffers, the Capital Conservation Buffer, began in 2016 with an additional 0.625% Common Equity Tier 1 (CET1) required to be set aside. This will gradually step up to 2.5% through to 2019 as described in Table 3.1. US regulators also have the discretion to mandate that Advanced Approaches BHCs set aside an additional buffer of up to 2.5% composed of CET1, at times when systemic vulnerabilities are unacceptably high. This buffer is known as the Counter-Cyclical Capital Buffer (CCyB). The CCyB is currently set at 0% in the US.

information asymmetries that accompany equity financing may be particularly burdensome for these institutions. In an effort to address investor scepticism, a smaller bank may prefer holding a higher buffer (Sivarama & Sukar, 2014). It could be expected that smaller banks 'stockpile' retained earnings over time to accumulate their buffers (Berger et al., 2008). This activity is likely to correspond with smaller banks holding a larger buffer at any given time.

Hannan and Hanweck (1988) find that markets, pricing in the likelihood of rescue under TBTF safety nets, apply a discount to the funding costs of larger banks. Consequently, these larger institutions may target a smaller buffer because when they need additional financing at short notice, an equity (or debt) issuance is less prohibitive on a relative basis. This finding supports the conclusion that larger banks have greater access to capital markets.

It is found by Berger and Bouwman (2013) that well-capitalised banks are more likely to, not only survive banking crises, but grow market share. They observe that higher aggregate capital benefits small banks always (i.e. during crises and normal times). Meanwhile, larger banks only benefit from stronger capitalisation during banking crises.[25] Demirguc-Kunt et al. (2013) analogously observe that for larger banks, superior capitalisation is associated with stock market outperformance during crisis times. However, variations in capitalisation across large banks was not found to influence stock market performance prior to crises. The limited utility of additional capital, for larger banks may explain why they cluster towards lower aggregate capital ratios when compared with their smaller peers.

The generalisation that larger banks hold smaller buffers is explored by Gong, Huizinga, and Laeven (2017). In that paper, the authors conclude that the effective capitalisation levels of small US BHCs is less than that which is reported, providing evidence of capital arbitrage.[26] The authors suggest that small BHCs exploited the regulatory 'freedoms' which up until 2014 did not require that they deduct investments in nonconsolidated banking affiliates from their reported Tier 1 capital figure. Meanwhile, large BHCs were required to deduct one-half of the total investments in unconsolidated affiliates from Tier 1 (and the other half from Tier 2 capital (between 2001 – 2013).

[25] See also Laeven, Ratnovski, and Tong (2016) whom similarly suggest that greater capitalisation benefits larger banks mainly during crises.
[26] The Federal Deposit Insurance Corporation considered BHCs with total consolidated assets of less than $150 million to be small BHCs. This ceiling was increased to $500 million in March 2006 and then again to $1 billion in March 2015.

It is unclear from the paper whether the reduction in the effective capitalisation levels of BHCs – after correcting for their interests in banking affiliates – is of such a magnitude as to reject the suggestion that larger banks hold smaller capital buffers. However, the authors demonstrate that the effective leverage ratio of small BHCs was overstated by 36.6% (Gong et al., 2017, p. 16) .

A further omission by the existing literature is the scant attention given toward understanding how the quality of capital buffers varies across bank size. This is surprising considering a core revision of Basel III is its promoting the role of quality with respect to aggregate capital and capital buffers. As mentioned earlier, there are important loss absorbency and cost characteristic distinctions between Tier 1 and Tier 2 capital. It is therefore misleading to only focus on the size of the capital buffer (which may be a fluctuating amalgam of Tier 1 and Tier 2 capital). This paper extends the discussion on the quality of capital buffers by addressing how capital buffer quality varies across bank size.

2.5. Shifting towards analysing the quality of capital buffers (RQ1)

The GFC revealed that the regulatory attention toward capital was, to that point in time, myopic (Chor & Manova, 2012; Fratzscher, 2012). Basel III addresses the regulatory shortcomings exposed during the GFC by raising not only the quantity of required regulatory capital but also its quality.[27] Evidence as to why this emphasis upon quality is considered sensible is found by Demirguc-Kunt et al. (2013). In that paper, the authors show that market perceptions surrounding bank capital quality changed significantly during the GFC (as compared with the period before the crisis). Demirguc-Kunt et al. (2013) find that differences across individual banks' capital quality did not materially impact stock returns before the crisis. However, during the crisis, variations in Tier 1 capital became much more determinative of the outperformance of individual banks, especially in respect of larger banks. This is evidence of the market beginning to distinguish a bank based upon the quality of its capital rather than the quantity of its capital. Essentially, markets were less concerned about how much capital a bank held, but rather how much Tier 1 capital a bank held.

[27] Basel III emphasises the importance of CET1 (i.e. shareholder equity) as part of a bank's total capitalisation. Refer to Basel III: A Global Regulatory Framework for More Resilient Banks and Banking Systems, released in December 2010 and revised in June 2011 (Basel Committee on Banking Supervision). Under Basel III the common equity Tier 1 capital to total risk-weighted assets increases from 2 to 4.5%. Banks must also hold Tier 1 capital to total-risk weighted assets ratio of 6%. Total capital to total risk-weighted assets ratio of 8%. A new capital measure is a countercyclical buffer of 0-2.5% imposed at the regulator's discretion. A bank-specific 'capital conservation' buffer of 2.5% of common equity is also phased in to 2019.

A focus on quality is reinforced by Lubberink and Willett (2016). In that study, it is found that the book value of equity and Tier 1 capital explain 87% of the variation in market returns for banks (Lubberink & Willett, 2016, p. 15).

Market frictions (such as information asymmetries and issuance costs) explain why Tier 1 capital is more expensive to raise than Tier 2 capital (Myers & Majluf, 1984).[28] Consequently, a bank must trade-off the quality and quantity of its capital buffers (Francis & Osborne, 2010).[29] The existing literature indicates that a bank actively manages, not only the size, but also the quality of its buffer (see, for instance Acharya et al. (2011) and Martín-Oliver (2012)).[30] The risk is that a bank, driven by a moral hazard, favours cheaper financing, such as subordinated debt (i.e. Tier 2 capital) before raising shareholder funds (i.e. Tier 1 capital). In turn, judging a bank's financial health based purely on the size of its capital buffer is not enough. Within this context, a study that examines the factors that influence a bank's capital buffer quality is of considerable importance. This motivates Research Question 1:

RQ1 - What bank characteristics influence the capital buffer quality of large banks?

[28] Myers and Majluf (1984) explain a firm's capital financing decision being subject to a 'pecking order'. They argue, from a costs perspective, that a firm requiring funding should preference internally generated funds before external financing. Retained earnings are not subject to 'market frictions' such as information asymmetries or transaction costs, making it the cheapest form of financing. Under this pecking order, should external funding be necessary, debt is favoured over equity as the relative transaction costs and information asymmetries of debt remain lower than equity. Equity financing becomes attractive at the point where further debt would jeopardise the firm's financial health due to the interest burden. And so, a firm's optimal capital structure will be a composite of debt and equity, with the appeal of the interest tax shield tempered with the risk of financial distress.

[29] It is shown in Ediz et al. (1998) that banks make a trade-off between the quality and quantity of capital buffers. That paper shows that when increasing the components of regulatory capital, banks prefer growing their Tier 2 capital base before the higher-grade Tier 1 capital. The trade-off between the quality and quantity of the capital buffer may be influenced by a bank's ability to raise capital, chiefly its access to capital markets (Francis & Osborne, 2010). It is found in Francis and Osborne (2010) that banks that have a greater reliance on higher-quality Tier 1 capital consistently maintain higher total risk-based capital ratios. This finding is rationalised by the authors on the basis that these, typically smaller, banks are encumbered with greater market access costs and so to reduce the expected cost of raising new capital, they maintain higher aggregate capital levels.

[30] Both these studies indicate that banks during the pre-GFC period favoured the issuance of Tier 2 capital instruments, such as hybrids over Tier 1 (common equity capital). Additionally, banks continued paying out substantial dividends. The net impact was that the quality of banks' capital holdings fell precisely at the time when it was most required to absorb losses (i.e. the GFC).

The existing literature establishes a negative association between bank size and the *quantity* of capital buffers. This relationship is suggested to be a product of larger banks: 1.) having greater flexibility in issuing hybrid securities, 2.) being covered by implicit state safety nets (TBTF) and 3.) having superior economies of scale in the monitoring of risky borrowers (Francis & Osborne, 2010). These explanations as to why larger banks hold smaller capital buffers are equally valid — although as yet untested — when considering how they manage their capital buffer quality. This leads to Hypothesis 1:

H1: There is a negative association between bank size and capital buffer quality.

As previously explained, buffer quality in this context is used to refer to the proportion of Tier 1 regulatory capital a bank discretionarily holds in its capital buffers. The greater the proportion of Tier 1 regulatory capital, the greater the quality of the capital buffer.

This study extends the analysis surrounding the bank size and buffer quality relationship by focusing upon four bank-specific characteristics: retail intensity, operational complexity, credit risk and investments in liquid assets. This further investigation is conducted to ascertain whether there is something more to bank size than size itself, which drives the association with capital buffer quality.

2.6. Retail intensity

There is no clear definition of a retail bank, although Hirtle and Stiroh (2007) propose a broad definition as including '*deposit-taking, lending and other financial services provided to consumers and small businesses through all delivery channels…*' (p.1107). A lesson from the GFC is that traditional risk-return indicators are incomplete mechanisms to supervising banks. A deeper attentiveness to the respective channels through which banks earn profits is, suggested by Köhler (2015) to enhance regulator's understanding of bank stability. Where a bank's lies on a scale between retail-intensive business models and wholesale-intensive business models has important implications with respect to performance and stability. In turn, the degree to which a bank finances its activities with traditional deposits could influence the quality of capital it holds.

Huang and Ratnovski (2009) find that retail intensity of Canadian banks and their small exposure to the US wholesale funding market were important factors in explaining why Canadian banks outperformed other OECD countries' banks during the GFC.[31] Retail-orientated banks are considered by Köhler (2015) to have more stable funding (i.e. customer deposits) which enhances their durability during crisis periods particularly in light of deposit insurance/guarantees offered by the state. This stable funding structure may deter retail banks from holding highly loss absorbent but costly capital buffers. However, there are competing reasons as to why a retail intensive bank may still favour high quality buffers.

Studying the characteristics that correspond with retail intensity, among German banks, Köhler (2014) finds that banks with high degrees of retail exposure tend to be unlisted and therefore have limited market access (Köhler, 2015). This may make raising capital — particularly Tier 2 capital — problematic for these banks. This limited market access is hypothesised to correlate with a retail-focused bank holding greater proportions of Tier 1 capital in its buffer. This could be a product of such a bank relying upon their retained earnings to establish its capital buffer, predominantly composed of Tier 1 capital or their restricted market access impeding their ability to issue Tier 2 capital instruments.

Understanding the composition of capital buffers for retail banks is complicated by the interaction of two opposing forces. On one hand, the greater retail exposure (particularly via deposit exposure) as a component of total liabilities, the greater the value of deposit insurance to the bank (Berger et al., 2008; Berger et al., 1995). If moral hazards drive that bank, then one would anticipate a smaller capital buffer. However, it is found by Berger et al. (2008) that retail banks hold higher capital buffers as compared with their wholesale peers. This can be rationalised on the footing that retail banks, reliant on depositor funding have greater charter values (Jokipii & Milne, 2008). To honour its charter value, a retail bank may be induced to hold additional Tier 1 as a composite of its capital buffers.

[31] The authors also point toward the nuances of the Canadian capital regime which favours Tier 1 capital, and particularly common equity required to satisfy Tier 1 capital (75% of Tier 1 capital must be formed by common equity). These stringent capital requirements the authors suggest restricted balance sheet growth and at the same time corresponded in banks engaging in less wholesale funding as retail deposits can meet a larger proportion of their financing needs.

Based upon the literature on retail intensity, it is suggested that this is an important factor in determining the quality of capital buffers maintained by a bank. Retail intensive banks have inhibited access to capital markets when compared with wholesale-facing banks (particularly with respect to their ability to issue Tier 2 capital). Hypothesis 2 therefore suggests:

H2: There is a positive association between retail intensity and capital buffer quality.

2.7. Operational complexity

The extent to which a bank is regarded as operationally complex may influence the overall composition of its capital buffer. One avenue through which opacity is considered in the existing literature is within the context of revenue diversification. Regulatory reforms in the US – culminating in the passage of the Gramm-Leach-Bliley Act (1999) – permitted banks to engage in an array of previously restricted non-traditional financial services (e.g. underwriting and advisory services) (Stiroh & Rumble, 2006).[32] A body of literature considers the impact that banks' expansion outside of their traditional lending and deposit-taking activities has had on several channels. Such channels include profitability, bank stability, as well as bank-specific and systemic risk.[33] Although no clear consensus is reached as to whether revenue diversification is beneficial, a recurrent theme is the impact revenue diversification has on the complexity of a bank.[34]

Corporate finance literature argues that agency conflicts are likely within more complex institutions, where scrutiny of management by outsiders is hampered by information asymmetries (Jensen & Meckling, 1976). This reasoning has been reconceptualised to explain the conundrum of a bank diversifying outside its immediate fields of competence (Milbourn, Boot, & Thakor, 1999). Such fundamental restructuring of a bank's operations has been regarded to lower accountability and aggravate further information asymmetries for outsiders (Milbourn et al., 1999). Laeven and Levine (2007) find evidence that markets ascribe a "diversification discount" to

[32] Furlong (2000) offers a detailed overview of the Gramm-Leach-Bliley Act (1999).
[33] For instance, Stiroh and Rumble (2006) assess revenue diversification's impact upon risk-adjusted profitability. Köhler (2014) assess whether entry into non-interest based income activities increases bank risk, while Butzbach (2016) considers its impact upon systemic risk.
[34] Reichert and Wall (2000), Campa and Kedia (2002), Baele, De Jonghe, and Vander Vennet (2007) and Sanya and Wolfe (2011) all find evidence supporting revenue diversification's positive impact on profitability. While DeYoung and Rice (2004), Stiroh (2004), Stiroh and Rumble (2006), Acharya, Hasan, and Saunders (2006), Laeven and Levine (2007) and find evidence querying revenue diversification's benefits.

financial institutions. Examining the Tobin's Q scores (a measure of valuation), the authors find that diversified financial institutions have lower Qs than the Qs they would have if the firm separated into portfolios of specialised firms.[35] The authors attribute this anomaly to the escalating agency problems associated with monitoring complicated banks.

A specific channel through which banks have diversified revenues is through off-balance sheet exposures. The growth in off-balance sheet exposures is closely related to increasing firm opacity (Laeven & Levine, 2007; Williams & Rajaguru, 2013). This complexity translates into pronounced information asymmetry dynamics. Specifically, these banks may prioritise reliance upon retained earnings to finance their activities (Gropp & Heider, 2010). Greater information asymmetry at operationally complex banks implies that alternative sources of finance will be costlier (Myers & Majluf, 1984).

Operational complexity is associated with the potential for uninformed funding sources, this uncertainty can result in sudden and unpredictable funding withdrawals (Huang & Ratnovski, 2011). To mitigate impact that such withdrawals could have on a bank's operations may encourage operationally complex banks to hold greater holdings of loss-absorbent Tier 1 capital as a component of their buffers.

Furthermore, an operationally complex bank may wish to signal to the market its ongoing viability (through holding loss-absorbent capital buffers). It may also wish to safeguard its exposures by maintain higher quality capital buffers. This leads to Hypothesis 3:

> **H3:** There is a positive association between operational complexity and capital buffer quality.

[35] Tobin's q measures the present value of future cash flows divided by the replacement costs of tangible assets (Laeven & Levine, 2007; Lang & Stulz, 1994).

2.8. Credit risk

Credit or loan portfolio risk refers to the potential that a bank's revenue-generating assets, consisting of its loan portfolio, deteriorates in quality (Chaudhry, 1994). Given that a bank's lending activities are regarded as central to its operations, credit risk is likely to be one of the main sources of risk a bank is exposed to. Regulators are, therefore, particularly concerned with how institutions manage their credit risk, and demand that high quality capital be available to absorb unexpected deterioration in a bank's loan portfolio (BCBS, 2011).

The literature has developed to connect credit risk with capital holdings via the capital buffer theory. Capital buffer theory predicts that a bank deliberately maintains a buffer above the regulatory capital minimum (Kleff & Weber, 2008).[36] Consequently, there should be a positive adjustment between regulatory capital holdings and loan portfolio risk. That is, while expanding credit risk, to maintain their target capital buffer, a bank should increase its capital buffer. This prediction has been confirmed in a series of US studies.[37]

However, the nature of the buffer-risk adjustment has also been observed to vary according to the degree of bank capitalisation. There is empirical evidence of a pronounced negative relationship between the quantity of capital buffers and credit risk for banks with a smaller capital buffer.[38] This observation can be interpreted as consistent with two scenarios. On the one hand, a bank operating near regulatory minimum has an incentive to re-establish its target capital buffer by decreasing loan portfolio risk while simultaneously increasing capital (consistent with capital buffer theory) (Heid et al., 2004). This would indicate that banks are attuned to the high explicit and implicit regulatory costs associated with falling below the regulatory minimum.[39] On the other hand, a poorly-capitalised bank may finance riskier projects or borrowers (thereby increasing credit risk), while effectively depleting its buffer. This gamble being justified upon the potential for higher returns that, if earned, would mitigate the likelihood of breaching the regulatory minimum (Calem & Rob, 1999; Jokipii & Milne, 2011). The moral hazard encouraged by the presence of the state safety net would theoretically, only intensify this risk-seeking behaviour. It is observed by Williams (2014),

[36] See Jokipii and Milne (2011) for further on the capital buffer theory.
[37] See Shrieves and Dahl (1992), Aggarwal and Jacques (2001).
[38] See Heid, Porath, and Stolz (2004) with respect to German savings banks and Jokipii and Milne (2011) in relation to US BHCs..
[39] A diminished charter value arising from regulatory interference is a suggested implicit cost (Milne & Whalley, 2001). Buser, Chen, and Kane (1981) provides a detailed discussion on the implicit costs of falling below the regulatory minimum. For further on charter value see Keeley (1990), Acharya (1996).

studying Asian financial institutions, that the overall relationship between bank risk and capital is U-shaped.[40] Williams (2014) finds that the intensity of this risk-seeking behaviour lessen as bank capitalisation levels improve, but only to a certain point of capitalisation. After this point is reached, well-capitalised banks maintain their buffer by increasing (decreasing) credit risk when capital increases (decreases). This is consistent with the predictions under the capital buffer theory. A positive relationship between credit risk and capital holdings for well-capitalised banks can be explained by the higher cost of capital thereby riskier investments are necessary to meet the shareholders' required rate of return (Williams, 2014).

Where the causality runs between credit risk and capital is a significant empirical consideration. In addressing this, Jokipii and Milne (2011) studies whether the short-term adjustment to capital and credit risk is simultaneously determined for a set of US BHCs. The authors find evidence supporting such a simultaneous two-way adjustment between capital and credit risk. They link the notion that banks maintain an internally optimal probability of default by adjusting both capital and credit risk. As above, the relevant adjustment is contingent upon bank capitalisation (i.e. negative simultaneous adjustment for low buffer banks, positive adjustments for high buffer banks). This is consistent with the predictions of the capital buffer theory.

It is desirable from a regulator's perspective that a bank with high loan portfolio risk maintains a higher quality capital buffer. Should the riskier loans of this bank sour, insufficient quality in its buffers may increase the probability of bankruptcy. The above-mentioned studies address the capital-credit risk adjustment by focusing on the size of either (1) the capital ratio or, (2) buffer. However, two banks with similar sized capital ratios might still have different compositions of Tier 1 to Tier 2 capital in their buffers. All else being equal, a bank with greater proportions of Tier 1 capital in its buffers is better placed to weather losses on a going-concern basis. The literature does not address this consideration and leaves unanswered how banks adjust the quality of their buffers with varying degrees of credit risk.

As credit risk increases so too does the need to signal ongoing viability (provided charter values are influential upon bank manager decision-making) (Jokipii & Milne, 2011). It follows that such banks should reflect such viability in the composition of their capital buffers. Furthermore, it could

[40] A similar U-shaped relationship is observed by Jokipii and Milne (2011) for a sample of US BHCs.

be that capital buffer quality reflects managerial risk-aversion (Ho & Saunders, 1981). If this is the case then a bank with high credit risk but, managed by risk-adverse bankers, will compensate for this by growing the quality of its capital buffers. This is consistent with Williams (2007)'s findings in relation to aggregate capital holdings. Therefore, Hypothesis 4 suggests:

H4: There is a positive association between credit risk and capital buffer quality.

2.9. Investments in liquid assets (RQ2)

Banks have been observed to be increasing their investments in liquid assets (Bates et al., 2009; Bordeleau & Graham, 2010).[41] Empirical testing by Bates et al. (2009) supports the 'precautionary motive' explanation for the holding of excess liquid assets in recent years. In that paper, it is found that firms hold cash to buffer against adverse shocks when access to markets is costly. Bordeleau and Graham (2010) suggest that the holding of liquid assets improves profitability to a certain point. However, additional liquid holdings beyond that point reduce profitability. This is because liquid assets have relatively low return characteristics and create an opportunity cost to the bank. But how do banks adjust their capital buffers considering their holdings of liquid assets?

Jokipii and Milne (2011) rationalise, that greater liquid assets reduces the need for insurance against falling below the minimum capital requirements. This is consistent with the precautionary motive for holding liquid assets. The paper also posits that the '*risk weight associated with liquid assets means that banks can increase their capital buffers by liquidating assets*' (p.170). What this paper leaves unanswered is whether the same 'trade-off' against capital buffers and liquid assets applies to capital buffer quality. This motivates Research Question 2:

RQ2 - Do large banks trade–off capital buffer quality with liquid asset investments?

[41] The literature indicates four reasons for why a firm chooses to hold liquid assets (Bates et al., 2009). The "agency motive" suggests firms with agency problems, will in the absence of investment opportunities, accumulate cash over returning surplus funds to shareholders (Jensen, 1986). The "precautionary motive" suggests firms hold cash as a buffer against cash flow shocks when access to capital markets is costly (Opler, Pinkowitz, Stulz, & Williamson, 1999). The "transaction motive" indicates firms incur costs in transforming noncash assets into cash for the purposes of executing a transaction, therefore cash on hand is preferable (Baumol, 1952) . The "tax motive" exist for multinationals that may incur tax implications in repatriation of earnings (Foley, Hartzell, Titman, & Twite, 2007).

In contrast to Jokipii and Milne (2011), a positive association is found between capital ratios and liquid assets by Ahmad et al. (2008) and Pereira and Saito (2015). The authors suggest, consistent with Angbazo (1997), that the liquidity premium on the required rate of return on equity falls with greater liquid assets. This makes equity financing cheaper and more desirable for firms to issue capital at such times.

The extant literature appears to indicate that a bank with high liquidity, targets lower capital buffers (Berger et al., 2008; Jokipii & Milne, 2011). This may be through risk minimalization, as suggested by Jokipii and Milne (2011) or higher liquid assets being indicative of market access restrictions (Bates et al., 2009). The existing literature is yet to isolate how the composition of capital buffers varies across the level of liquid assets held by banks. This leads to Hypothesis 5:

H5: There is a negative association between asset liquidity and capital buffer quality.

2.10. Chapter Summary

This chapter provides the theoretical background on capital buffer quality. The resulting research questions and hypotheses are summarised in Table 2.1

Table 2.1 Summary of research questions and hypotheses

Research Question	**Hypotheses**
1. What bank characteristics influence capital buffer quality of large banks?	i. There is a negative association between bank size and capital buffer quality ii. There is a positive association between retail intensity and capital buffer quality iii. There is a positive association between operational complexity and capital buffer quality iv. There is a positive association between credit risk and capital buffer quality
2. Do banks trade off capital buffer quality with liquid asset investments?	v. There is a negative association between asset liquidity and capital buffer quality

Chapter 3: Data and Methodology

3.1. Introduction

This chapter, in describing the sample and methodology, is structured as follows: Section 3.2 elaborates upon the sample, data source and the sampling procedure adopted. Section 3.3 describes the empirical method utilised. Section 3.4 discusses the construction of dependent, hypothesis and control variables. Section 3.5 addresses econometric issues, which are pertinent given the potential for endogeneity in the proposed model. Section 3.6 provides guidance on further robustness tests to be performed while Section 3.7 concludes and summarises the chapter.

3.2. Sample selection

The sample comprises an unbalanced panel of US Bank Holding Companies (BHC), Financial Holding Companies (FHC) and, Savings and Loan Holding Companies (SLHC) (hereon collectively referred to as BHC) data covering the quarterly periods between 2001 and 2016.[42] Including three holding company variations (i.e. BHC, FHC and SLHC) is desirable given that significant variations exist across the operating activities of these entities. From the perspective of the hypothesis variables, this heterogenous characteristic enhances understanding as to what drives capital buffer quality amongst a collection of the largest banks. The requirement that large BHCs deduct investments in nonconsolidated affiliates (from their regulatory capital) only commenced from Quarter 1 2001. Failing to (1) recognise these affiliate structures and, (2) make appropriate deductions to the BHC's regulatory capital as a consequence, has been recognised by Gong et al. (2017) as a potential source of capital arbitrage. Obtaining a true and consistent evaluation of a bank's regulatory capital is central to this study. It is therefore appropriate to commence the sample period from the date from which large BHCs were required to make these deductions – Quarter 1 2001.

All BHC data is obtained from the holding company regulatory reports filed quarterly to the Federal Reserve, FR Y-9C and published by the Federal Reserve Bank of Chicago.[43] Consistent with the existing literature (for instance, Shim (2013) or Stiroh and Rumble (2006)), the focus is on BHCs, as opposed to individual commercial banks (which are in turn owned by BHCs). This approach is

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[42] See Appendix A.1 for the definitions used by US regulators in respect of these three regulatory structural holding companies.

[43] This data is publicly available at www.chicagofed.org/applications/bhc/bhc-home.

steeped in the regulator's "source of strength" doctrine, which leaves BHCs financially responsible for their subsidiary banks. [44] It is also consistent with capital adequacy requirements being judged on a consolidated basis. In turn, bank managers are expected to execute their financial strategy with the overall corporate group in mind. Consistent with that rationalisation, capital management policies are best understood at the BHC level.

Additionally, the US banking system is complicated by cross-ownership interests vis-à-vis some BHCs. To eliminate duplicate counting of the same activities under this tiered banking system, only top-tiered BHCs are included in the sample (Shim, 2013; Stiroh & Rumble, 2006).

Top-tiered BHCs must either file a FR Y-9C report or FR Y-9SP report with the regulator. BHCs with total consolidated assets exceeding $1 billion are automatically required to file the quarterly FR Y-9C report.[45] BHCs with asset sizes that do not meet this threshold must file the bi-annual FR Y-9SP report. The necessary data points to this study (including the components of regulatory capital) are only captured by the FR Y-9C filings.[46] Because this study is concerned with understanding whether there is something beyond the size of a large bank which drives its capital buffer quality, only large BHCs filing FR Y-9C reports are included in the sample.

Furthermore, only including large BHCs in the sample avoids the capitalisation trap examined by Gong et al. (2017), where the effective capitalisation ratios of small BHCs were found to be overstated. All BHCs contained in the data sample to this study are required to comply with the same regulatory standards with respect to the deductibility of minority interests held in banking affiliates. This consistent regulatory environment across the sample is essential to reporting accurate results.[47]

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[44] The 'source of strength' doctrine prescribed in Sec 38A Federal Deposit Insurance Corporation Improvement Act of 1991 where it states that "*bank holding company …[must]…serve as a source of financial strength for any subsidiary of the bank holding company… that is a depository institution.*"

[45] The reporting threshold for FR Y-9C reports was set at a minimum of $1 billion in total consolidated assets in March 2015. Before that, it was $500 million from March 2006. And before March 2006 it was $150 million.

[46] Data limitations prevent including banks who file FR Y-9SP reports in this study. Nonetheless, isolating larger banks has the benefit of unpacking whether there is something closer to their organisational structures that drives the quality of the capital buffers they maintain than their mere institutional size (such as retail intensity, operational complexity, credit risk and liquid asset investments). The hypothesis variables of this study are intended to capture these more fundamental variations in organisational structure.

[47] Gong et al. (2017) conduct their calculation of effective bank capitalisation ratios by two methods: The 'decompression' method and the 'deduction' method. The first of these involves pro forma consolidation of the minority-owned affiliates onto the balance sheet of the parent BHC. While the "deduction method" performed in

In relation to mergers and acquisitions, the target and acquirer are treated as unique observations for as long as the data is reported separately. The BHC regulatory code (known as the "RSSD ID") is used as the unique institutional identifier. Where the BHC RSSD ID changes, this is regarded as a newly created institution, reflecting the fact that such reorganisations indicate significant structural changes to the institution (Stiroh & Rumble, 2006). This approach mitigates sample-selection bias (Kashyap, Rajan, & Stein, 2002). If such newly created entities meet the minimum observations requirement (specified below), they are included in the sample.

Over the sample period consisting of 16 years, the reporting structure of FR Y-9C reports has undergone significant revisions. This presents the risk where two data item codes used over time, although identical in titles, are designed to capture different, albeit overlapping information points. Therefore, care is taken to ensure the codes utilised for construction of variables are consistent through time.[48] Care is also taken to address typographical errors that appear to be have been made during some stage of the reports being filed.

To be included in the data sample, each BHC must report a minimum of 8 quarters. This approach is consistent with previous studies concerned with examining BHCs over a similar number of years (Kashyap et al., 2002). Additionally, data is winsorised at the 1st and 99th percentiles (Elsas, Hackethal, & Holzhäuser, 2010). The final data set holds 78,963 observations over the 64 quarters commencing Quarter 1 2001 and ending Quarter 4 2016. Table 3.2 presents a summary of the observations included in the data sample. As between the three distinct regulatory holding company structures, Bank Holding Companies compose the majority of the sample (approximately 75.9% of the total observations). A sizeable contribution is also made by Financial Holding Companies (approximately 23.7%). The relatively large observance of FHCs is unsurprising given that the majority of BHCs who are permitted to operate in the wider array of activities permitted under the FHC classification, tend to themselves to be very large BHCs. Savings and Loan Holding Companies compose the remainder (approximately 0.4%) of the sample.

that study deducts from the parent BHC its investments in affiliates from its own equity. A version of the latter of these is the current approach taken by FDIC. It should be acknowledged that (Gong et al., 2017) prefer the 'decompression' method for its accuracy. However, this thesis follows the deduction method. This is in part because it is consistent with the Basel Accords. Furthermore, reconstructing the complex organisational structures of the 2,885 BHCs in the data sample was not feasible.

[48] Please refer to Appendix A.3 for the data item codes used in this study to compose the sample and construct the variables used in this study.

Table 3.1 – Sample data breakdown – Regulatory structure holding company classifications
This table lists the number of holding companies observed in the sample data according to their respective regulatory classifications over the 64 quarters commencing Quarter 1 2001 and ending Quarter 4 2016.

Criteria	**No. Observations**	**No. Bank IDs**
Classified as Bank Holding Company for regulatory purposes	59,952	2,165
Classified as Financial Holding Company for regulatory purposes	18,690	679
Classified as Savings and Loan Holding Company for regulatory purposes	321	41
Total	78,963	2,885
Number of unique holding companies with data for all 64 quarters		365

3.3. Empirical framework

This study adopts a partial adjustment model, consistent with the existing literature on bank capital buffer management (Ayuso et al., 2004; Jokipii & Milne, 2008; Pereira & Saito, 2015). This model is predicated on banks being thought of (1) having a pre-determined optimal capital buffer target, and (2) adjusting towards their target over time. Per Shrieves and Dahl (1992) and E. L. Brewer, G. G. Kaufman, and L. D. Wall (2008), the observed change in a bank's capital buffer, at any time can be compartmentalised into two parts, (1) a discretionary adjustment towards their target capital buffer, and (2) an adjustment forced by exogenous circumstances:

$$\Delta BUF_{i,t} = \Delta^{d} BUF_{i,t} + E_{i,t} \quad (1)$$

where, the subscripts *i*, and *t* denote individual banks and time horizons, ΔBUF is representative of the observed change in the capital buffer, $\Delta^{d}BUF$ denotes the desired discretionary change in the capital buffer, and *E* is an exogenously determined random shock term (E. L. Brewer et al., 2008). However, adjustment costs impede a bank's freedom to make instantaneous adjustments to their target capital buffer. In turn, the buffer adjustment, ΔBUF is not instantaneous with banks only partially adjusting to their target buffer, BUF^{*} between $t - 1$ and t (Pereira & Saito, 2015). The speed at which banks move towards their target buffer is captured by an adjustment term, θ.

$$\Delta BUF_{i,t} = \theta(BUF^{*}_{i,t} - BUF_{i,t-1}) + \varepsilon_{i,t} \quad (2)$$

or,

$$BUF_{i,t} = (1 - \theta)BUF_{i,t-1} + \theta BUF^{*}_{i,t} + \varepsilon_{i,t} \quad (3)$$

where, the subscripts *i*, and *t* again denote individual banks and time horizons. *BUF* denotes the capital buffer, θ is the speed of adjustment, *BUF** is the target capital buffer and, ε is a stochastic error term. The speed of adjustment term, θ, should be bound between 0 and 1. As the costs of adjusting to the target capital buffers falls, the term should approach 1 (i.e. complete instantaneous adjustment). The model assumes that exogenous circumstances will impact the ability of a bank to reach its target buffer, at times pushing an individual bank closer or further away from its desired buffer (Jokipii & Milne, 2011). Equation (2) in turn suggests the requirement for a bank to alter their actual buffer in order to return to their target buffer.

However, because the target capital buffer BUF^{*} is not observable, it is approximated by assuming it to be a function of a set of ***N*** explanatory variables:

$$BUF^{*}_{i,t} = \sum_{n=1}^{N} \theta \delta_n X_{ni,t} \quad (4)$$

Where, *X* is a vector of *N* explanatory factors and δ is a vector of parameters. The full suite of parameters used to explain target buffers are described in detail in Section 3.4.2. However, restating Equation (3) with the previously developed hypotheses and control variables generates the following model tested in this study:

$$\begin{aligned} BUF_{i,t} = (1 - \theta)BUF_{i,t-1} &+ \alpha_1 SIZE_{i,t} + \alpha_2 FIXASSETS_{i,t} + \alpha_3 HHI_{i,t} \\ &+ \alpha_4 RWA_{i,t-2} + \alpha_5 CASHMKTSEC_{i,t} + \beta_1 ROE_{i,t} \\ &+ \beta_2 MKTDISCIPLINE_{i,t} + Timedummies + \varepsilon_{i,t} \end{aligned} \quad (5)$$

3.4. Variable descriptions

3.4.1 Dependent variables

Before advancing to the buffer quality measure adopted in this study, understanding buffer size remains relevant. Although the emphasis of hypothesis testing is with respect to buffer quality, presenting results for buffer size offers a relevant comparison point against buffer quality, particularly with respect to speeds of adjustment terms.

Buffer size is defined as the amount of total capital held in excess to the regulatory minimum (Fonseca & González, 2010; Jokipii & Milne, 2011).

$$BUFFERSIZE = \frac{\frac{TIER1 + TIER2}{RWA} - REGMIN}{REGMIN} \quad (6)^{49}$$

where, *BUFFERSIZE* is the total capital buffer maintained by a bank each quarter; *TIER1* and *TIER2* are the total Tier 1 and Tier 2 capital respectively held by a bank in a quarter; *RWA* is the total risk weighted assets of the bank calculated quarterly; *REGMIN* is the regulatory minimum total risk-weighted capital ratio. Throughout the sample period, the regulatory minimum total risk-weighted capital ratio imposed by FDIC upon BHCs is 8% (FDIC, 2015).

In formulating an appropriate measure of buffer quality, a few preliminary points must be addressed. Although the Federal Deposit Insurance Corporation (FDIC) has required that BHCs hold 8% risk-weighted capital ratios, there have been restrictions placed upon the forms of capital that can count towards that 8% minimum. Before FDIC required that BHCs become compliant with its interpretation of Basel III (i.e. Quarter 1 2014), at least half of the 8% must have been Tier 1 capital. This study is concerned with that part of the total regulatory Tier 1 capital holdings that banks discretionarily hold above this 50% minimum of total regulatory capital. Therefore, an appropriate measure of buffer quality must isolate accordingly, what proportion of regulatory capital do banks hold discretionarily as either Tier 1 or Tier 2 capital:

$$\begin{aligned} BUFFERQUALITY \\ &= TOTAL\ TIER1\ CAPITAL \\ &- MINIMUM\ LEVEL\ OF\ TIER1\ CAPITAL \end{aligned} \quad (7)$$

The first term in Equation (7), *TOTAL TIER1 CAPITAL*, can be formally expressed as:

[49] Prior to Basel III, BHCs were permitted to hold Tier 3 regulatory capital (for market risk). However, no BHCs in the sample reported for Tier 3 capital.

$$TOTAL\,TIER1\,CAPITAL = \frac{TIER1}{RWA} \tag{8}$$

The second term in Equation (7) makes the necessary adjustment to subtract from a bank's Tier 1 capital holdings the proportion stipulated by the regulator:

$$MINIMUM\ LEVEL\ OF\ TIER1\ CAPITAL = \left(\frac{1}{2} \times \frac{TIER1 + TIER2}{RWA}\right) \tag{9}$$

Substituting these terms into Equation (7) gives the measure of buffer quality:

$$BUFFERQUALITY = \frac{TIER1}{RWA} - \left(\frac{1}{2} \times \frac{TIER1 + TIER2}{RWA}\right) \tag{10}$$

Equation (10) serves an appropriate measure of buffer quality prior to the adoption of Basel III. However, Basel III ushered in a new regime which raised the minimum level of quality banks need to hold. Firstly, the Tier 1 risk-based capital ratio lifted from 4% to 6%. Although the total risk-based capital ratio minimum remains at 8% under Basel III, the increased Tier 1 risk-based capital ratio requirement implies that a greater proportion of Tier 1 capital must constitute that 8%. Specifically, $\frac{6\%\ Tier\ 1\ capital\ minimum}{8\%\ Total\ capital\ minimum}$ implying that 75% of a bank's regulatory capital must qualify as Tier 1 capital (up from 50%).

In addition to raising the Tier 1 risk-based capital ratio, Basel III, among other things, also introduced two capital buffer mandates. The combination of the two buffers is intended to (1) address procyclicality in capital positions of banks and, (2) protect against the consequences of systemic risks that accumulate over time (BCBS, 2013). The phasing in of the first of these buffers, the Capital Conservation Buffer (CCB), began in 2016 with an additional 0.625% Common Equity Tier 1 (CET1) required to be set aside. This will gradually step up to 2.5% through to 2019 as described in Table 3.2.

Table 3.2 – Capital Conservation Buffer phase-in

Year	Capital Conservation Buffer
2016	0.625%
2017	1. 25%
2018	1.875%
2019	2.50%

This introduces a degree of complication to constructing the measure of buffer quality. The regulations identify CET1 as the necessary instrument to compose the CCB. However, the measure of buffer quality used in this study is more broadly classed as Tier 1 capital (and therefore treats CET1 and Additional Tier 1 capital indifferently) vs Tier 2 capital. Prior to Basel III's adoption, FR Y-9C reports were not structured in a manner that either stated CET1 or provided the necessary reporting details to accurately calculate it. Because much of the sample period for this study is set prior to Basel III, use of a broader buffer quality measure is a necessity.

Including the newly mandated Capital Conservation Buffer is appropriate for the 2016 sample period as:

$$BUFFERQUALITY16 = \frac{TIER1}{RWA} - \left(\frac{6.625}{8} \times \frac{TIER1 + TIER2}{RWA}\right) \tag{11}$$

A second buffer measure introduced under Basel III is the Counter-Cyclical Capital Buffer (CCyB). US regulators have the discretion to mandate that Advanced Approaches BHCs set aside an additional buffer of up to 2.5% CET1 at times when systemic vulnerabilities are unacceptably high.[50] Importantly though, to this point the Federal Reserve Board has left the CCyB at 0%.[51] Therefore, as the CCyB is dormant during the sample period, no adjustment is necessary to the measure of buffer quality.

[50] Under Basel II, approved banks can use internal models to calculate the amount of capital required to be held for operational risk. These banks operate under the 'advanced measurement approach' (AMA). Basel II also allows approved banks to rely upon their internal models for credit risk purposes under the internal ratings-based (IRB) systems for credit risk. This avoids a bank using the risk-weight pools prescribed under the Basel Accords (BCBS, 2006; Lubbe & Snyman, 2010). These alternative methodologies are followed in Basel III too. Banks who use both the AMA and IRB are known as Advanced Approaches Banks.

[51] https://www.federalreserve.gov/newsevents/pressreleases/bcreg20161024a.htm

Table 3.3 Variable definitions and data sources for Equation 5

This table defines all variables used in Equation 5. All measures are calculated by the author using FR Y-9C reports.

Variables	Measures	Definition	Prior Literature
Panel A: Dependent variables			
BUFSIZE	Capital buffer size	Amount of total Tier 1 and Tier 2 regulatory capital held in excess to the regulatory minimum	Fonseca and González (2010); Jokipii and Milne (2011); Pereira and Saito (2015)
BUFQUAL	Capital buffer quality	Proportion of Tier 1 regulatory capital discretionarily held by a bank	
Panel B: Alternative dependent variable			
TONE	Capital buffer quality	Total Tier 1 regulatory capital to risk-weighted assets (in thousands)	Francis and Osborne (2010)
Panel C: Primary independent variables			
SIZE	Bank size	Natural log of bank total assets (in thousands)	Nier and Baumann (2006); Jokipii and Milne (2011)
FIXASSETS	Retail intensity	Fixed assets to total assets (in thousands)	Williams (2014)
HHI	Operational complexity	The extent of diversification between total interest income and non-interest income	Stiroh and Rumble (2006); Sanya and Wolfe (2011)
RWA_{t-2}	Credit risk	Two period lag of risk-weighted assets to total assets	Rime (2001); Laeven and Majnoni (2003); Prasad and Espinoza (2010); Jokipii and Milne (2011); Shim (2013)
CASHMKTSEC	Investments in liquid assets	Cash and marketable securities to total assets (in thousands)	Kashyap et al. (2002); Berger and Bouwman (2013); Shim (2013)
Panel D: Alternative independent variables			
OBS/SIZE	Composite measure of bank size and off-balance sheet activities	Natural log of off-balance sheet activities to the natural log of total assets (in thousands)	Berger et al. (2008); Ziadeh-Mikati (2013)
$NPL_{t\,t-2}$	Credit risk	Non-performing loans to total loans (in thousands)	Ayuso et al. (2004); Shim (2013); Pereira and Saito (2015)
$PROV_{t-2}$	Credit risk	Loan loss provisions to total assets (in thousands)	Francis and Osborne (2010); Fonseca and González (2010)

COMLOAN $_{t-2}$	Credit risk	Commercial and industrial loans to total loans (in thousands)	Jokipii and Milne (2011)
LOANEXP	Retail intensity	Credit card loans, other consumer loans and 1 – 4 family mortgages to total loans (in thousands)	Hirtle and Stiroh (2007)
DEPOSIT	Retail intensity	NOW account, small time deposits and savings account deposits to total deposits (in thousands)	Hirtle and Stiroh (2007)
MKTSEC	Investments in liquid assets	Marketable securities to total assets (in thousands)	Kashyap et al. (2002); Loutskina (2011)
Panel E: Interaction variables			
$DQUAL_{LOW}$	Degree of capitalisation	A dummy variable taking the value of unity if $Bank_i$ is in the bottom 20 percentile of observations in terms of its proportion of Tier 1 regulatory capital discretionarily held, and 0 otherwise	Jokipii and Milne (2011)
$DQUAL_{HIGH}$	Degree of capitalisation	A dummy variable taking the value of unity if $Bank_i$ is in the top 20 percentile of observations in terms of its proportion of Tier 1 regulatory capital discretionarily held, and 0 otherwise	Jokipii and Milne (2011)
$DSIZE_{LOW}$	Degree of capitalisation	A dummy variable taking the value of unity if $Bank_i$ is in the bottom 20 percentile of observations in terms of the size of its capital buffer	Jokipii and Milne (2011)
$DSIZE_{HIGH}$	Degree of capitalisation	A dummy variable taking the value of unity if $Bank_i$ is in the top 20 percentile of observations in terms of the size of its capital buffer	Jokipii and Milne (2011)
$DTONE_{LOW}$	Degree of capitalisation	A dummy variable taking the value of unity if $Bank_i$ is in the bottom 20 percentile of observations in terms of the size of its Tier 1 regulatory capital ratio to risk-weighted assets, and 0 otherwise	Jokipii and Milne (2011)
$DTONE_{HIGH}$	Degree of capitalisation	A dummy variable taking the value of unity if $Bank_i$ is in the top 20 percentile of observations in terms of the size of its Tier 1 regulatory capital ratio to risk-weighted assets, and 0 otherwise	Jokipii and Milne (2011)
Panel F: Control variables			
ROE	Opportunity cost of capital	Average quarterly return on equity (ratio of quarterly earnings to quarterly average equity)	Berger et al. (1995); Jokipii and Milne (2008); Francis and Osborne (2010); Pereira and Saito (2015)
SUBORD	Market discipline	Subordinated debt to total liabilities (in thousands)	Francis and Osborne (2010); Pereira and Saito (2015)

3.4.2 Hypotheses variables

$SIZE_{i,t}$ is calculated as the natural log of total assets. A negative association with buffer quality could indicate an ability of larger banks to raise external Tier 1 capital with lower transaction costs (Kleff & Weber, 2008). With superior market access and an ability to leverage off their reputation as "Too Big to Fail", a larger bank is better placed to actively manage the quality of its idle capital. Given that this study draws a population of banks classified by the regulator to be "large" (having a minimum of $500 million in total assets), it is particularly interesting to understand whether the size factor persists across the largest institutions.

$FIXASSETS_{i,t}$ measured as the share of fixed assets to total assets. A high proportion of fixed assets tends to be characteristic of retail banks, reflecting their investment in bank branches and product distribution networks such as ATMs. Retail banks are considered to have restricted access to capital (Hirtle & Stiroh, 2007). With limited access to capital markets, a positive association could exist between retail intensity and the proportion of Tier 1 capital in the buffers. An impeded capacity to tap capital markets at short notice is thought to limit retail intensive banks' ability to raise Tier 2 capital. For both these reasons, the expected sign is positive.

$HHI_{i,t}$, measures revenue diversification by using a Herfindahl-Hirschman index to proxy for operational complexity. A bank with diversified revenue lines is structurally more complex and prone to agency problems (Laeven & Levine, 2007; Stiroh & Rumble, 2006). This may increase the desirability for an operationally complex bank to signal its ongoing viability by having a higher quality capital buffer. Moreover, hedging against exposures and preserving their charter value would be further explanations for such a bank holding a higher quality capital buffer (Jokipii & Milne, 2008).

Mathematically, $HHI_{i,t}$, calculates the extent to which a bank is diversifying its revenues by:

$$HHI = 1 - (SH_{INT}^2 + SH_{NON}^2) \tag{12}$$

where, SH_{INT}^2 is the share of total operating revenue from interest income and, SH_{NON}^2 is the share of operating revenue from non-interest sources, defined as:

$$SH_{INT} = \frac{INT}{INT + NON} \tag{13}$$

$$SH_{NON} = \frac{NON}{INT + NON}$$

A lower *HHI* indicates a bank with a less diversified revenue base – 0.0 indicating complete revenue concentration, with all revenue being generated from a single source. A *HHI* of 0.5 indicates an equal split between interest income and non-interest income (i.e. complete diversification), as described by Stiroh and Rumble (2006). Hypothesising that an operationally complex bank desires signalling its ongoing viability with higher quality capital buffers, a positive sign is expected.

Greater exposure to off-balance sheet activities, similarly to revenue diversification, is also closely related to firm opacity (Laeven & Levine, 2007; Williams & Rajaguru, 2013). Therefore, as an alternative measure of operational complexity the natural log of off-balance sheet activities to the natural log of total assets is used to calculate $OBS/SIZE_{i,t}$.[52]

$RWA_{i,t-2}$ measured as the proportion of risk-weighted assets to total assets. The ratio of risk-weighted assets to total assets is broadly acknowledged as a reliable proxy for credit portfolio risk (Jokipii & Milne, 2011). The Basel accords methodology for calculating risk-weighted assets focuses on credit risk as differentiated from market risk. Regulators are specifically concerned with credit risk, and desire that banks exposed to higher credit risk levels be made to hold higher quality capital buffers to mitigate their risk of failing (BCBS, 2013; Jokipii & Milne, 2011).

In this study, the intertemporal dynamic between capital and risk is explored by taking a two-period lag of risk-weighted assets. This structure mitigates potential endogeneity problems and is adopted in the prior literature for that purpose (Francis & Osborne, 2010; Laeven & Majnoni, 2003; Prasad & Espinoza, 2010). The direction of causality that this study is interested in, is how credit risk influences capital buffer quality. It is generally recognised that a bank requires time to make a desired capital adjustment following realisation of its credit risk exposure (Prasad & Espinoza, 2010). And so, in addition to mitigating potential endogeneity problems (Laeven & Majnoni, 2003), this structure achieves the desired causality direction (Prasad & Espinoza, 2010).

[52] As reported in the Table 4.2 – Correlation Matrix, there is a high correlation between the measure of OBS and *SIZE*. Therefore, a composite measure of the two is used in robustness testing.

A negative sign would indicate moral hazard behaviour whereby banks with greater credit risk hold smaller proportions of Tier 1 capital in their buffers. A positive sign may support risk aversion where banks with a higher risk loan portfolio hold higher quality buffers to signal their ongoing viability. In robustness testing two alternative measures of credit risk are introduced. $NPL_{i,t}$ is calculated as non-performing loans to total loans, while $PROVISIONS_{i,t}$ is measured as loan loss provisions to total assets.

$CASHMKTSEC_{i,t}$ measured as cash and marketable securities divided by total assets. This is used in this study to proxy for liquid asset investments. A bank with greater investments in low yielding, liquid assets (such as cash and marketable securities), may hold a smaller proportion of Tier 1 capital in its buffers. This could be a function of lower profits translating into smaller Tier 1 capital holdings. Equally, with greater investments in liquid assets, a bank may gravitate towards lower quality buffers because there is less need for buffers in the presence of low risk, highly liquid assets. However, a positive sign may be explained by banks capitalising upon a lowered required rate of return on bank shares due to their investments in assets regarded as safe (Pereira & Saito, 2015). Greater investment in liquid assets could imply that the liquidity premium on raising equity lowers, this may encourage banks to raise equity while the cost of Tier 1 capital is cheaper (Ahmad et al., 2008; Angbazo, 1997). Loutskina (2011) suggests that cash holdings will, in part, represent required reserves and therefore cannot be expected to be easily drawn upon. For this reason, $MKTSEC_{i,t}$ which measures marketable securities to total assets, is included as an alternative measure.

3.4.3 Interaction terms

Equation (5) assumes that the speed of adjustment term is consistent across all banks. Across a heterogenous collection of entities with varying capitalisation levels, this is perhaps an unrealistic assumption. The capital buffer theory suggests that degrees of capitalisation will inform how banks' capital buffer quality vary. Under the theory, undercapitalised banks are expected to improve their capitalisation toward an internally optimal target (Peura & Keppo, 2006). Meanwhile, well-capitalised banks sustain capital at their target buffer. By extension it should be expected that banks with smaller buffers have faster adjustment speeds than superiorly capitalised banks (Jokipii & Milne, 2011).

To capture these variations a pair of interaction terms are introduced into the regressions. Consistent with the methodology adopted by Jokipii and Milne (2011) $DQUAL_{LOW}$ is a dummy that equals unity if BUFQUAL is in the bottom 20th percentile of observations, and zero otherwise. $DQUAL_{HIGH}$ is a dummy that equals unity if the BUFQUAL is in the top 20th percentile, and zero otherwise. These dummies are interacted with the speed of adjustment term to ascertain how buffer quality adjustment speeds varies depending on the degree of bank capitalisation.

3.4.4 Control variables

Some form of profitability measure is consistently adopted in the existing literature to proxy for the opportunity cost of capital. In this study, $ROE_{i,t}$ is used, consistent with the existing literature, however equity is normalised (by taking the average of the start and end quarterly equity figures) to provide a more accurate profitability proxy. It is suggested that financially sound banks may substitute earnings for capital, and particularly Tier 1 capital (Milne, 2004b). This would correspond with a negative relationship between buffer quality and profitability. However, it is also acknowledged by Jokipii and Milne (2008) that interpreting ROE may require revenue analysis, as opposed to a opportunity cost analysis. From a revenue perspective, profitable banks may be better placed to grow their capital buffer quality, relatively cheaply. Under this interpretation, a positive association with buffer quality could be anticipated.

$SUBORD_{i,t}$ measured as the share of interbank deposits and subordinated debt to total liabilities. A bank which has a greater proportion of uninsured funding is likely to be more exposed to market discipline (Francis & Osborne, 2010). If banks are responsive to market disciplinary effects, then to signal their ongoing viability, higher quality capital buffers may be desirable. Under this hypothesis, a positive association with buffer quality is anticipated for higher levels of uninsured funding.

3.5. Econometric considerations

The capital-risk decision is widely regarded as a two-way relationship (Ayuso et al., 2004; Shrieves & Dahl, 1992). This reality saddles the partial adjustment model with endogeneity complications. The literature has developed two primary means of addressing the endogeneity between capital and risk. The first approach is to solve for the two through simultaneous equations (for instance, this approach is followed by Rime (2001) and Jokipii and Milne (2011)). This method offers insights into the coordination of the capital-risk decision (Pereira & Saito, 2015). However, the simultaneous equations approach has been criticised in part because unobserved bank heterogeneity may persist when using least squares estimators in two or three stage models (which are commonly used in the simultaneous equations approach) (Fiordelisi, Marques-Ibanez, & Molyneux, 2011; Pereira & Saito, 2015). The second approach is to address endogeneity issues directly within the econometric model adopted (Alfon, Argimon, & Bascuñana-Ambrós, 2004; Francis & Osborne, 2010; Lindquist, 2004). This thesis utilises the latter approach as its primary estimation method.

Equation (5) is expressed as a dynamic structure in a panel data context (García-Suaza et al., 2012). For that reason, the system GMM estimator first proposed by Arellano and Bond (1991) and later refined by Blundell and Bond (1998) is the primary econometric model for this study. The suitability of a system GMM is emphasised through its ability to model dependent variables that are themselves dependent upon their own past occurrences (Roodman, 2006). This is important in the context of a lagged buffer quality measure, the coefficient of which explains the speed of adjustment. The introduction of more instruments by assuming that the first differences of instrument variables are uncorrelated with the fixed effects is an important efficiency gain associated with the system GMM over the difference GMM (Roodman, 2006). This is achieved through combining regressions in differences with a regression in levels (Pereira & Saito, 2015). A two-step process is adopted because of its asymptotic efficiency gains over the first stage estimator (Roodman, 2006).

To avoid a large number of instruments – which results in severely downward biased standard errors – lags are limited and instruments collapsed using the method outlined by Holtz-Eakin, Newey, and Rosen (1988) (consistent with Roodman (2006)). The standard errors are notoriously downward biased, and so in addition to limiting and collapsing instruments (which both mitigate this bias), the Windmeijer (2005) finite sample correction to the two-step covariance matrix is applied. Furthermore, to ascertain whether the instruments are valid the Hansen test of over-identifying restrictions is reported, as too is the Arellano and Bond (1991) autocorrelation test in the residuals AR(1) and AR(2).

The results' robustness is tested by introducing two additional econometric models, being pooled ordinary least squares (POLS) and two-way fixed effects panel models (FE). This is consistent with the methodology advanced by Bond (2002) and as used by Francis and Osborne (2010) (in relation to FE only) and Prasad and Espinoza (2010) and Pereira and Saito (2015) (in relation to both POLS and FE). The POLS estimation defines all variables in levels, but as acknowledged by Pereira and Saito (2015) the lagged dependent variable is endogenous to the omitted fixed effect term. The POLS estimates are also upward biased (Prasad & Espinoza, 2010). The FE panel model addresses the endogeneity problem encountered in the POLS estimate by removing fixed effects and addressing unobserved heterogeneity (Kenward & Roger, 1997). However, the within group FE estimates are downward Nickell biased (Nickell, 1981). Further still, the FE estimate ignores the correlation between the lagged dependent variable and the error term Pereira and Saito (2015).Therefore, by constructing valid instrumental variables, the system GMM remains the primary model. This is achieved by using lagged structures for endogenous terms (Blundell & Bond, 1998).

3.6. Robustness testing

In addition to the robustness associated with modelling techniques employed in this thesis, a series of additional robustness checks are performed. These involve (1) an alternative dependent variable for capital quality (2) testing across time subsamples, and (3) alternative hypothesis variable specifications.

3.7. Chapter summary

After identifying research questions in Chapter 1 and developing corresponding hypotheses in Chapter 2, this chapter is designed to elaborate upon the empirical framework used to test the hypotheses. This includes discussing the econometric models to be employed, constructing dependent, hypothesis and control variables and examining the collection method used to develop the data sample.

Table 3.4 – Summary of hypotheses and expected testing results

Hypothesis	Expected testing result
H1. There is a negative association between bank size and capital buffer quality	The estimated value of α_1 (bank size coefficient) in Equation 5 is negative and statistically significant.
H2. There is a positive association between retail intensity and capital buffer quality	The estimated value of α_2 (retail intensity coefficient) in Equation 5 is positive and statistically significant.
H3. There is a positive association between operational complexity and capital buffer quality	The estimated value of α_3 (operational complexity coefficient) in Equation 5 is positive and statistically significant.
H4. There is a positive association between credit risk and capital buffer quality	The estimated value of α_4 (credit risk coefficient) in Equation 5 is positive and statistically significant.
H5. There is a negative association between asset liquidity and capital buffer quality	The estimated value of α_5 (liquid assets coefficient) in Equation 5 is positive and statistically significant.

Chapter 4: Results

4.1. Introduction

This chapter presents the results to the hypotheses developed in Chapter 2. Section 4.2 describes the summary statistics for the regression variables. Section 4.3 reports the regression results. Section 4.4 describes the results to additional robustness tests. Section 4.5 concludes with a chapter summary.

4.2. Summary statistics

Table 4.1 reports the descriptive statistics for the regression variables. Despite the sample consisting of 'large' banks, the dispersion of the *SIZE* variable, which ranges from a natural log of total assets of 11.92 to 20.62 and has a mean of 13.62, reveals material variation in bank size. It is also worth acknowledging that the largest observation of off-balance sheet activities (22.74) is greater than the largest observation of bank size (20.52).[53] This study is interested in understanding a bank's notional exposure to off-balance sheet activities. For this reason, taking the absolute values of the totals reported is preferable for the respective off-balance sheet activities (the totals of which include positive and negative exposures).

Table 4.1 – Descriptive statistics

This table presents the summary statistics for the variables that represent specific characteristics of the banks in the sample on a quarterly basis. Where *BUFQUAL* is the proportion of Tier 1 regulatory capital discretionarily held by a bank. *TONE is* the total Tier 1 regulatory capital to risk-weighted assets. *BUFSIZE* is the amount of total Tier 1 and Tier 2 regulatory capital held in excess to the regulatory minimum. *SIZE* is the natural log of total bank assets. *FIXASSET* is the proportion of fixed assets to total bank assets. *LOANEXP* is the proportion of retail loans to total loans. *DEPOSIT* is the proportion of short term deposits held to total deposits. *HHI* measures the revenue diversification between non-interest income and total interest income. *OBS* is the natural log of the notional value of off-balance sheet activities. *OBS/SIZE* is the natural log of the notional value of off-balance sheet activities divided by the natural log of total bank assets. RWA_{t-2} is a two-period lag of risk-weighted assets to total assets. NPL_{t-2} is a two-period lag of non-performing loans to total loans. $PROV_{t-2}$ is a two-period lag of loan loss provision to total assets. $COMLOAN_{t-2}$ is a two-period lag of commercial loans to total loans. *CASHMKTSEC* is cash and marketable securities to total bank assets. *MKTSEC* is marketable securities to total bank assets. *ROE* is the average return on equity. SUBORD is the proportion of subordinated debt to total liabilities. A full description of each variable is presented in Table 3.2. All variables are estimated quarterly for each bank.

Year	Obs.	Mean	Std. Dev	Min	Max
BUFQUAL	78963	0.0562	0.0273	-0.0177	0.2198
TONE	78963	13.2136	5.0602	-3.5300	45.2000
BUFSIZE	78963	0.0671	0.0500	-0.1153	0.3965
SIZE	78963	13.6243	1.2955	11.9205	20.5186
FIXASSET	78963	0.0187	0.0099	0.0010	0.0535
LOANEXP	78963	0.3430	0.1725	0.0108	0.9527
DEPOSIT	78953	0.7014	0.1146	0.0934	0.9618
HHI	78963	0.2527	0.1096	0.0110	0.4996
OBS	78963	10.8601	2.0197	5.0752	22.7408
OBS/SIZE	78963	0.7923	0.0849	0.4168	1.0926
RWA_{t-2}	73396	0.7162	0.1148	0.3334	1.0189
NPL_{t-2}	73396	0.0160	0.0225	0.0000	0.2491
$PROV_{t-2}$	73396	0.0022	0.0044	-0.0048	0.0750

[53] This anomalous result is driven by a few observations with respect to the largest FHCs in the sample, such as Goldman Sachs, JP Morgan and Citibank.

COMLOAN$_{t-2}$	73396	0.1538	0.0945	0.0000	0.5666
CASHMKTSEC	78963	0.1794	0.1047	0.0128	0.5799
MKTSEC	78963	0.1303	0.0983	0.0000	0.5326
ROE	78963	0.0483	0.1918	-8.6523	0.6873
SUBORD	78963	0.0093	0.0136	0.0000	0.0812

Table 4.2 reports the correlations between the regression variables. A persistent negative correlation is observed across all credit risk measures and the buffer quality measure. Interestingly, this theme is replicated across both buffer size and Tier 1 ratios (an alternative measure of capital quality). Such a negative correlation can be thought of as consistent with high risk tolerant banks favouring high leverage (low capital) and higher asset risk (Kim & Santomero, 1988). Ho and Saunders (1981) argue that capital holdings proxy for managerial risk-aversion which is supported by these relationships (Williams, 2007). Further, as is suggested (and similarly found) by Jokipii and Milne (2011) this negative association can be attributed to the variation across cross-sectional risk preference. Such a result (with respect to non-performing loans) is specifically consistent with Shrieves and Dahl (1992), Jacques and Nigro (1997) and Aggarwal and Jacques (1998). Furthermore, the statistical significance of the credit risk variables correlations with other variables, and particularly the dependent buffer quality variable, reiterates the validity of using a two-period lag structure.

Of note is a high correlation between off-balance sheet activities and bank size. This is not an unsurprising result, given that larger banks are generally expected to be large participants in utilising off-balance sheet activities as a means of generating additional income. For this reason, the primary measure of operational complexity utilised in this study references revenue diversification (via HHI). For robustness testing, a composite measure of off-balance sheet activities to bank size is introduced. The negative correlation between buffer quality and bank size is preliminary evidence of the largest institutions holding lower quality buffers.

Table 4.2 – Correlation matrix

This table presents the correlations between the variables that represent specific characteristics of the banks in the sample on a quarterly basis. *BUFQUAL* is the proportion of Tier 1 regulatory capital discretionarily held by a bank. *TONE is* the total Tier 1 regulatory capital to risk-weighted assets. *BUFSIZE* is the amount of total Tier 1 and Tier 2 regulatory capital held in excess to the regulatory minimum. *SIZE* is the natural log of total bank assets. *FIXASSET* is the proportion of fixed assets to total bank assets. *LOANEXP* is the proportion of retail loans to total loans. *DEPOSIT* is the proportion of short term deposits held to total deposits. *HHI* measures the revenue diversification between non-interest income and total interest income. *OBS* is the natural log of the notional value of off-balance sheet activities. *OBS/SIZE* is the natural log of the notional value of off-balance sheet activities divided by the natural log of total bank assets. RWA_{t-2} is a two-period lag of risk-weighted assets to total assets. NPL_{t-2} is a two-period lag of non-performing loans to total loans. $PROV_{t-2}$ is a two-period lag of loan loss provision to total assets. $COMLOAN_{t-2}$ is a two-period lag of commercial loans to total loans. *CASHMKTSEC* is cash and marketable securities to total bank assets. *MKTSEC* is marketable securities to total bank assets. *ROE* is the average return on equity. SUBORD is the proportion of subordinated debt to total liabilities. All variables are estimated quarterly for each bank. *, **, *** Significance at the 10, 5 and 1% levels of significance, respectively.

	BUF QUAL	*BUF* $QUAL_{t-1}$	*TONE*	$TONE_{t-1}$	*BUF SIZE*	*BUF* $SIZE_{t-1}$	*SIZE*	*FIX ASSET*	*LOAN EXP*	*DEPOSIT*	*HHI*
BUFQUAL	1										
$BUFQUAL_{t-1}$	0.963***	1									
TONE	0.911***	0.901***	1								
$TONE_{t-1}$	0.890***	0.919***	0.979***	1							
BUFSIZE	0.862***	0.853***	0.982***	0.960***	1						
$BUFSIZE_{t-1}$	0.843***	0.870***	0.961***	0.982***	0.976***	1					
SIZE	-0.206***	-0.196***	-0.0928***	-0.0900***	-0.0587***	-0.0553***	1				
FIXASSET	-0.0845***	-0.0879***	-0.125***	-0.125***	-0.126***	-0.126***	-0.198***	1			
LOANEXP	0.241***	0.239***	0.231***	0.230***	0.215***	0.214***	-0.0512***	0.0521***	1		
DEPOSIT	0.0360***	0.0342***	0.0147***	0.0139***	0.0055	0.0046	0.0468***	0.0325***	0.247***	1	
HHI	-0.0469***	-0.0483***	0.0169***	0.0108**	0.0359***	0.0303***	0.325***	0.119***	0.0370***	0.00911*	1
OBS	-0.303***	-0.294***	-0.210***	-0.206***	-0.175***	-0.171***	0.900***	-0.173***	-0.0894***	0.0215***	0.335***
OBSTOSIZE	-0.342***	-0.335***	-0.288***	-0.284***	-0.263***	-0.258***	0.612***	-0.101***	-0.120***	0.00175	0.265***
RWA_{t-2}	-0.514***	-0.521***	-0.533***	-0.536***	-0.513***	-0.518***	0.101***	0.0584***	-0.411***	-0.0443***	-0.0714***
NPL_{t-2}	-0.0506***	-0.0485***	-0.0471***	-0.0411***	-0.0247***	-0.0169***	0.0977***	0.0338***	-0.0785***	-0.0299***	0.0110**
$PROV_{t-2}$	-0.116***	-0.121***	-0.136***	-0.137***	-0.115***	-0.115***	0.0949***	0.0214***	-0.0686***	-0.0010	-0.0033
$COMLOAN_{t-2}$	-0.153***	-0.152***	-0.141***	-0.141***	-0.125***	-0.125***	0.0955***	-0.0836***	-0.404***	-0.124***	0.102***
CASHMKTSEC	0.418***	0.413***	0.413***	0.405***	0.396***	0.388***	-0.238***	-0.0228***	0.0519***	-0.0683***	0.0603***
MKTSEC	0.412***	0.407***	0.387***	0.383***	0.364***	0.359***	-0.282***	-0.0204***	0.112***	0.0121**	-0.0048
ROE	0.133***	0.109***	0.145***	0.113***	0.144***	0.106***	-0.0307***	-0.0177***	0.0255***	-0.0005	0.0619***
SUBORD	-0.327***	-0.329***	-0.253***	-0.254***	-0.160***	-0.161***	0.317***	0.0373***	-0.192***	-0.0346***	0.0838***

	OBS	*OBS TO SIZE*	RWA_{t-2}	NPL_{t-2}	$PROV_{t-2}$	*COM* $LOAN_{t-2}$	*CASH MKT SEC*	*MKTSEC*	*ROE*	*SUBORD*
OBS	1									
OBSTOSIZE	0.891^{***}	1								
RWA_{t-2}	0.241^{***}	0.340^{***}	1							
NPL_{t-2}	0.0183^{***}	-0.0561^{***}	-0.0212^{***}	1						
$PROV_{t-2}$	0.0508^{***}	0.0029	0.150^{***}	0.476^{***}	1					
COM_{t-2}	0.106^{***}	0.0840^{***}	0.230^{***}	-0.0992^{***}	-0.0089^{*}	1				
CASHMKTSEC	-0.326^{***}	-0.364^{***}	-0.525^{***}	-0.0375^{***}	-0.0962^{***}	-0.0157^{***}	1			
MKTSEC	-0.354^{***}	-0.372^{***}	-0.492^{***}	-0.147^{***}	-0.162^{***}	-0.0300^{***}	0.910^{***}	1		
ROE	-0.0059	0.0141^{***}	-0.0478^{***}	-0.357^{***}	-0.304^{***}	0.0414^{***}	0.0442^{***}	0.0932^{***}	1	
SUBORD	0.328^{***}	0.273^{***}	0.270^{***}	0.222^{***}	0.183^{***}	0.0685^{***}	-0.244^{***}	-0.280^{***}	-0.127^{***}	1

The reported correlations serve as an informative early stage analysis. However, understanding how the variables operate beyond two-way relationships is only possible by considering the regression results presented below in Section 4.3.

4.3. Overview of empirical results

The empirical estimations to equation (5) are presented in Table 4.3 for all banks covering the entire sample period (Quarter 1 2001 – Quarter 4 2016) with the dependent variable *BUFQUAL* (the primary measure of capital buffer quality). The same analysis is then presented separately according to the three regulatory holding company structures (Bank Holding Company, Finance Holding Company and Savings and Loan Holding Company) in Tables 4.4 – 4.6. Appendix A.2 reports results for re-estimations of equation (5) while replacing the dependent variable with *BUFSIZE* (the measure of capital buffer size), therefore offering a direct comparison to the existing literature that study capital buffers in aggregate.

4.3.1. Results for buffer quality

This section answers RQ1 and RQ2 by addressing Hypotheses 1 -5 (which are listed in Table 2.1). The results to the capital buffer quality estimations are presented in Table 4.3. Following the existing literature, Models (1) and (2) are estimated using a Pooled Ordinary Least Squares (POLS) regression; Models (3) and (4) are estimated using two-way fixed effects panel (FE) regressions and Models (5) and (6) are estimated using the two-step Blundell and Bond (1998) system GMM (the primary estimation model adopted in this study) (Francis & Osborne, 2010; García-Suaza et al., 2012; Pereira & Saito, 2015).

The autocorrelation test indicates that the condition of the absence of second-order serial correlations is met for the system GMM models. Further the Hansen statistic does not imply over-identification restrictions on the estimated equations for Models (5) and (6).

H1 is tested using the estimate for *SIZE*. A consistently negative and statistically significant coefficient for *SIZE* across the six models is estimated. This extends the existing literature's observation that larger banks hold smaller capital buffers, by indicating that larger banks also hold lower quality buffers. This may be because larger banks are met with less market scepticism when raising capital, and so can afford to hold lower quality buffers (given the high opportunity costs of idle capital) (Kleff & Weber, 2008) . It may also be a product of larger banks operating under implicit TBTF expectations. This pronounced negative association stands despite the sample itself being drawn from the largest financial institutions in the US.

Contrary to H2, statistically significant negative estimates are reported in Models (1) – (3) for the coefficient to *FIXASSET*. An explanation for this may be that retail intensive banks, due to the 'stable' nature of their traditional banking services (the stability of which is only increased in the presence of deposit insurance), are considered less exposed to shock funding withdrawals. This stable funding structure may deter retail banks from holding highly loss absorbent but costly capital buffers (Köhler, 2015).[54] However, both system GMM models find no statistically significant relationship between *FIXASSET* and *BUFQUAL*.

The positive association between *HHI* and *BUFQUAL,* in models (5) and (6) is suggestive of more operationally complex, diversified banks holding higher quality capital buffers. This may be driven by the increased agency problems associated with more complex institutions making it more desirable that they signal to the markets their financial good health (Jensen & Meckling, 1976; Laeven & Levine, 2007). Operational complexity is also associated with the potential for uninformed funding sources, this uncertainty can result in sudden and unpredictable funding withdrawals (Huang & Ratnovski, 2011). To mitigate impact that such withdrawals could have on a bank's operations may encourage operationally complex banks to hold greater holdings of loss-absorbent Tier 1 capital as a component of their buffers. This finding supports H3. Although Model (2) and Model (4) both report negative associations between *HHI* and *BUFQUAL*, it is worth mentioning that these are two models which interact degrees of capitalisation with adjustment speeds, and so are not the focus of the analysis.

Contrary to H4, RWA_{t-2} is consistently negative at the 1% significance level in Models (1) – (5). Taking Model (5)'s estimate, indicates that a 1% increase in risk-weighted assets two quarters ago (as a proportion of total assets) leads to a decline in *BUFQUAL* of 8% ceteris paribus. This may suggest that a bank with greater credit risk has a thorough risk management system in place to handle this added risk (resulting in a lowered need to hold loss-absorbent buffers) (Francis & Osborne, 2012). It could also be consistent with such a bank gambling on their increased credit risk as a means of re-establishing their buffer quality (via greater earnings) (Jokipii & Milne, 2011). This estimate is also consistent with banks buying market share, such that lower capital is recovered by writing similar loans at lower margins (Williams, 2007). Shim (2013) suggests that a negative association with credit risk might still be tolerable if a bank gains risk reduction through effective revenue diversification (thus lowering or maintain a level of overall bank risk).

The positive coefficient estimates on *LIQUID* are statistically insignificant in the primary GMM Models (5) and (6). However, Models (1) – (4). While contrary to H5, this may be consistent with a highly liquid bank, using a

[54] This is also consistent with moral hazard behaviour by retail intensive banks (Berger et al., 2008; Berger et al., 1995).

combination of these liquid assets and better quality buffers to capitalise upon growth opportunities (Pereira & Saito, 2015). A positive coefficient is also consistent higher managerial risk aversion, and banks adjusting in anticipation of Basel III's liquidity requirements (Ho & Saunders, 1981).

The coefficient on the lagged $BUFQUAL_{t-1}$ is statistically significant across all models. These estimates are bound between the required range of $0 - 1$ and can therefore be thought of as reflecting the speed of adjustment towards the desired buffer quality (Jokipii & Milne, 2011). The system GMM estimate in Model (5) indicates that on a quarterly basis, banks narrow the gap between their actual and target buffer quality by 51.6%, on average. The significance of the lagged buffer quality indicates that the costs of adjusting buffers are an important explanation of holding a better quality buffer (Francis & Osborne, 2012).

In comparison to studies on buffer size, this is substantially faster than that observed by Jokipii and Milne (2011) of 9% while studying US banks between 1986 and 2008. Half the sample observations are in the post-GFC period for this thesis. Comparing the results to Jokipii and Milne (2011) may indicate that banks have learnt a lesson post-GFC. This lesson translates into faster adjustment speeds of buffer quality. The observed adjustment speeds in this thesis is however, slower than that observed by Francis and Osborne (2010) of 77% (for UK banks) and Pereira and Saito (2015) of 82% (for Brazilian banks).

Models (2), (4) and (6) interact adjustment speeds with degrees of capitalisation. All three iterations indicate that well-capitalised banks can adjust their buffer quality significantly quicker. This is contrary to capital buffer theory which suggests that under-capitalised banks make a positive adjustment to re-establish their buffer. Model (6) reports that well-capitalised banks adjust their buffer quality 8% faster than the mean bank. The statistically significant negative estimates for poorly-capitalised banks in Models (2) and (4) indicate in that poorly capitalised banks cannot raise new capital effectively. This is consistent with Berger et al. (2008) who ascribe this phenomenon to the troubled nature of poorly-capitalised banks.

Table 4.3 – Capital buffer quality (Q1 2001 – Q4 2016)

Specifications (1) and (2) are estimated by pooled OLS. Specifications (3) and (4) are estimated using fixed effects panel regression Specifications (5) and (6) are estimated using the two-step Blundell and Bond (1998) system GMM for panel data; the endogenous variables are instrumented with one to eleven lags, and the instruments are collapsed. Dependent variable is *BUFQUAL*, the proportion of Tier 1 regulatory capital discretionarily held by a bank. The explanatory variables are as follows $BUFQUAL_{t-1}$ is the first lag of the dependent variable, $DQUAL_{LOW}$ is a dummy variable taking the value of unity if $Bank_i$ is in the bottom 20 percentile of observations in terms of its proportion of Tier 1 regulatory capital discretionarily held, and 0 otherwise. $DQUAL_{HIGH}$ is a dummy variable taking the value of unity if $Bank_i$ is in the top 20 percentile of observations in terms of its proportion of Tier 1 regulatory capital discretionarily held, and 0 otherwise. *SIZE* is the natural log of total bank assets. *FIXASSET* is the proportion of fixed assets to total bank assets. *HHI* measures the revenue diversification between non-interest income and total interest income. RWA_{t-2} is a two-period lag of risk-weighted assets to total assets. *CASHMKTSEC* is cash and marketable securities to total bank assets. *ROE* is the average return on equity. *SUBORD* is the proportion of subordinated debt to total liabilities. Regressions are estimated for quarter 1 2001 – quarter 4 2016. Quarter time dummies included but not reported. The Hansen test is the test for over-identification restrictions. AR(1) and AR(2) represent first and second order residual tests. For these tests, p-values are reported. Robust t-statistics are presented in parentheses. *, **, *** reports significance at the 10, 5 and 1% levels of significance, respectively.

VARIABLES	(1) POLS	(2) POLS	(3) FE	(4) FE	(5) GMM	(6) GMM
$BUFQUAL_{t-1}$	0.950***		0.846***		0.516***	
	(342.40)		(416.70)		(6.97)	
$DCAP_{LOW}$ * $BUFQUAL_{t-1}$		-0.536***		-0.448***		0.3160
		(-101.4)		(-43.12)		(0.64)
$DCAP_{HIGH}$ * $BUFQUAL_{t-1}$		0.480***		0.377***		0.559***
		(227.80)		(42.57)		(2.62)
SIZE	-0.0003***	-0.0004***	-0.0013***	-0.0031***	-0.0162**	-0.0293**
	(-11.06)	(-7.560)	(-10.52)	(-7.500)	(-2.173)	(-2.575)
FIXASSET	-0.00846***	-0.0348***	-0.0283***	0.0029	2.4530	-0.2170
	(-2.697)	(-6.098)	(-4.549)	(0.10)	(1.48)	(-0.116)
HHI	0.0002	-0.00213***	0.00302***	-0.00684***	0.0526**	0.0961***
	(0.49)	(-3.842)	(6.29)	(-3.193)	(2.28)	(3.03)
RWA_{t-2}	-0.00238***	-0.0194***	-0.00303***	-0.0286***	-0.0820***	-0.0652
	(-5.924)	(-32.18)	(-6.054)	(-10.42)	(-4.505)	(-1.466)
CASHMKTSEC	0.00465***	0.00447***	0.0111***	0.0114***	0.0642	0.0842
	(11.92)	(7.42)	(20.94)	(4.50)	(0.87)	(0.99)
ROE	0.00389***	0.0113***	0.00516***	0.0106***	0.00479***	0.0173**
	(12.58)	(18.13)	(38.48)	(15.78)	(4.11)	(2.03)
SUBORD	-0.0023	-0.202***	-0.0277***	-0.0723***	0.2780	0.483**
	(-0.892)	(-37.94)	(-8.524)	(-3.619)	(1.61)	(2.38)
Constant	0.00779***	0.0706***	0.0245***	0.115***	0.234*	0.450***
	(12.42)	(80.11)	(14.83)	(18.00)	(1.89)	(2.58)
# Observations	73,388	73,388	73,388	73,388	73,388	73,388
R-squared	0.929	0.790	0.836	0.567		
# Banks			2,489	2,489	2,489	2,489
# Instruments					14	13
AR(1) p-value					0	0.0468
AR(2) p-value					0.394	0.260

With respect to the control variables, *ROE* is positive and statistically significant (at the 1% level of significance in five models and at the 5% level in one model). This suggests that retained earnings is important for building Tier 1 capital in banks' buffers. It is counter to the trade-off theory predicting a negative coefficient due to the high cost of idle capital. Such a finding is however, consistent with the pecking order theory predicting that retained earnings are a cost-effective and preferable source of funding, particularly in light of asymmetric information (Myers & Majluf, 1984; Pereira & Saito, 2015). In relation to market discipline's relationship with buffer quality, *SUBORD* has ambiguous estimates across the six models. It is therefore unclear whether higher market discipline demands that banks hold higher quality capital buffers.

Tables 4.4 – 4.6 disaggregates the regressions according to regulatory holding company classifications (i.e. Bank Holding Companies, Financial Holding Companies and Savings and Loan Holding Companies). This is done in a desire to understand which hypothesis variables influence the buffer quality of different regulatory holding company structures.

4.3.2. Disaggregated results for buffer quality – Bank Holding Companies

This subsection filters the data sample to only include holding companies that, for regulatory purposes, are classified as Bank Holding Companies. The intention is to understand whether the trends described in Table 4.3 for the entire holding company data sample persist across Bank Holding Companies specifically. The Equation (5) is regressed with Bank Holding Companies only and the results presented in Table 4.4. As before, Models (1) and (2) are estimated using a pooled Ordinary Least Squares regression; Models (3) and (4) are estimated using two-way fixed effects panel regressions and Models (5) and (6) are estimated using the two-step Blundell and Bond (1998) system GMM.

All six models again predict a negative association between buffer quality and bank size, as indicated by the coefficient for *SIZE* (five of which are statistically significant). This finding emphasises that larger Bank Holding Companies, similar to the full sample of holding companies, hold lower quality buffers (consistent with H1). Of note, Model (6) gains significance at the 1% level (previously 5%). As with the overall buffer quality results, the coefficient for the retail intensity proxy, *FIXASSET*, only has reportable significance in Models (1) – (3). The negative coefficient for *FIXASSET* provides some evidence for retail intensive Bank Holding Companies holding lower quality capital buffers. The results for RWA_{t-2} with respect to Bank Holding Companies, are consistent with those obtained for the entire sample such that Models (1) – (5) retain significance and broadly reflect similar magnitudes. This negative relationship might again be explained by a moral hazard behaviour. In turning to a bank's investments in liquid assets, as before, *LIQUID* is only statistically significant in Models (1) – (4). The positive direction of the coefficient again suggest liquid assets and high-quality buffers are complementary tools for exploiting growth opportunities.

With respect to the lagged *BUFQUAL* term it again falls within the estimated restrictions of 0 – 1 and so can be interpreted as the adjustment speed of buffer quality. The coefficient retains its significance in all models in which it is estimated (Models (1) (3) and (5)). With respect to Model (5) the magnitude is marginally slower when compared with the broader sample, but unchanged in Models (1) and (3).

When considering how the adjustment speed interacts with degrees of capitalisation, while $DQUAL_{LOW}$ * $BUFQUAL_{t-1}$ falls outside the required parameter of 0 – 1, its negative coefficient can again be interpreted as an inability of poorly capitalized banks to rebuild their buffer quality (Berger et al., 2008). Meanwhile, the coefficient on $DQUAL_{HIGH}$ * $BUFQUAL_{t-1}$ falls within the required bounding parameter in all three models in which it is estimated (Models (2), (4) and (6)). The speed is approximately 23% faster in Model (6) but mostly unchanged in Models (2) and (4).

In turning to the control variables, the positive and statistically significant coefficient for *ROE* is indicative of Bank Holding Companies, utilising retained earnings to build quality in their capital buffers. *SUBORD* is ambiguous across the results with Models (2), (3) and (4) all indicating positive and statistically significant coefficients while Models (5) and (6) negative and statistically significant coefficients.

Table 4.4 – Capital buffer quality for Bank Holding Companies (Q1 2001 – Q4 2016)

Specifications (1) and (2) are estimated by pooled OLS. Specifications (3) and (4) are estimated using fixed effects panel regression Specifications (5) and (6) are estimated using the two-step Blundell and Bond (1998) system GMM for panel data; the endogenous variables are instrumented with one to eleven lags, and the instruments are collapsed. Dependent variable is *BUFQUAL*, the proportion of Tier 1 regulatory capital discretionarily held by a bank. The explanatory variables are as follows $BUFQUAL_{t-1}$ is the first lag of the dependent variable, $DQUAL_{LOW}$ is a dummy variable taking the value of unity if $Bank_i$ is in the bottom 20 percentile of observations in terms of its proportion of Tier 1 regulatory capital discretionarily held, and 0 otherwise. $\mathrm{DQUAL}_{\mathrm{HIGH}}$ is a dummy variable taking the value of unity if $Bank_i$ is in the top 20 percentile of observations in terms of its proportion of Tier 1 regulatory capital discretionarily held, and 0 otherwise. *SIZE* is the natural log of total bank assets. *FIXASSET* is the proportion of fixed assets to total bank assets. *HHI* measures the revenue diversification between non-interest income and total interest income. RWA_{t-2} is a two-period lag of risk-weighted assets to total assets. *CASHMKTSEC* is cash and marketable securities to total bank assets. *ROE* is the average return on equity. *SUBORD* is the proportion of subordinated debt to total liabilities. Regressions are estimated for quarter 1 2001 – quarter 4 2016. Quarter time dummies included but not reported. The Hansen test is the test for over-identification restrictions. AR(1) and AR(2) represent first and second order residual tests. For these tests, p-values are reported. Robust t-statistics are presented in parentheses. *, **, *** reports significance at the 10, 5 and 1% levels of significance, respectively.

VARIABLES	(1) POLS	(2) POLS	(3) FE	(4) FE	(5) GMM	(6) GMM
$BUFQUAL_{t-1}$	0.952***		0.846***		0.495***	
	(322.5)		(357.7)		(6.3)	
$DQUAL_{LOW}$ * $BUFQUAL_{t-1}$		-0.513***		-0.417***		0.6670
		(-90.73)		(-34.52)		(-0.56)
$DQUAL_{HIGH}$ * $BUFQUAL_{t-1}$		0.478***		0.371***		0.689***
		(212.1)		(37.1)		(2.7)
				-		-
SIZE	-0.0004***	0.0001	-0.0013***	0.0026***	-0.0212***	0.0374***
	(-9.328)	(0.8)	(-8.864)	(-4.492)	(-3.568)	(-2.838)
FIXASSET	-0.0133***	-0.0560***	-0.0419***	-0.0217	-0.0336	3.3460
	(-3.851)	(-8.995)	(-5.805)	(-0.643)	(-0.0292)	-1.012
				-		
HHI	0.0006	-0.00137**	0.00343***	0.0090***	0.0659***	0.125***
	(1.6)	(-2.124)	(6.1)	(-3.668)	(3.0)	(2.9)
	-			-		
RWA_{t-2}	0.00230***	-0.0211***	-0.0031***	0.0300***	-0.0786***	-0.0953
	(-4.944)	(-30.85)	(-5.247)	(-9.998)	(-4.092)	(-0.994)
CASHMKTSEC	0.00497***	0.00614***	0.0113***	0.0107***	0.0565	-0.0163
	(11.5)	(8.7)	(18.3)	(3.7)	(1.0)	(-0.157)
ROE	0.00375***	0.0118***	0.00487***	0.0100***	0.00281***	0.0134
	(12.1)	(17.0)	(33.6)	(12.8)	(3.0)	(1.1)
SUBORD	-0.0042	-0.242***	-0.0271***	-0.103***	0.317***	0.846**
	(-1.434)	(-38.45)	(-7.044)	(-4.324)	(3.9)	(2.4)
Constant	0.00842***	0.0668***	0.0253***	0.109***	0.341***	0.512**
	(10.4)	(59.5)	(12.7)	(13.2)	(3.9)	(2.6)
# Observations	55,063	55,063	55,063	55,063	55,063	55,063
R-squared	0.934	0.792	0.829	0.546		
# Banks			2,115	2,115	2,115	2,115
# Instruments					15	13
AR(1) p-value					8.14e-11	0.310
AR(2) p-value					0.112	0.177
Hansen p-value					0.100	0.539

4.3.3. Disaggregated results for buffer quality – Financial Holding Companies

The Financial Holding Company results to Equation (5) are presented in Table 4.5. Noticeably, most of the System GMM results presented in Models (5) and (6) carry little statistical significance. Broadly, there is also a decline in the levels of significance observed for the results of the POLS and FE panel regressions.

However, there still are some important insights provided in the regression estimations for Financial Holding Company. As with the overall data sample, the coefficient for *SIZE* is estimated as negative (but only statistically significant in Models (1) – (4)). Meanwhile, the sign for the *FIXASSET* coefficient reverses and sustains statistical significance at the 1% level in Models (1) - (3). The positive relationship with *BUFQUAL* suggests that Financial Holding Companies with greater exposure to retail activities hold higher quality capital buffers. Restricted market access is unlikely to be an explanation for this because the grant of FHC status increases their theoretical market access. It could be that these banks are signalling their ongoing charter values in the presence of greater exposure to riskier, non-traditional financial transactions.

While previously the coefficient for *HHI* has been ambiguous or mostly positive, Models (1) and (2) both report statistically significant negative relationships with *BUFQUAL*.[55] This may suggest that operationally complex Financial Holding Companies experience reductions in their overall risk through further revenue diversification, and in turn have a lowered incentive to hold highly loss-absorbent and expensive buffers. RWA_{t-2} sustains its negative relationship with *BUFQUAL* for Financial Holding Companies, as was the case in the Bank Holding Company and full data sample regressions. This provides further evidence of large banks potentially engaging in morally hazardous behaviour, whereby the credit risk estimated two periods' ago influences the future buffer quality negatively. An alternative explanation is banks buying market share with diminishing returns on equity for loans of similar risk but smaller returns (Williams, 2007). While it appears that once again investments in liquid assets and higher quality buffers are established to capitalise upon growth opportunities, as indicated by the positive sign on *LIQUID*.

The lagged *BUFQUAL* term where estimated is statistically significant and within the bounding parameter of 0 – 1. Model (5) records an adjustment speed significantly faster than the overall population of holding companies. This may be a function of Financial Holding Companies capitalising upon their particularly strong market access to absorb shocks by actively managing their buffer quality (Kashyap et al., 2002). The estimates in Models (2), (4) and (6) all indicate that although the strongly capitalised Financial Holding Companies adjust their buffer

[55] *HHI* in the full data sample regressions was statistically significant and positive in Models (3), (5) and (6) but negative in Models (2) and (4). While in the Bank Holding Company regressions it was statically significant and (3), (5) and (6) but negative in (2) and (4).

quality at similar speeds to the overall sample, poorly capitalised Financial Holding Companies have increased difficult in making necessary adjustments to their buffer quality.

With respect to *ROE*, although positive coefficients are estimated across all models, only Models (1) and (3) have statistical significance. And as has been the case previously, *SUBORD* is ambiguously estimated, suggesting that market discipline does not inform the quality of the buffer maintained by Financial Holding Companies.

Table 4.5 – Capital buffer quality for Financial Holding Companies (Q1 2001 – Q4 2016)

Specifications (1) and (2) are estimated by pooled OLS. Specifications (3) and (4) are estimated using fixed effects panel regression Specifications (5) and (6) are estimated using the two-step Blundell and Bond (1998) system GMM for panel data; the endogenous variables are instrumented with one to eleven lags, and the instruments are collapsed. Dependent variable is *BUFQUAL*, the proportion of Tier 1 regulatory capital discretionarily held by a bank. The explanatory variables are as follows $BUFQUAL_{t-1}$ is the first lag of the dependent variable, $DQUAL_{LOW}$ is a dummy variable taking the value of unity if $Bank_i$ is in the bottom 20 percentile of observations in terms of its proportion of Tier 1 regulatory capital discretionarily held, and 0 otherwise. $\mathrm{DQUAL}_{\mathrm{HIGH}}$ is a dummy variable taking the value of unity if $Bank_i$ is in the top 20 percentile of observations in terms of its proportion of Tier 1 regulatory capital discretionarily held, and 0 otherwise. *SIZE* is the natural log of total bank assets. *FIXASSET* is the proportion of fixed assets to total bank assets. *HHI* measures the revenue diversification between non-interest income and total interest income. RWA_{t-2} is a two-period lag of risk-weighted assets to total assets. *CASHMKTSEC* is cash and marketable securities to total bank assets. *ROE* is the average return on equity. *SUBORD* is the proportion of subordinated debt to total liabilities. Regressions are estimated for quarter 1 2001 – quarter 4 2016. Quarter time dummies included but not reported. The Hansen test is the test for over-identification restrictions. AR(1) and AR(2) represent first and second order residual tests. For these tests, p-values are reported. Robust t-statistics are presented in parentheses. *, **, *** reports significance at the 10, 5 and 1% levels of significance, respectively.

VARIABLES	(1) POLS	(2) POLS	(3) FE	(4) FE	(5) GMM	(6) GMM
$BUFQUAL_{t-1}$	0.940***		0.797***		0.726***	
	(128.2)		(166.9)		(4.2)	
$DQUAL_{LOW} * BUFQUAL_{t-1}$		-0.594***		-0.526***		0.661
		(-42.71)		(-26.85)		(0.8)
$DQUAL_{HIGH} * BUFQUAL_{t-1}$		0.472***		0.363***		0.777
		(88.2)		(20.2)		(1.3)
SIZE	-0.0002***	-0.0008***	-0.0017***	-0.0047***	-0.0132	-0.0111
	(-4.277)	(-8.842)	(-6.567)	(-7.279)	(-0.689)	(-0.346)
FIXASSET	0.0132*	0.0584***	0.0284*	0.0684	-0.325	3.056
	(1.8)	(4.3)	(1.9)	(1.1)	(-0.0989)	(0.7)
HHI	-0.00183**	-0.00641***	-0.0011	-0.0009	0.0247	0.00447
	(-2.172)	(-5.377)	(-0.991)	(-0.227)	(0.4)	(0.1)
RWA_{t-2}	-0.0028***	-0.0163***	-0.0039***	-0.0347***	-0.124*	-0.104
	(-3.262)	(-12.43)	(-3.578)	(-5.893)	(-1.677)	(-0.705)
CASHMKTSEC	0.00276***	0.0011	0.0130***	0.0158***	-0.0678	0.0765
	(3.1)	(1.0)	(11.0)	(3.2)	(-0.276)	(0.4)
ROE	0.00610***	0.00233	0.00900***	0.00166	0.00661	0.0244
	(8.4)	(1.3)	(11.9)	(0.9)	(0.5)	(1.1)
SUBORD	0.00357	-0.0868***	-0.0199***	0.0847***	0.506	0.17
	(0.6)	(-9.601)	(-2.847)	(3.6)	(0.6)	(0.1)
Constant	0.00759***	0.0730***	0.0334***	0.138***	0.298	0.198
	(5.8)	(40.8)	(8.8)	(11.7)	(0.9)	(0.4)
# Observations	17,230	17,230	17,230	17,230	17,230	17,230
R-squared	0.909	0.790	0.820	0.598		

# Banks	661	661	661	661
# Instruments			14	13
AR(1) p-value			0.000351	0.269
AR(2) p-value			0.442	0.784
Hansen p-value			0.739	0.647

4.3.4. Disaggregated results for buffer quality – Savings and Loan Holding Companies

Disaggregating the results into Savings and Loan Holding Company regressions (as presented in Table 4.6) is problematic given the relatively small number of observations (239). This meant that the system GMM model allowing degrees of capitalisation to interact with the adjustment speed term was not possible. A further implication of this small sample is that fewer consistent coefficient estimates are generated across all five models for each variable.

SIZE, when significant has contrasting signs across Models (2), (3) and (4). This leaves unanswered whether larger Savings and Loan Holding Companies hold lower quality buffers, as is the case with their Bank and Financial Holding Company peers. Meanwhile, of the two estimations where the coefficient for *FIXASSETS* is significant (Models (1) and (3)), it is positive. This conflicts with the overall results generated in Table 4.3, as well as that estimated for Bank Holding Companies specifically in Table 4.4 (where *FIXASSETS* was consistently negative). The positive association with buffer quality is similarly noted with respect to Financial Holding Companies. It is likely that as determined by their regulatory classification, Savings and Loan Holding Companies have a greater emphasis upon traditional retail banking activities (H. E. Jackson, 1993). This structural orientation favouring retail banking may imply that Savings and Loan Holding Companies face higher barriers to the issuance of Tier 2 capital instruments. Greater proportions of Tier 1 capital in their buffers may be a direct consequence of these market access restrictions limiting their ability to issue alternatives. With respect to credit risk, the coefficient for RWA_{t-2} is ambiguously estimated. In five models it is estimated with a negative coefficient, only one of these is statistically significant (Model (3)). Meanwhile, Model (2) estimates a positive and statistically significant coefficient.

The coefficient for *ROE* across the five models does not render any coherent conclusions with four models finding no significant association and only one model (Model (3)) supporting a negative association at the 10% level of significance. Unlike previously, there is some evidence that Savings and Loan Holding Companies with greater exposure to market discipline, as proxied by *SUBORD* hold lower quality buffers.

Reviewing the results presented in Tables 4.3 – 4.6 with consideration towards the five hypotheses indicates that material evidence (with respect to the entire data sample) exists to imply that, consistent with H1, larger banks hold lower quality buffers. Furthermore, contrary to H2, retail intensive banks appear to hold lower quality buffers, but no support for this is found in the primary models, the system GMM estimates. Operationally complexity appears to serve as an incentive for banks to hold higher quality buffers (consistent with H3). While contrary to H4, banks with greater exposure to credit risk appear to hold lower quality buffers. Finally, banks with greater liquid asset investments are not observed to hold higher quality buffers with statistical significance in the system GMM models. When the results are filtered according to the regulatory classification of the holding company (as either Bank Holding Companies, Financial Holding Companies or Savings and Loan Holding Companies), the overall data sample results are mostly reflected by those contained for Bank Holding Companies. This is followed by Financial Holding Companies and then by Savings and Loan Holding Companies.

Table 4.6 – Capital buffer quality for Savings and Loan Holding Companies (Q1 2001 – Q4 2016)

Specifications (1) and (2) are estimated by pooled OLS. Specifications (3) and (4) are estimated using fixed effects panel regression Specification (5) is estimated using the two-step Blundell and Bond (1998) system GMM for panel data; the endogenous variables are instrumented with one to eleven lags, and the instruments are collapsed. Dependent variable is *BUFQUAL*, the proportion of Tier 1 regulatory capital discretionarily held by a bank. The explanatory variables are as follows $BUFQUAL_{t-1}$ is the first lag of the dependent variable, $DQUAL_{LOW}$ is a dummy variable taking the value of unity if $Bank_i$ is in the bottom 20 percentile of observations in terms of its proportion of Tier 1 regulatory capital discretionarily held, and 0 otherwise. $\text{DQUAL}_{\text{HIGH}}$ is a dummy variable taking the value of unity if $Bank_i$ is in the top 20 percentile of observations in terms of its proportion of Tier 1 regulatory capital discretionarily held, and 0 otherwise. *SIZE* is the natural log of total bank assets. *FIXASSET* is the proportion of fixed assets to total bank assets. *HHI* measures the revenue diversification between non-interest income and total interest income. RWA_{t-2} is a two-period lag of risk-weighted assets to total assets. *CASHMKTSEC* is cash and marketable securities to total bank assets. *ROE* is the average return on equity. *SUBORD* is the proportion of subordinated debt to total liabilities. Regressions are estimated for quarter 1 2001 – quarter 4 2016. Quarter time dummies included but not reported. The Hansen test is the test for over-identification restrictions. AR(1) and AR(2) represent first and second order residual tests. For these tests, p-values are reported. Robust t-statistics are presented in parentheses. *, **, *** reports significance at the 10, 5 and 1% levels of significance, respectively.

VARIABLES	(1) POLS	(2) POLS	(3) FE	(4) FE	(5) GMM
$BUFQUAL_{t-1}$	0.966***		0.356***		0.0384
	(40.7)		(5.0)		(0.0)
$DQUAL_{LOW} * BUFQUAL_{t-1}$		-0.358***		-0.0709	
		(-4.118)		(-1.03)	
$DQUAL_{HIGH} * BUFQUAL_{t-1}$		0.594***		0.145***	
		(24.1)		(4.1)	
SIZE	0.0001	0.00208***	-0.0229***	-0.0190*	-0.0146
	(0.2)	(2.7)	(-4.059)	(-1.759)	(-0.678)
FIXASSET	0.123**	-0.0236	2.552***	2.151	2.633
	(2.1)	(-0.201)	(5.6)	(1.5)	(0.7)
HHI	-0.000944	-0.0287***	-0.0101	-0.00181	-0.0341
	(-0.303)	(-4.472)	(-1.263)	(-0.270)	(-0.350)
RWA_{t-2}	-0.00802	0.0207***	-0.0321**	-0.0216	-0.0556
	(-1.318)	(2.6)	(-2.144)	(-0.672)	(-0.356)
CASHMKTSEC	-0.0137	0.0360**	0.0227	0.00386	-0.0341
	(-1.001)	(2.3)	(1.4)	(0.3)	(-0.112)
ROE	0.000938	0.0269	-0.0222*	-0.00384	0.0313
	(0.2)	(0.9)	(-1.833)	(-0.407)	(0.5)

SUBORD	0.0203	-0.321***	-0.850***	-1.081***	-0.675
	(0.5)	(-5.198)	(-7.031)	(-4.582)	(-0.648)
Constant	0.00453	-0.00791	0.364***	0.319*	0.276
	(0.5)	(-0.540)	(4.3)	(1.9)	(0.6)
# Observations	239	239	239	239	239
R-squared	0.941	0.759	0.644	0.589	
# Banks			41	41	41
# Instruments					10
AR(1) p-value					0.729
AR(2) p-value					0.709
Hansen p-value					0.875

4.4. Robustness testing

A series of robustness checks are conducted in this thesis. This includes presenting additional results for time sub-samples (subsection 4.4.1); an alternative measure of capital quality as a dependent variable (subsection 4.4.2); and alternative measures of hypothesis variables (subsections 4.4.3 – 4.4.6).

4.4.1. Time subsamples

Large BHCs were treated homogenously from 2001 – 2013 (inclusive) with respect to the deductibility of nonconsolidated investment in banking and finance subsidiaries.[56] This time-frame also coincides with the pre-Basel II era. However, the four quarters of 2014 of large BHCs, FDIC distinguished those using the Advanced Approaches methodology for differential treatment in relation to the deductibility of non-consolidated investments in banking affiliates.[57] From Quarter 1 2015 that distinction was abolished and a new methodology applied irrespective of whether a BHC used the Advanced Approaches methodology or not.[58] Because the sample data captures periods where BHCs were under differing regulatory treatment, a robustness test upon the time subsample when all BHCs in the sample were treated homogenously (with respect to the required deductions to regulatory capital) is desirable. For this reason, Table 4.7 reports the results of the system GMM regressions on equation (5) for the period commencing Quarter 1 2001 and ending Quarter 4 2013.

[56] Prior to 2014, large BHCs were all required to make a 50% deduction to Tier 1 and Tier 2 regulatory capital for nonconsolidated investments in banking and finance subsidiaries (FDIC, 2016; Gong et al., 2017).
[57] During the period Quarter 1 2014 to Quarter 4 2014, the deductions for advanced approaches banks were distinguished based upon whether the investment was ‘non- significant’ (if BHC owns equal to or less than 10% in banking affiliate) or ‘significant’ (if BHC owns greater than 10% in banking affiliate. If the aggregate calculation of non- significant investments totalled above the 10% threshold of BHCs’ CET1 then the amount above 10% is deducted from the BHC’s regulatory capital using the deduction approach and the amount below 10% threshold is risk-weighted (FDIC, 2016; Gong et al., 2017). All non-advanced approaches BHCs fell under the same regulatory treatment that applied before Quarter 1 2014.
[58] From Quarter 1 2015 all BHCs (advanced approaches or otherwise) were phased-in to the reporting rules prescribed to advanced approaches BHCs from Quarter 1 2014 (refer above) (FDIC, 2016).

Of the hypothesis variables previously estimated, only *HHI* and RWA_{t-2} have coefficients with statistical significance. Consistent with the main results for *BUFQUAL* in Table 4.3, operationally complex banks (with higher *HHI*s) hold more loss absorbent capital buffers. While banks with higher credit risk (i.e. higher RWA_{t-2}) in this subperiod held lower quality buffers. This finding is consistent with that estimated in the main results. In the main results, both *SIZE* and *ROE* held statistical significance which is lost in this robustness check.

Table 4.7 – Capital buffer quality (Q1 2001 – Q4 2013)

Specifications (1) and (2) are estimated using the two-step Blundell and Bond (1998) system GMM for panel data; the endogenous variables are instrumented with one to eight lags, and the instruments are collapsed. Dependent variable is *BUFQUAL*, the proportion of Tier 1 regulatory capital discretionarily held by a bank. The explanatory variables are as follows $BUFQUAL_{t-1}$ is the first lag of the dependent variable, $DQUAL_{LOW}$ is a dummy variable taking the value of unity if $Bank_i$ is in the bottom 20 percentile of observations in terms of its proportion of Tier 1 regulatory capital discretionarily held, and 0 otherwise. $DQUAL_{HIGH}$ is a dummy variable taking the value of unity if $Bank_i$ is in the top 20 percentile of observations in terms of its proportion of Tier 1 regulatory capital discretionarily held, and 0 otherwise. *SIZE* is the natural log of total bank assets. *FIXASSET* is the proportion of fixed assets to total bank assets. *HHI* measures the revenue diversification between non-interest income and total interest income. RWA_{t-2} is a two-period lag of risk-weighted assets to total assets. *CASHMKTSEC* is cash and marketable securities to total bank assets. *ROE* is the average return on equity. *SUBORD* is the proportion of subordinated debt to total liabilities. Regressions are estimated for quarter 1 2001 – quarter 4 2013. Quarter time dummies included but not reported. The Hansen test is the test for over-identification restrictions. AR(1) and AR(2) represent first and second order residual tests. For these tests, p-values are reported. Robust t-statistics are presented in parentheses. *, **, *** reports significance at the 10, 5 and 1% levels of significance, respectively.

VARIABLES	(1) GMM	(2) GMM
$BUFQUAL_{t-1}$	0.900***	
	(9.6)	
$DQUAL_{LOW} * BUFQUAL_{t-1}$		-0.3880
		(-0.430)
$DQUAL_{HIGH} * BUFQUAL_{t-1}$		1.033***
		(5.0)
SIZE	-0.0132	0.0209
	(-0.852)	(0.7)
FIXASSET	2.9610	3.9070
	(1.1)	(1.0)
HHI	0.0956***	-0.0121
	(2.8)	(-0.167)
RWA_{t-2}	-0.0509***	-0.0345*
	(-3.708)	(-1.935)
CASHMKTSEC	0.0460	0.1060
	(0.5)	(0.7)
ROE	0.0019	-0.0024
	(1.5)	(-0.194)
SUBORD	0.3220	-1.2170
	(0.5)	(-0.919)
Constant	0.1290	-0.2980
	(0.5)	(-0.711)
# Observations	64,805	64,805
# Banks	2,429	2,429
# Instruments	11	12
AR(1) p-value	0	3.77e-06
AR(2) p-value	0.641	0.316
Hansen p-value	0.544	0.681

To investigate how the relationship with buffer quality and the hypothesis variables has changed over time, additional results are presented for three time period sub-samples: pre-GFC (Quarter 1 2001 – Quarter 4 2006), GFC (Quarter 1 2007 to Quarter 4 2009) and, post GFC (Quarter 1 2010 to Quarter 4 2016). The results are presented in Table 4.8. While the adjustment speed coefficient for $BUFQUAL_{t-1}$ is consistently statistically positive, of the hypothesis variables, credit risk (RWA_{t-2}) is the only one to hold statistical significance, and this is only in the post-GFC sub-period.

There are important implications for the speed of adjustment coefficients estimated in Models (1), (3) and (5). The findings indicate that banks in the post-GFC period have been adjusting their capital buffer quality far quicker than previously. The post-GFC speed adjustment is 30.01% faster than during the GFC, and 37.41% faster than before the GFC. This is further evidence of banks attuning to the importance of buffer quality.

Table 4.8 – Capital buffer quality time sub-periods

Specifications (1) - (6) are estimated using the two-step Blundell and Bond (1998) system GMM for panel data; the endogenous variables are instrumented with one to ten lags, and the instruments are collapsed. Specifications (1) and (2) are estimated for quarter 1 2001 – quarter 4 2006. Specifications (3) and (4) are estimated for quarter 1 2007 – quarter 4 2009. Specifications (5) and (6) are estimated for quarter 1 2010 – quarter 4 2016. Dependent variable is *BUFQUAL*, the proportion of Tier 1 regulatory capital discretionarily held by a bank. The explanatory variables are as follows $BUFQUAL_{t-1}$ is the first lag of the dependent variable, $DQUAL_{LOW}$ is a dummy variable taking the value of unity if $Bank_i$ is in the bottom 20 percentile of observations in terms of its proportion of Tier 1 regulatory capital discretionarily held, and 0 otherwise. $DQUAL_{HIGH}$ is a dummy variable taking the value of unity if $Bank_i$ is in the top 20 percentile of observations in terms of its proportion of Tier 1 regulatory capital discretionarily held, and 0 otherwise. *SIZE* is the natural log of total bank assets. *FIXASSET* is the proportion of fixed assets to total bank assets. *HHI* measures the revenue diversification between non-interest income and total interest income. RWA_{t-2} is a two-period lag of risk-weighted assets to total assets. *CASHMKTSEC* is cash and marketable securities to total bank assets. *ROE* is the average return on equity. *SUBORD* is the proportion of subordinated debt to total liabilities. Quarter time dummies included but not reported. The Hansen test is the test for over-identification restrictions. AR(1) and AR(2) represent first and second order residual tests. For these tests, p-values are reported. Robust t-statistics are presented in parentheses. *, **, *** reports significance at the 10, 5 and 1% levels of significance, respectively.

VARIABLES	(1) GMM 01-06	(2) GMM 01-06	(3) GMM 07-09	(4) GMM 07-09	(5) GMM 10-16	(6) GMM 10-16
$BUFQUAL_{t-1}$	0.548***		0.579*		0.753**	
	(2.7)		(1.8)		(2.1)	
$DQUAL_{LOW}$ * $BUFQUAL_{t-1}$		-0.7280		-0.1450		-0.799**
		(-1.132)		(-0.174)		(-2.018)
$DQUAL_{HIGH}$ * $BUFQUAL_{t-1}$		0.591***		0.1860		0.6620
		(3.1)		(0.2)		(1.4)
SIZE	-0.0326	-0.0141	-0.0038	0.0198	-0.0162	0.0017
	(-1.311)	(-0.484)	(-0.178)	(0.5)	(-0.302)	(0.1)
FIXASSET	-3.2120	-1.3050	-3.1240	-3.5830	-0.3330	3.9860
	(-1.261)	(-0.406)	(-0.592)	(-0.597)	(-0.269)	(1.2)
HHI	0.0612	0.0385	0.1500	0.1130	-0.1550	-0.0914
	(0.9)	(0.7)	(0.9)	(0.4)	(-1.362)	(-0.636)
RWA_{t-2}	-0.0143	-0.0041	-0.0343	-0.0069	-0.196**	0.0691
	(-0.888)	(-0.323)	(-0.652)	(-0.0791)	(-1.979)	(0.9)
CASHMKTSEC	-0.0536	-0.0099	0.1500	0.2310	-0.2440	0.2310
	(-0.742)	(-0.160)	(0.8)	(0.7)	(-1.533)	(1.4)
ROE	-0.0046	0.0025	0.0087	0.0195	0.0130**	0.0152

	(-0.353)	(0.3)	(1.4)	(1.6)	(2.1)	(1.5)
SUBORD	1.0460	0.4510	2.7760	6.5530	0.0520	0.3260
	(1.5)	(0.5)	(1.1)	(1.4)	(0.0)	(0.2)
Constant	0.5180	0.2540	0.0574	-0.3250	0.4740	-0.1160
	(1.6)	(0.6)	(0.2)	(-0.540)	(0.6)	(-0.234)
# Observations	38,290	38,290	11,075	11,075	24,023	24,023
# Banks	2,267	2,267	1,101	1,101	1,250	1,250
# Instruments	11	12	13	12	12	12
AR(1) p-value	0.00915	0.0225	0.000396	0.178	0.000763	0.00964
AR(2) p-value	0.545	0.0903	0.958	0.527	0.00277	0.0632
Hansen p-value	0.533	0.398	0.957	0.983	0.0734	0.167

4.4.2. Alternative dependent variable

Following Francis and Osborne (2010) the Tier 1 regulatory capital ratio is also employed as an alternative measure of capital quality, calculated as:

$$TONE = \frac{TIER1}{RWA} \qquad (14)$$

where, *TONE* is the Tier 1 regulatory capital ratio maintained by a bank each quarter; *TIER1* is the total Tier 1 capital held by a bank in a quarter; and *RWA* is the total risk-weighted assets of the bank calculated quarterly.

TONE is used as an alternative dependent measure because of isolates Tier 1 capital, and therefore it considers capital quality (Tier 1 capital being the highest quality capital). However, it is less preferable to the primary buffer quality variable, *BUFQUAL* for two connected reasons. *TONE* does not isolate the capital buffer, but rather focuses on the quality of aggregate capital. Consequently, it cannot properly adjust for the proportion of Tier 1 capital a bank discretionarily holds as compared to the Tier 2 capital it holds.

The results to this robustness check are presented in Table 4.9. The magnitudes to the coefficients are noticeably larger under this specification. Of the hypothesis variables, *FIXASSETS* is statistically significant (at the 10% level) and positive. This is consistent with the Hypothesis 2 suggesting retail intensive banks encounter restricted market access and so hold higher levels of Tier 1 capital. It is however, less consistent with the prior estimations for *FIXASSETS*. The coefficient for *HHI* is significant (at the 10% level) and positive. This is consistent with Hypothesis 3 that operational complexity serves as a reason to hold more loss absorbent capital. Similar to the results presented for the primary measure of buffer quality (*BUFQUAL*) estimations for credit risk are negatively related to Tier 1 capital holdings and statistically significant (counter to H4). The results are also consistent with prior estimations finding a positive coefficient for *LIQUID* (counter to H5).

Table 4.9 – Alternative capital quality measure (Q1 2001 – Q4 2016)

Specifications (1) and (2) are estimated using the two-step Blundell and Bond (1998) system GMM for panel data; the endogenous variables are instrumented with one to nine lags, and the instruments are collapsed. Dependent variable is *TONE*, the total Tier 1 regulatory capital to risk-weighted assets. The explanatory variables are as follows $TONE_{t-1}$ is the first lag of the dependent variable, $DTONE_{LOW}$ is a dummy variable taking the value of unity if $Bank_i$ is in the bottom 20 percentile of observations in terms of the size of its Tier 1 regulatory capital ratio to risk-weighted assets, and 0 otherwise. $DTONE_{HIGH}$ is a dummy variable taking the value of unity if $Bank_i$ is in the top 20 percentile of observations in terms of the size of its Tier 1 regulatory capital ratio to risk-weighted assets, and 0 otherwise. *SIZE* is the natural log of total bank assets. *FIXASSET* is the proportion of fixed assets to total bank assets. *HHI* measures the revenue diversification between non-interest income and total interest income. RWA_{t-2} is a two-period lag of risk-weighted assets to total assets. *CASHMKTSEC* is cash and marketable securities to total bank assets. *ROE* is the average return on equity. *SUBORD* is the proportion of subordinated debt to total liabilities. Regressions are estimated for quarter 1 2001 – quarter 4 2016. Quarter time dummies included but not reported. The Hansen test is the test for over-identification restrictions. AR(1) and AR(2) represent first and second order residual tests. For these tests, p-values are reported. Robust t-statistics are presented in parentheses. *, **, *** reports significance at the 10, 5 and 1% levels of significance, respectively.

VARIABLES	(1) GMM	(2) GMM
$TONE_{t-1}$	0.527***	
	(3.1)	
$DTONE_{LOW}$ * $TONE_{t-1}$		0.364
		(1.3)
$DTONEL_{HIGH}$ * $TONE_{t-1}$		0.624***
		(2.9)
SIZE	-3.088	-4.843
	(-0.969)	(-1.477)
FIXASSET	13.71*	16.93**
	(1.9)	(2.3)
HHI	915.5*	-157.5
	(1.7)	(-0.328)
RWA_{t-2}	-8.338***	-7.197**
	(-3.158)	(-2.515)
CASHMKTSEC	30.54*	21.3
	(1.7)	(1.0)
ROE	1.865***	1.898***
	(3.3)	(4.2)
SUBORD	251.1*	237.5
	(1.9)	(1.4)
Constant	25.83	73.77
	(0.5)	(1.5)
# Observations	73,388	73,388
# Banks	2,489	2,489
# Instruments	12	14
AR(1) p-value	0.0261	0.00146
AR(2) p-value	0.229	0.0589
Hansen p-value	0.0586	0.123

4.4.3. Alternative retail intensity measures

Following Hirtle and Stiroh (2007) two additional measures of retail intensity are introduced and regressed by system GMM models. The first of these is $LOANEXP_{i,t}$ defined as a bank's share of credit card; other consumer and 1 – 4 family mortgages as a proportion of total loans. The second alternative measure of retail intensity is $DEPOSIT_{i,t}$ defined as a bank's share of retail deposits to total deposits.

The results are presented in Table 4.10. Models (1) and (2) are estimated by introducing *LOANEXP* as the retail intensity proxy while Models (3) and (4) are estimated using *DEPOSIT*. Across the four models neither *LOANEXP* or *DEPOSIT* are statistically significant. The introduction of these two alternative variables do not seem to alter the conclusions drawn with respect to the other hypothesis variables (e.g. *SIZE* and RWA_{t-2} are still mostly negative while *HHI* is positive, while *LIQUID* retains no significance across the four models).

Table 4.10 – Alternative retail intensity measures (Q1 2001 – Q4 2016)

Specifications (1) - (4) are estimated using the two-step Blundell and Bond (1998) system GMM for panel data; the endogenous variables are instrumented with one to eleven lags, and the instruments are collapsed. Dependent variable is *BUFQUAL*, the proportion of Tier 1 regulatory capital discretionarily held by a bank. The explanatory variables are as follows $BUFQUAL_{t-1}$ is the first lag of the dependent variable, $DQUAL_{LOW}$ is a dummy variable taking the value of unity if $Bank_i$ is in the bottom 20 percentile of observations in terms of its proportion of Tier 1 regulatory capital discretionarily held, and 0 otherwise. $DQUAL_{HIGH}$ is a dummy variable taking the value of unity if $Bank_i$ is in the top 20 percentile of observations in terms of its proportion of Tier 1 regulatory capital discretionarily held, and 0 otherwise. *SIZE* is the natural log of total bank assets. *LOANEXP* is the proportion of retail loans to total loans. *DEPOSIT* is the proportion of short term deposits held to total deposits. *HHI* measures the revenue diversification between non-interest income and total interest income. RWA_{t-2} is a two-period lag of risk-weighted assets to total assets. *CASHMKTSEC* is cash and marketable securities to total bank assets. *ROE* is the average return on equity. *SUBORD* is the proportion of subordinated debt to total liabilities. Regressions are estimated for quarter 1 2001 – quarter 4 2016. Quarter time dummies included but not reported. The Hansen test is the test for over-identification restrictions. AR(1) and AR(2) represent first and second order residual tests. For these tests, p-values are reported. Robust t-statistics are presented in parentheses. *, **, *** reports significance at the 10, 5 and 1% levels of significance, respectively.

VARIABLES	(1) GMM	(2) GMM	(3) GMM	(4) GMM
$BUFQUAL_{t-1}$	0.440***		0.528***	
	(5.2)		(7.4)	
$DQUAL_{LOW} * BUFQUAL_{t-1}$		0.293		0.276
		(0.6)		(0.5)
$DQUAL_{HIGH} * BUFQUAL_{t-1}$		0.603**		0.582**
		(2.1)		(2.5)
SIZE	-0.0275***	-0.0264*	-0.0189**	-0.0272*
	(-4.178)	(-1.716)	(-2.570)	(-1.900)
LOANEXP	-0.0777	0.0249		
	(-1.545)	(0.3)		
DEPOSIT			0.0269	0.011
			(0.5)	(0.2)
HHI	0.0318	0.106**	0.0566**	0.0902**
	(1.0)	(2.1)	(2.2)	(2.2)
RWA_{t-2}	-0.0717***	-0.0651	-0.0868***	-0.0632
	(-3.874)	(-1.354)	(-4.786)	(-1.400)
CASHMKTSEC	0.0613	0.075	0.0507	0.0889
	(0.9)	(0.8)	(0.7)	(0.9)
ROE	0.00355***	0.0172*	0.00402***	0.0164*
	(4.0)	(1.9)	(4.3)	(1.8)
SUBORD	0.0718	0.561	0.413***	0.486**
	(0.3)	(1.5)	(3.0)	(2.3)
Constant	0.465***	0.396	0.300**	0.408*

	(4.7)	(1.6)	(2.4)	(1.8)
# Observations	73,388	73,388	73,378	73,378
# Banks	2,489	2,489	2,489	2,489
# Instruments	14	13	14	13
AR(1) p-value	2.65e-09	0.0545	0	0.0513
AR(2) p-value	0.105	0.225	0.279	0.319
Hansen p-value	0.132	0.226	0.0897	0.199

4.4.4. Alternative operational complexity measure

As an alternative measure of operational complexity, the notional value of off-balance sheet activities is introduced (Berger et al., 2008). Because of the high correlation with the bank size variable (*SIZE*), a composite measure is introduced as:

$$OBS/SIZE \ = \frac{SIZE}{OBS}$$

where *OBS/SIZE* is calculated as the ratio of *SIZE* to *OBS*; where *SIZE* is the natural log of Total Assets for a bank in a quarter; *OBS* is the natural log of off-balance sheet activities.[59]

Table 4.11 presents the results for system GMM models estimated using *OBS/SIZE*. While the new variable is not estimated with statistical significance, it does alter the magnitude and sign to the *FIXASSET* coefficient. Unlike the persistent theme for previous estimations, FIXASSET is now strongly positive (significant at the 5% level). This is supportive of H2 suggesting retail intensive banks hold higher quality buffers because of their restricted market access.

[59] The absolute value as opposed to the reported totals for off-balance sheet items is preferred because it gives a better indication of a bank's notional exposure to off-balance sheet activities. A full list of the off-balance sheet item codes used to construct the variable are listed in Appendix A.3.

Table 4.11 – Alternative operational complexity measure (Q1 2001 – Q4 2016)

Specifications (1) and (2) are estimated using the two-step Blundell and Bond (1998) system GMM for panel data; the endogenous variables are instrumented with one to ten lags, and the instruments are collapsed. Dependent variable is *BUFQUAL*, the proportion of Tier 1 regulatory capital discretionarily held by a bank. The explanatory variables are as follows $BUFQUAL_{t-1}$ is the first lag of the dependent variable, $DQUAL_{LOW}$ is a dummy variable taking the value of unity if $Bank_i$ is in the bottom 20 percentile of observations in terms of its proportion of Tier 1 regulatory capital discretionarily held, and 0 otherwise. $DQUAL_{HIGH}$ is a dummy variable taking the value of unity if $Bank_i$ is in the top 20 percentile of observations in terms of its proportion of Tier 1 regulatory capital discretionarily held, and 0 otherwise. *OBS/SIZE* is the natural log of the notional value of off-balance sheet activities divided by the natural log of total bank assets. *FIXASSET* is the proportion of fixed assets to total bank assets. RWA_{t-2} is a two-period lag of risk-weighted assets to total assets. *CASHMKTSEC* is cash and marketable securities to total bank assets. *ROE* is the average return on equity. *SUBORD* is the proportion of subordinated debt to total liabilities. Regressions are estimated for quarter 1 2001 – quarter 4 2016. Quarter time dummies included but not reported. The Hansen test is the test for over-identification restrictions. AR(1) and AR(2) represent first and second order residual tests. For these tests, p-values are reported. Robust t-statistics are presented in parentheses. *, **, *** reports significance at the 10, 5 and 1% levels of significance, respectively.

VARIABLES	(1) GMM	(2) GMM
$BUFQUAL_{t-1}$	0.603***	
	(7.8)	
$DQUAL_{LOW} * BUFQUAL_{t-1}$		-0.347
		(-0.726)
$DQUAL_{HIGH} * BUFQUAL_{t-1}$		0.931***
		(5.8)
OBS/SIZE	0.0124	0.0682
	(0.3)	(1.6)
FIXASSET	4.421**	3.322
	(2.4)	(1.4)
RWA_{t-2}	-0.0976***	-0.0177
	(-4.846)	(-0.347)
CASHMKTSEC	0.181***	0.157*
	(2.9)	(2.0)
ROE	0.00481***	0.00564***
	(2.9)	(2.9)
SUBORD	0.0291	-0.112
	(0.1)	(-0.498)
Constant	-0.0334	-0.0906
	(-0.537)	(-1.141)
# Observations	73,388	73,388
# Banks	2,489	2,489
# Instruments	13	13
AR(1) p-value	2.29e-10	1.79e-05
AR(2) p-value	1.56e-09	0.191
Hansen p-value	0.457	0.785

4.4.5. Alternative credit risk measures

Three additional measures of credit risk are introduced to understand whether the apparently negative relationship with buffer quality is unique to RWA_{t-2} or consistent with other proxies for credit risk. Importantly, to mitigate the endogeneity potential a two-period lag is taken on each of the alternative credit risk measures. The first of these being NPL_{t-2}, calculated as a bank's non-performing loans as a proportion of its total loans.

The second proxy for credit risk is $PROV_{t-2}$, calculated as the fraction of provisions for bad and doubtful debts to total assets for a bank. The third proxy is $COMLOAN_{t-2}$, calculated as the fraction of commercial loans to total loans for a bank in a quarter;

The results for the regressions including the alternative credit risk proxies are presented in Table 4.12. Models (1) and (2) are estimated by introducing NPL_{t-2}, Models (3) and (4) are estimated with $PROV_{t-2}$, Models (5) and (6) are estimated using $COMLOAN_{t-2}$. The estimated coefficient for NPL_{t-2} is positive and significant (at the 10% level). The existing literature usually regards non-performing loans as an ex-post measure of credit risk, and so a negative coefficient for non-performing loans would also be expected (Ayuso et al., 2004). This prediction is only reinforced by the lagged nature of non-performing loans utilised in this thesis (i.e. taking a two-period lag should emphasise the ex-post nature to non-performing loans).[60] This provides some evidence that a bank manages its buffer quality as a hedge against the risks that may materialise in its loan portfolio. This estimation is counter to the results ascertained in respect of the primary credit risk variable (RWA_{t-2}).

The coefficient for $PROV_{t-2}$ is negative in Model's (3) and (4). While this is consistent with that ascertained for RWA_{t-2} in the main results, the explanatory power of $PROV_{t-2}$ is substantially less significant (only significant at the 10% level in Model (3)). $COMLOAN_{t-2}$ is not estimated with any significance in Models (5) and (6). In summation, the reduced explanatory power of NPL_{t-2}, $PROV_{t-2}$ and $COMLOAN_{t-2}$ serve as validations for the use of RWA_{t-2} as the primary measure of credit risk in this thesis.

[60] Because a two-period lag in a study using quarterly periods is still quite proximate to the current period, longer lags were taken on non-performing loans to test whether the relationship changes. However, in these longer time periods the statistical significance of non-performing loans was lost. For brevity, these results are not tabulated.

Table 4.12 – Alternative credit risk measures (Q1 2001 – Q4 2016)

Specifications (1) - (6) are estimated using the two-step Blundell and Bond (1998) system GMM for panel data; the endogenous variables are instrumented with one to ten lags, and the instruments are collapsed. Dependent variable is *BUFQUAL*, the proportion of Tier 1 regulatory capital discretionarily held by a bank. The explanatory variables are as follows $BUFQUAL_{t-1}$ is the first lag of the dependent variable, $DQUAL_{LOW}$ is a dummy variable taking the value of unity if $Bank_i$ is in the bottom 20 percentile of observations in terms of its proportion of Tier 1 regulatory capital discretionarily held, and 0 otherwise. $\mathrm{DQUAL_{HIGH}}$ is a dummy variable taking the value of unity if $Bank_i$ is in the top 20 percentile of observations in terms of its proportion of Tier 1 regulatory capital discretionarily held, and 0 otherwise. *SIZE* is the natural log of total bank assets. *FIXASSET* is the proportion of fixed assets to total bank assets. *HHI* measures the revenue diversification between non-interest income and total interest income. NPL_{t-2} is a two-period lag of non-performing loans to total loans. $PROV_{t-2}$ is a two-period lag of loan loss provision to total assets. $COMLOAN_{t-2}$ is a two-period lag of commercial loans to total loans. *CASHMKTSEC* is cash and marketable securities to total bank assets. *ROE* is the average return on equity. *SUBORD* is the proportion of subordinated debt to total liabilities. Regressions are estimated for quarter 1 2001 – quarter 4 2016. Quarter time dummies included but not reported. The Hansen test is the test for over-identification restrictions. AR(1) and AR(2) represent first and second order residual tests. For these tests, p-values are reported. Robust t-statistics are presented in parentheses. *, **, *** reports significance at the 10, 5 and 1% levels of significance, respectively.

	(1)	(2)	(3)	(4)	(5)	(6)
VARIABLES	GMM	GMM	GMM	GMM	GMM	GMM
	NPL	NPL	PROV	PROV	COMM	COMM
$BUFQUAL_{t-1}$	-0.173		0.0315		0.118	
	(-1.137)		(0.3)		(1.2)	
$DQUAL_{LOW} * BUFQUAL_{t-1}$		-0.447***		-0.489*		-0.506
		(-2.998)		(-1.710)		(-1.465)
$DQUAL_{HIGH} * BUFQUAL_{t-1}$		0.557***		1.012***		0.901
		(3.3)		(2.9)		(1.1)
SIZE	-0.0708***	-0.0223**	-0.0601***	0.00438	-0.0496***	-0.00284
	(-4.306)	(-2.464)	(-5.993)	(0.2)	(-4.448)	(-0.0380)
FIXASSET	-4.172	-0.379	-2.799	3.172	0.0371	1.507
	(-1.187)	(-0.198)	(-1.110)	(0.8)	(0.0)	(0.1)
HHI	0.172***	0.0810***	0.166***	0.0286	0.121***	0.0299
	(3.6)	(3.2)	(5.0)	(0.4)	(4.1)	(0.3)
$NPL_{t\,t-2}$	0.877*	0.397*				
	(1.9)	(1.7)				
$PROV_{t-2}$			-0.192*	-0.0411		
			(-1.893)	(-0.232)		
$COMLOAN_{t-2}$					0.0531	-0.104
					(0.7)	(-0.230)
CASHMKTSEC	0.114	0.113	-0.0274	0.0907	0.0304	0.0611
	(0.9)	(1.3)	(-0.276)	(0.6)	(0.3)	(0.2)

ROE	0.0221**	0.0120***	0.0162***	0.00559**	0.00580***	0.00575**
	(2.4)	(2.7)	(2.6)	(2.6)	(2.9)	(2.3)
SUBORD	1.068**	0.305	0.785**	-0.159	0.804***	-0.187
	(2.3)	(1.6)	(2.3)	(-0.312)	(2.6)	(-0.231)
Constant	1.022***	0.310**	0.882***	-0.102	0.674***	0.0514
	(3.8)	(2.2)	(5.1)	(-0.229)	(3.4)	(0.0)
# Observations	73,388	73,388	73,388	73,388	73,388	73,388
# Banks	2,489	2,489	2,489	2,489	2,489	2,489
# Instruments	13	14	12	13	14	12
AR(1) p-value	0.624	1.87e-06	0.00428	0.00174	0.00179	0.0949
AR(2) p-value	0.567	0.0300	0.707	0.0313	0.841	0.0275
Hansen p-value	0.145	0.384	0.0326	0.752	0.000414	0.519

4.4.6. Alternative liquid assets measure

Loutskina (2011) suggests that cash holdings will, in part, represent required reserves and therefore cannot be expected to be easily drawn upon. For this reason, *MKTSEC* which measures marketable securities to total assets, is included as an alternative measure of liquid assets. The regression results with this alternative measure of liquid assets are presented in Table 4.13. The coefficient on *MKTSEC* although positive, is not significant in either model.

Table 4.13 – Alternative liquid assets measure (Q1 2001 – Q4 2016)

Specifications (1) and (2) are estimated using the two-step Blundell and Bond (1998) system GMM for panel data; the endogenous variables are instrumented with one to nine lags, and the instruments are collapsed. Dependent variable is *BUFQUAL*, the proportion of Tier 1 regulatory capital discretionarily held by a bank. The explanatory variables are as follows $BUFQUAL_{t-1}$ is the first lag of the dependent variable, $DQUAL_{LOW}$ is a dummy variable taking the value of unity if $Bank_i$ is in the bottom 20 percentile of observations in terms of its proportion of Tier 1 regulatory capital discretionarily held, and 0 otherwise. $DQUAL_{HIGH}$ is a dummy variable taking the value of unity if $Bank_i$ is in the top 20 percentile of observations in terms of its proportion of Tier 1 regulatory capital discretionarily held, and 0 otherwise. *SIZE* is the natural log of total bank assets. *FIXASSET* is the proportion of fixed assets to total bank assets. *HHI* measures the revenue diversification between non-interest income and total interest income. RWA_{t-2} is a two-period lag of risk-weighted assets to total assets. *MKTSEC* is marketable securities to total bank assets. *ROE* is the average return on equity. *SUBORD* is the proportion of subordinated debt to total liabilities. Regressions are estimated for quarter 1 2001 – quarter 4 2016. Quarter time dummies included but not reported. The Hansen test is the test for over-identification restrictions. AR(1) and AR(2) represent first and second order residual tests. For these tests, p-values are reported. Robust t-statistics are presented in parentheses. *, **, *** reports significance at the 10, 5 and 1% levels of significance, respectively.

VARIABLES	(1) GMM	(2) GMM
$BUFQUAL_{t-1}$	0.565***	
	(4.5)	
$DQUAL_{LOW} * BUFQUAL_{t-1}$		-0.187
		(-0.147)
$DQUAL_{HIGH} * BUFQUAL_{t-1}$		1.096
		(1.4)
SIZE	-0.0142	-0.00034
	(-1.003)	(-0.00678)
FIXASSET	2.642	1.183
	(1.3)	(0.2)
HHI	0.0483	0.0308
	(1.2)	(0.3)
RWA_{t-2}	-0.0852***	-0.0342
	(-3.758)	(-0.335)
MKTSEC	0.0488	0.0556
	(0.5)	(0.3)
ROE	0.00442***	0.00501
	(2.9)	(0.2)
SUBORD	0.293	0.0741
	(1.4)	(0.1)
Constant	0.209	0.0274
	(1.0)	(0.0)
# Observations	73,388	73,388
# Banks	2,489	2,489
# Instruments	12	11
AR(1) p-value	1.43e-07	0.0922
AR(2) p-value	0.126	0.297
Hansen p-value	0.105	0.243

4.5. Chapter summary

This chapter reported the empirical results from testing the five hypotheses associated with RQ1 and RQ2. This is summaries in Table 4.14.

Table 4.14 – Hypotheses, testing procedures and results

This table summarises the findings with respect to the five hypotheses and buffer quality.

	Hypotheses	Testing procedure	Results
H1	There is a negative association between bank size and capital buffer quality	The estimated value of $\propto_1$ (coefficient of *SIZE)* in Equation (5) is negative and statistically significant from zero.	$\propto_1$ is negative and statistically significant, indicating that larger banks hold lower quality capital buffers. Thus, support for H1 is found.
H2	There is a positive association between retail intensity and capital buffer quality	The estimated value of $\propto_2$ (coefficient of *FIXASSET)* in Equation (5) is positive and statistically significant from zero.	$\propto_2$ is not statistically significant, in the primary system GMM model thus, rejecting H2.
H3	There is a positive association between operational complexity and capital buffer quality	The estimated value of $\propto_3$ (coefficient of *HHI)* in Equation (5) is positive and statistically significant from zero.	$\propto_3$ is positive and statistically significant, indicating that operationally complex banks hold higher quality capital buffers. Thus, providing support for H3.
H4	There is a positive association between credit risk and capital buffer quality	The estimated value of $\propto_4$ (coefficient of RWA_{t-2}) in Equation (5) is positive and statistically significant from zero.	$\propto_4$ is negative and statistically significant, indicating that banks with greater credit risk hold lower quality capital buffers. Thus, rejecting H4 and finding in the alternative.
H5	There is a negative association between asset liquidity and capital buffer quality	The estimated value of $\propto_5$(coefficient of *CASHMKTSEC)* in Equation (5) is negative and statistically significant from zero.	$\propto_5$ is positive and but statistically insignificant, in the primary system GMM model thus, rejecting H5.

In respect of H1, there is evidence that larger banks hold lower quality buffers over the entire sample period. These results are particularly driven by the holding companies with the regulatory classification of Bank Holding Companies, and Financial Holding Companies (albeit to a lesser extent). This negative association between bank size and capital buffer quality however is not robust to time period sub-samples.

For H2, retail intensive banks appear to hold lower quality buffers. This result is only visible in the POLS and FE regressions where the coefficient is measured with statistical significance, not the preferred system GMM regressions. This is also reflected in the Bank Holding Company subsample regressions (and to a lesser extent, the Financial Holding Company regressions). The results however, are not robust to time period sub-samples. The introduction of alternative retail intensity measures does not estimate statistically significant coefficients.

While the main results to *HHI* provide ambiguous results (with some models estimating positive coefficients with significance and other models estimating negative coefficients with significance) further testing tends to support H3 that more operationally complex banks hold higher quality capital buffers. This is consistent with the system GMM models presented in the primary results on buffer quality. A positive association is robust to the subperiod Quarter 1 2001 – Quarter 4 2013 (when all large BHCs were under the same regulatory treatment in relation to the deductibility of interests in non-consolidating banking affiliates). It is also robust to using the Tier 1 ratio as an alternative measure of capital quality. However, such a finding is not sustained with significance in relation to the alternative measure of operational complexity which focuses on off-balance sheet activities.

With respect to H4, higher levels of credit risk appear to correspond with lower quality buffers. This rejects H4 and finds, with statistical significance to the contrary. This finding is pronounced for both Bank Holding Companies and Financial Holding Companies (and Savings and Loan Holding Companies to a lesser extent). The negative coefficient estimate is seen to be robust to time sub-samples (particularly in the overlapping periods of Quarter 1 2001 – Quarter 4 2013 and Quarter 1 2010 – Quarter 4 2016) as well as an alternative measure of capital quality as the dependent variable. Alternative proxies for credit risk (alternatives to RWA_{t-2}) do not have strong explanatory power upon buffer quality.

The primary model, system GMM fails to find statistical support for a relationship between liquid asset investments and buffer quality.

Chapter 5 Conclusion

5. 1 Introduction

This chapter concludes this thesis. Section 5.2 reviews the research questions and hypotheses in light of the empirical results. Section 5.3 links these findings to the academic contributions. While Section 5.4 links the findings to the policy implications. Section 5.5 outlines limitations to this study. Section 5.6 makes recommendations for future research.

5. 2 Review of research questions

This purpose of this thesis has been to examine the capital buffer quality of large US BHCs during the period Quarter 1 2001 – Quarter 4 2016 by composing an unbalanced panel set with 78,963 bank-quarter observations. The research was guided by the following research questions, which were the product of current themes in the regulatory environment and gaps in the prior literature:

RQ1 – What bank characteristics influence capital buffer quality of large banks?

RQ2 – Do large banks trade–off capital buffers quality with liquid asset investments?

The following discussion to this subsection summarises the corresponding hypotheses and findings in relation to each research question.

5.2.1 What operating activities influence the composition of capital buffers of large banks? (RQ1)

RQ1 was investigated by testing the following hypotheses:

H1: There is a negative association between bank size and capital buffer quality

H2: There is a positive association between retail intensity and capital buffer quality

H3: There is a positive association between operational complexity and capital buffer quality

H4: There is a positive association between credit risk and capital buffer quality

The primary econometric technique to addressing each of these hypotheses, in this study is the two-step system GMM estimator (Arellano & Bond, 1991; Blundell & Bond, 1998). This approach is favoured for its ability to directly address endogeneity and model a dependent variable which is itself dependent upon their own past occurrences (Roodman, 2006).[61] Consistent with prior literature, results are also presented for POLS and two-way FE models (Bond, 2002; Francis & Osborne, 2010; Pereira & Saito, 2015; Prasad & Espinoza, 2010). These additional results are insightful and reportable however, the system GMM remains the primary model by constructing valid instrumental variables. Table 5.1 summarises the findings with respect to RQ1 and its associated hypotheses.

[61] The system GMM estimator is also desirable from the perspective of its treatment and testing of autocorrelation, heteroscedasticity (via the Arellano-Bond tests and the Hansen test-statistic).

Table 5.1 – Summary for RQ1

RQ1: What operating activities influence the composition of capital buffers of large banks?			
Hypotheses	**Methodology**	**Testing procedure**	**Results**
H1: There is a negative association between bank size and capital buffer quality	Equation (5) estimated using system GMM in conjunction with Pooled OLS and two-way Fixed Effects Panel regressions	The estimated value of $\propto_1$ (coefficient of *SIZE)* in Equation (5) is negative and statistically significant from zero.	Overall, larger banks hold lower quality capital buffers. This is not robust to time subsample or to the alternative measure of capital quality. When considering the respective regulatory holding company structures, the negative relationship is most significant with respect to Bank Holding Companies and, Financial Holding Companies to a lesser extent.
H2: There is a positive association between retail intensity and capital buffer quality	Equation (5) estimated using system GMM in conjunction with Pooled OLS and two-way Fixed Effects Panel regressions	The estimated value of $\propto_2$ (coefficient of *FIXASSET)* in Equation (5) is positive and statistically significant from zero.	There is some support for a retail intensive banks holding lower quality capital buffers in the main results. This is, however, not of observable significance in the preferred system GMM econometric model. When an alternative measure of capital quality is used the relationship becomes positive, while it is not significant to alternative measures of retail intensity.
H3: There is a positive association between operational complexity and capital buffer quality	Equation (5) estimated using system GMM in conjunction with Pooled OLS and two-way Fixed Effects Panel regressions	The estimated value of $\propto_3$ (coefficient of *HHI)* in Equation (5) is positive and statistically significant from zero.	Operationally complex banks appear to hold higher quality capital buffers (as indicated by the preferred system GMM econometric model). This is robust to the Q1 2001 – Q4 2013 time subsample and the alternative measure of capital quality. It is however, not significant to an alternative measure of operational complexity.
H4: There is a positive association between credit risk and capital buffer quality	Equation (5) estimated using system GMM in conjunction with Pooled OLS and two-way Fixed Effects Panel regressions	The estimated value of $\propto_4$ (coefficient of RWA_{t-2}) in Equation (5) is positive and statistically significant from zero.	There is strong evidence suggesting that banks exposed to greater degrees of credit risk hold lower quality capital buffers in the main results. This finding is most supported with respect to Bank Holding Companies and Financial Holding Companies. It is also robust to the Q1 2001 – Q4 2013 and post-GFC (Q1 2010 – Q4 2016) time subsamples as well as an alternative measure of capital quality. Alternative measures of credit risk provide ambiguous results.

The main results indicate that there is some influential power to bank size upon buffer quality, namely that the two are inversely related (supporting H1). However, this study's objective has been to establish if there are bank characteristics that influence buffer quality other than bank size itself. That there is something more to capital buffer quality at large banks than their bank size is most clearly established with respect to credit risk. Contrary to H4, there is strong evidence to indicate that higher credit risk implies lower buffer quality. This finding is particularly pronounced with respect to Bank Holding Companies and Financial Holding Companies. It is also robust to the Q1 2001 – Q4 2013 time subsample (when all reporting banks were under a homogenous regulatory framework regarding deductions to regulatory capital for interests in banking affiliates). The relationship is also statistically significant in the post-GFC period (Q1 2010 – Q4 2016).

Further evidence that there is something more to bank size that drives buffer quality is found in relation to operational complexity (H3). Consistent with H3, it appears that operationally complex banks hold higher quality capital buffers. This is robust to the alternative measure of capital quality. The relationship is statistically significant in the Q1 2001 – Q4 2013 time subsample.

5.2.2 Do large banks trade-off the composition of capital buffers with liquid asset investments? (RQ2)

RQ2 was investigated by testing the following hypothesis (H5): There is a negative association between asset liquidity and capital buffer quality. In relation to methodology, H5 is econometrically tested contemporaneous with H1 – H4 (i.e. using Equation (5) for system GMM, POLS and FE models). Table 5.2 summarises the findings with respect to RQ2 and its associated hypotheses.

Table 5.2 – Summary for RQ2

RQ2: Do large banks trade-off the composition of capital buffers with liquid asset investments?			
Hypothesis	**Methodology**	**Testing procedure**	**Results**
H5: There is a negative association between asset liquidity and capital buffer quality	Equation (5) estimated using system GMM in conjunction with Pooled OLS and two-way Fixed Effects Panel regressions	The estimated value of $\propto_5$(coefficient of *CASHMKTSEC)* in Equation (5) is negative and statistically significant from zero.	There is some evidence that banks with greater liquid asset investments hold higher quality buffers. This is however, not observed in the results of the primary econometric technique (system GMM).

The results of the preferred interpretive model, system GMM do not find statistical significance to support H5. This pattern is reflected for time subsamples, the alternative capital quality dependent variable and the restricted liquid assets variable (which excludes cash). In answering RQ2, it is not possible to conclude with statistical significance that large banks trade-off buffer quality with liquid asset investments.

5. 3 Academic contributions

The results offer several academic contributions. By extending the discussion to capital buffer quality, this study explores an area presently neglected by the literature, but of contemporary importance. This study shows bank size itself is not a sufficient explanatory tool of buffer quality. By calculating adjustments speeds of buffer quality, this thesis offers previously unexplored insights into whether banks are increasingly prioritising the importance of capital buffer quality over the years. This thesis also reveals new information in relation to the bank characteristics that determine buffer quality, both negatively (i.e. credit risk and bank size, to a lesser extent) and positively (i.e. operational complexity) while also examining whether banks trade-off buffer quality with liquid asset investments.

By calculating adjustment speeds with respect to buffer quality, this thesis adds a previously unexplored dimension analysing adjustment speeds. The findings indicate that banks in the post-GFC period have begun adjusting their capital buffer quality far quicker than previously. The post-GFC speed adjustment is 30.01% faster than during the GFC, and 37.41% faster than before the GFC. Adjustments to buffer quality are also observed to be far quicker than the previous literature's findings in relation to buffer size (Jokipii & Milne, 2011). The prior literature on this considers time frames before and during the GFC. Taken together, these findings provides evidence that banks have learnt a lesson from the GFC, and are now focused on quickly adjusting their buffer quality.

A further contribution is made by interacting adjustment speeds with degrees of capitalisation. In these tests, it is found that well-capitalised banks make faster adjustments to buffer quality. Meanwhile, it is shown that under-capitalised banks struggle to re-establish buffer quality. These predictions are novel and distinct from that predicted under the capital buffer theory (where the reverse would be expected to prevail).

This thesis adds a novel contribution to the existing literature on operational complexity's influence on bank capital by extending the analysis to capital buffer quality. The key finding that operationally complex banks hold higher quality capital buffers is a consistent and insightful extension to the existing literature's positive association between bank capital and operational complexity.

Additionally, this thesis extends the literature by considering credit risk's influence upon capital buffer quality. The capital-risk association is a field extensively researched but examining the mix of Tier 1 and Tier 2 capital that banks discretionarily hold, in light of their credit risk exposures, is a topic that no prior study has studied.

This thesis also offers novel findings in relation to the distinct regulatory classifications of holding companies by disaggregating results separately for Bank Holding Companies, Financial Holding Companies and, Savings and Loan Holding Companies. The existing literature does not appear to consider this respective dimension.[62] The results are found to sustain the greatest consistent significance with respect to Bank Holding Companies, followed by Financial Holding Companies.

In addition to studying buffer quality, this study provides results for buffer size (see Appendix A.2). This presents an opportunity to test the prior literature's assertion that larger banks hold smaller capital buffers.[63] Interestingly, no statistical significance is attributed to bank size in these buffer size regressions, contrary to the prior literature. This could be attributed to this study being the first of its kind to study post-GFC and Basel III time periods.[64] It could also be in part explained by the prior literature failing to properly adjust for the differential treatment between large and small banks with respect to their required deductions to regulatory capital because of investments in non-consolidated banking affiliates (Gong et al., 2017). The failure of bank size to explain capital buffers held by large banks in this thesis is indicative of there being something more than bank size itself which dictates both the size and quality of a bank's capital buffer.

From a choice of econometric technique, this thesis finds that the two-step system GMM is the preferred model. The prior literature's sometimes over-reliance upon alternative specifications such as fixed effects models (e.g. Francis and Osborne (2010)) or pooled ordinary least squares (e.g. Pereira and Saito (2015)) appear to imply artificial statistical significance without properly addressing endogeneity concerns.

5. 4 Policy implications

The empirical results to this thesis also offer several practical implications. From a regulator's perspective, an important implication of the increased adjustment speeds of capital buffer quality, following the GFC serves as further validation for scrutinising buffer quality over buffer size. Pleasingly from a regulator's perspective, it appears that banks are more acutely aware than ever of the need to raise buffer quality quickly (adjustment speeds have increased by up to 37% after the GFC).

Particular implications also relate to the interaction between adjustment speeds and degrees of capitalisation. Discovering that poorly-capitalised banks have difficulty re-establishing their capital buffer quality suggests

[62] While Jokipii and Milne (2011) appear to consider the universe of US BHCs, they do not prepare results for individual holding company-types as defined by their regulatory classifications.
[63] See for instance Ayuso et al. (2004), Fonseca and González (2010), Francis and Osborne (2010); (Jokipii & Milne, 2011); Pereira and Saito (2015) who all assert negative associations between bank size and buffer size.
[64] The prior literature considered in this thesis consider either pre-GFC or GFC time periods.

that perhaps a greater regulatory emphasis needs to be placed upon earlier intervention. The desire being to avoid these ‘at-risk’ institutions becoming poorly capitalised and their capital quality becoming irretrievable.

Further important regulatory implications lie with respect to the association between buffer quality and: (1) operational complexity, and (2) credit risk. Regarding the first of these, the finding that operationally complex banks holding better quality buffers has implications for the current regulatory path. Following the GFC, there has been a legislative emphasis upon reigning-in the array of non-traditional activities that banks are permitted to participate in (for example the Dodd-Frank Wall Street Reform). What needs to be considered in drafting these policies is that banks with more diverse revenue bases (and therefore, are more operationally complex) tend to hold higher quality buffers. Is this finding sufficient? Should such banks, holding more loss-absorbent buffers be granted permission to retain operating in multiple non-traditional revenue sources?

That consideration requires a deeper understanding as to why these banks hold higher quality buffers. It could be motivated by a desire to signal their ongoing viability, in the presence of greater agency problems. An alternative explanation could be that the specific activities these banks are diversifying into increases their overall bank risk.[65] Understanding which explanation leads to the outcome of higher buffer quality should assist how regulators respond. That means addressing whether the increase in buffer quality is sufficient to offset the agency problems or growth in bank risk. If it is insufficient, then perhaps the current regulatory path is warranted by narrowing the fields banks can earn revenue in. If it is sufficient, then regulators must consider whether activity restriction really is the preferred policy.

Secondly, the negative association between buffer quality and credit risk should be of relevance to regulators. This finding may indicate a ‘gambling’ mentality where a bank takes on further risk in an attempt to re-establish its buffer quality (Jokipii & Milne, 2011). Regulators need to be attentive to the risk that these banks are incentivised by a moral hazard or are aggressively buying market share with diminishing returns to capital (Williams, 2007). A downstream consequence for depositors and other bank creditors is the need to price in to their required return the higher credit risk and lower buffer quality.

Practical implications are expected for a bank’s strategic decision-making. The results imply that a banker cannot compare capital buffer quality without examining a peers’ operational complexity and credit risk. The empirical results to this study strongly suggest that differences across these two characteristics influence a

[65] As indicated previously, the impact revenue diversification has upon overall bank risk is not decisively concluded upon by the literature.

bank's capital buffer quality. Shareholders should also be attuned to where their bank differs from the 'norm'. For instance, banks who moderate their capital buffer quality downward while growing their complexity (perhaps by growing the diversity of their revenue streams) are acting out of step with that of their peers. This may serve as a basis for shareholders to question the motivations behind management's decision-making. This same logic applies to whether a bank is consistent with its peers' management of buffer quality in light of changes to credit risk.

5. 5 Study limitations

There are limitations which do impact this thesis' findings. For instance, this thesis makes the assumption that a bank targets its regulatory capital holding (in particular that a bank targets its capital buffer quality). This is an approach used extensively in the literature. However, as acknowledged by (Jokipii & Milne, 2011), it is entirely possible that a particular bank may target other forms of capital, such as the market value of its equity.

Additionally, data limitations restrict this thesis to scrutinising a bank's capital buffer by its mix of Tier 1 and Tier 2 capital. Tier 1 capital can be composed of some hybrid instruments that would otherwise count towards a bank's Tier 2 capital (i.e. by way of 'Additional Tier 1 capital'). This does impact how Tier 1 is distinguished from Tier 2 capital. Common Equity Tier 1 capital, which is not impacted by the influences of Tier 2 capital instruments, remains the preferred starting point for an examination of quality. Data limitations prevented the use of Common Equity Tier 1 in this thesis. The FR Y-9C report, prior to Basel III's adoption in 2014, was not formatted in a way which allowed Common Equity Tier 1 to be accurately calculated. For that reason, Tier 1 capital was relied upon.

Over the sample period, from which this study is drawn, regulatory changes influence the calculation of a bank's capital buffer. This is the case with respect to a bank's capital buffer following Basel III's implementation. This regulatory reform raised the mandated levels and forms of capital that a bank must hold. In turn, the amount of capital a bank discretionarily held (if it made no adjustment to its capital holdings) from this date onwards (i.e. Quarter 1 2014) is less than that which it held previously. Attempts have been made to appropriately adjust for such increasing levels of mandated capital. However, what is not observable is how a bank responds to bank-specific capital calls imposed upon them by the regulator. FDIC, under its bank examination system, the Uniform Financial Institutions Rating System (also referred to as the 'Capital adequacy Assets Management capability Earnings Liquidity Sensitivity' (or CAMELS) System), can impose further capital requirements following bank inspections (FDIC, 2016). These ratings and their consequences are not publicly disclosed however, could influence what is a bank's 'discretionary' capital.[66] There is no precise way of knowing the quantity and quality of a bank's true discretionary capital level, based upon publicly available information. This thesis approximates the buffer based upon the capital rules operationalised by FDIC from time to time.

Finally, in handling the impact of investments in non-consolidated banking affiliates on regulatory capital, this thesis follows a version of the 'deduction' method as opposed to the 'decompression' method which is favoured by (Gong et al., 2017). The decision to use the deduction variant was made because it is consistent with the Basel Accords. Furthermore, reconstructing the complex organisational structures of the 2,885 BHCs in the data sample (which is necessary to execute the decompression method) was not feasible.

5. 6 Suggestions for future work

The findings of this thesis present a few logical paths for future work. One suggestion relates to the finding that increased buffer quality follows from greater degrees of operational complexity. For instance, understanding whether this evidence of banks' risk-aversion in light of higher overall bank risk (following from the effects of revenue diversification) is one suggested field.

Another suggestion is to link the findings with respect to buffer quality to shareholder wealth maximisation. This would be in a similar research field to Demirguc-Kunt et al. (2013) findings that Tier 1 capital is more determinative of bank stock outperformance than other forms of capital. Assessing the quality of the buffer's ability to influence stock market performance of a bank is one such suggested area of research.

This study was concerned with large BHC. Including smaller BHCs in the sample data was not appropriate because of the different regulatory framework smaller BHCs have been under with respect to regulatory capital deductions. However, a separate analysis of only smaller BHCs is a suggested extension of this study. Understanding whether something other than bank size of large banks drives their capital buffer quality was the primary concern of this study. Applying the same lens of investigation to smaller BHCs would also be beneficial, given that they represent approximately 85% of all BHCs in the US.

[66] For instance, if a bank is required to hold further capital following an examination conducted by FDIC, then the buffer it held previously (if it held a buffer) is reduced. If the bank did not hold a buffer, and was undercapitalised (which is the more likely circumstance), then the degree to which it is undercapitalised is enlarged following the examination.

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Appendices

A.1. Regulatory classifications of holding companies

The following definitions are summaries of the definitions used by US regulators (the Federal Reserve and the Federal Deposit Insurance Corporation) in respect of regulatory classifications of holding companies. These definitions were extracted from the National Information Center website.[67]

Regulatory classification of holding company	**Definition**
Bank Holding Company	A company that owns and/or controls one or more U.S. banks or one that owns, or has controlling interest in, one or more banks. A bank holding company may also own another bank holding company, which in turn owns or controls a bank; the company at the top of the ownership chain is called the top holder.
Financial Holding Company	A financial entity engaged in a broad range of banking-related activities, created by the Gramm-Leach-Bliley Act of 1999. These activities include: insurance underwriting, securities dealing and underwriting, financial and investment advisory services, merchant banking, issuing or selling securitized interests in bank-eligible assets, and generally engaging in any non-banking activity authorized by the Bank Holding Company Act.
Savings and Loan Holding Company	A company that directly or indirectly controls a savings association or another savings and loan holding company. This excludes any company that is also a bank holding company. A Savings and Loan Association is a financial institution that accepts deposits primarily from individuals and channels its funds primarily into residential mortgage loans.

[67] This is available at https://www.ffiec.gov/nicpubweb/content/help/institution%20type%20description.htm

A.2. Results for buffer size

In addition to studying whether the hypothesis variables influence buffer quality, studying whether these same variables influence the buffer's size is beneficial as a comparison to the existing literature on buffer size. The results to the buffer size estimations are presented in Table 6.1. The autocorrelation tests indicate that the conditions of the absence of first and second-order serial correlations are met. Further, the Hansen statistic does not imply over-identification restrictions on the estimated equations.

Although the prior literature suggests larger banks hold smaller capital buffers, no conclusive evidence of this is observed in this study. The coefficient for *SIZE* varies across the six models, both in respect of magnitude and significance. [68] The inability to determine a coherent pattern across the models implies the poor predictive power bank size has upon buffer size, when considered holistically, alongside the other explanatory variables to this study. This functions as further evidence that there are operational qualities more unique to a large bank that determines the size of its capital buffer, beyond the size of the institution

The inability to reconcile this finding (of bank size's insignificance) with the existing literature may be a consequence of how the prior literature address the nonconsolidated investments in banking affiliates. When suggesting that larger banks hold smaller capital buffers, the existing literature appears to ignore recent evidence indicating the impact of investments in non-consolidated banking affiliates have upon a bank's regulatory capital. It is found by Gong et al. (2017) that smaller BHCs, at least up until 2014, were given concessionary treatment for deductions to their regulatory capital for such investments, as compared with their larger peers. The authors conclude that the leverage ratio of smaller BHCs could be overstated by as much as 37% under FDIC's framework. The existing literature is silent as to whether it properly controls for this consideration. Failing to consider this factor is likely to overstate the previously observed inverse relationship between bank size and the quantity of capital buffers. Because the sample to this thesis isolates large BHCs (which receive homogenous regulatory treatment with respect to their deductions to regulatory capital due to investments in nonconsolidated affiliates) its findings are not inhibited by the difficulty in comparing small BHCs to large BHCs.

In considering the other hypothesis variables and their influence upon *BUFSIZE*, retail intensity (as proxied by *FIXASSET*) appears to correspond with lower quantities of capital buffers. This can again be construed as indicating the stable nature of retail banking (particularly in the context of deposit insurance) serves as a disincentive for holding larger capital buffers. *HHI* is consistently positive suggesting that operationally

[68] *SIZE* is negative in Models (1), (3), (5) and (6) but only in Models (1) and (3) are those negative signs statistically significant. Contrastingly, *SIZE* is estimated as positive in Models (2) and (4).

complex BHCs have an incentive to signal their ongoing viability by holding bigger buffers to compensate for their larger agency problems (Laeven & Levine, 2007). Credit risk is another factor that appears to play a significant role in predicting the size of the capital buffer maintained by a bank. According to Model (5), a one percentage increase in RWA_{t-2} implies a 9% reduction in the size of the buffer ceteris paribus. *LIQUID* has statistical significance across all 6 models in a positive direction. This is consistent with banks using their liquid assets and capital buffers to capitalise upon growth opportunities (Pereira & Saito, 2015).

The coefficient for *ROE* is positive (and statistically significant) across all six models. This is the same result ascertained with respect to the *BUFQUAL* regressions. Again, this is consistent with the pecking order theory's prediction that retained earnings are an important source for banks to grow the size of their buffers (Ayuso et al., 2004; Myers & Majluf, 1984). There is also some support that banks exposed to increased market discipline (as proxied by *SUBORD*) hold larger buffers, with all models predicting positive coefficients for *SUBORD* but only Models (1), (3) and (4) holding statistical significance.

The adjustment speed calculated in Model (5) is noticeably slower than that estimated in the matching model to *BUFQUAL* (as presented in Table 4.3) where it is estimated to be 15% faster.

Although the existing literature indicates an inverse relationship between buffer size and bank size no such distinction is apparent in the data considered in this study. This finding implies that larger banks cannot be treated as homogenous with respect to the size of their capital buffers. Attention towards the specific operating activities a bank engages in (such as whether it is retail orientated, is operationally complex, has high credit risk or has high investments in liquid assets) provides more coherent conclusions on what influences the size of a bank's capital buffer.

Table 6.1 – Capital buffer size (Q1 2001 – Q4 2016)

Specifications (1) and (2) are estimated by pooled OLS. Specifications (3) and (4) are estimated using fixed effects panel regression Specifications (5) and (6) are estimated using the two-step Blundell and Bond (1998) system GMM for panel data; the endogenous variables are instrumented with one to ten lags, and the instruments are collapsed. Dependent variable is *BUFSIZE*, the amount of total Tier 1 and Tier 2 regulatory capital held in excess to the regulatory minimum. The explanatory variables are as follows $BUFSIZE_{t-1}$ is the first lag of the dependent variable, $DSIZE_{LOW}$ is a dummy variable taking the value of unity if $Bank_i$ is in the bottom 20 percentile of observations in terms of the size of its capital buffer, and 0 otherwise. $\mathrm{DSIZE}_{\mathrm{HIGH}}$ is a dummy variable taking the value of unity if $Bank_i$ is in the top 20 percentile of observations in terms the size of its capital buffer, and 0 otherwise. *SIZE* is the natural log of total bank assets. *FIXASSET* is the proportion of fixed assets to total bank assets. *HHI* measures the revenue diversification between non-interest income and total interest income. RWA_{t-2} is a two-period lag of risk-weighted assets to total assets. *CASHMKTSEC* is cash and marketable securities to total bank assets. *ROE* is the average return on equity. *SUBORD* is the proportion of subordinated debt to total liabilities. Regressions are estimated for quarter 1 2001 – quarter 4 2016. Quarter time dummies included but not reported. The Hansen test is the test for over-identification restrictions. AR(1) and AR(2) represent first and second order residual tests. For these tests, p-values are reported. Robust t-statistics are presented in parentheses. *, **, *** reports significance at the 10, 5 and 1% levels of significance, respectively.

	(1)	(2)	(3)	(4)	(5)	(6)
VARIABLES	POLS	POLS	FE	FE	GMM	GMM
$BUFSIZE_{t-1}$	0.965***		0.882***		0.442*	
	(552.00)		(505.10)		(1.89)	
$DSIZE_{LOW}$ * $BUFSIZE_{t-1}$		0.292***		0.227***		0.843**
		(31.64)		(9.97)		(2.28)
$DSIZE_{HIGH}$ * $BUFSIZE_{t-1}$		0.654***		0.450***		0.4830
		(258.90)		(38.31)		(1.37)
SIZE	-0.000142***	0.000763***	-0.00286***	0.00333***	-0.0233	-0.0380
	(-3.555)	(7.08)	(-14.64)	(3.73)	(-0.473)	(-0.794)
FIXASSET	-0.0232***	-0.191***	-0.0607***	-0.207***	13.0700	6.9120
	(-4.756)	(-17.78)	(-5.904)	(-3.745)	(1.27)	(0.84)
HHI	0.00173***	0.0124***	0.00376***	0.0216***	0.0939	0.1260
	(3.43)	(10.98)	(4.75)	(5.17)	(0.79)	(1.02)
RWA_{t-2}	-0.00151***	-0.0543***	0.0000	-0.0707***	-0.0945***	-0.0772**
	(-2.589)	(-41.28)	(0.01)	(-12.67)	(-2.767)	(-2.412)
CASHMKTSEC	0.00914***	0.0155***	0.0251***	0.0385***	0.449**	0.507**
	(14.84)	(12.46)	(28.64)	(6.75)	(2.18)	(2.25)
ROE	0.0103***	0.0265***	0.0133***	0.0251***	0.0240***	0.0199**
	(14.56)	(18.18)	(59.95)	(16.56)	(2.83)	(2.28)
SUBORD	0.0260***	0.0044	0.0469***	0.131***	2.9710	2.4700
	(6.50)	(0.35)	(8.82)	(3.59)	(1.55)	(1.42)
Constant	0.00297***	0.0721***	0.0392***	0.0474***	0.0451	0.3460
	(3.97)	(38.86)	(14.37)	(3.62)	(0.06)	(0.47)
# Observations	73,388	73,388	73,388	73,388	73,388	73,388
R-squared	0.954	0.769	0.833	0.507		
# Banks			2,489	2,489	2,489	2,489
# Instruments					13	13
AR(1) p-value					0.901	0.00164
AR(2) p-value					0.160	0.707
Hansen p-value					0.373	0.451

A.3. FR Y-9C Regulatory codes

Variable	Variable Description	**Code**	**Purpose**
ID	ID	RSSD9017	*Primary identification variable - used to separate each reporting bank*
ID	ID	RSSD9999	*Used to construct time series*
ID	ID	RSSD9052	*Used to determine if bank meets minimum reporting observations (8 observations)*
ID	ID	RSSD9053	*Used to determine if bank meets minimum reporting observations (8 observations)*
ID	ID	RSSD9346	*Used to verify that reporting entity is a holding company*
ID	ID	RSSD9132	*Used to verify that reporting entity is a holding company*
ID	ID	RSSD9016	*Used to filter FHC*
ID	ID	RSSD9198	*Used to filter SLHC*
ID	ID	RSSD9101	*Used to remove entities not physically operating in US*
ID	ID	RSSD9329	*Used to remove majority (50% and above) foreign owned banks*
ID	ID	RSSD9364	*Used to remove banks whom are majority owned by another bank in the data sample*
ID	ID	BHCK2948	*Total Liabilities*
ID	ID	BHCK3210	*Equity*
ID	ID	BHCK4340	*Net income*
ID	ID	BHCK2122	*Total Loans*
ID	ID	BHCK3459	*Total shares outstanding*
ID	ID	BHCK4062	*Subordinated debt*
ID	ID	BHCKC699	*Subordinated debt payable to trusts*

Dependent Variable	Capital Buffer Quality / Capital Buffer Size	BHCK1395	Used to determine if any Tier 3 issued
Dependent Variable	Capital Buffer Quality / Capital Buffer Size	BHCK3792	Total risk- based capital
Dependent Variable	Capital Buffer Quality / Capital Buffer Size	BHCK7206	Alternative measure of Capital Quality
Dependent Variable	Capital Buffer Quality / Capital Buffer Size	BHCK7205	Total capital ratio
Dependent Variable	Capital Buffer Quality / Capital Buffer Size	BHCKA223	Total RWA - Used to construct multiple variables
Dependent Variable	Capital Buffer Quality / Capital Buffer Size	BHCA8274	Total Tier 1
Dependent Variable	Capital Buffer Quality / Capital Buffer Size	BHCA5311	Total Tier 2
Dependent Variable	Capital Buffer Quality / Capital Buffer Size	BHCW5311	Total Tier 2 (advanced approaches)
Dependent Variable	Capital Buffer Quality / Capital Buffer Size	BHCA3792	Total regulatory capital
Dependent Variable	Capital Buffer Quality / Capital Buffer Size	BHCW3792	Total regulatory capital (advanced approaches)
Dependent Variable	Capital Buffer Quality / Capital Buffer Size	BHCA7206	T1 ratio - Alternative measure of Capital Quality
Dependent Variable	Capital Buffer Quality / Capital Buffer Size	BHCW7206	T1 ratio (advanced approaches) - Alternative measure of Capital Quality
Dependent Variable	Capital Buffer Quality / Capital Buffer Size	BHCA7205	Total capital ratio
Dependent Variable	Capital Buffer Quality / Capital Buffer Size	BHCW7205	Total capital ratio (advanced approaches)
Dependent Variable	Capital Buffer Quality / Capital Buffer Size	BHCWA223	Used to construct multiple variables
Dependent Variable	Capital Buffer Quality / Capital Buffer Size	BHCAA223	Used to construct multiple variables
Credit Risk	Risk-weighted assets to total assets	BHCAA223	Used to construct multiple variables
Credit Risk	Risk-weighted assets to total assets	BHCKA223	Used to construct multiple variables
Credit Risk	Risk-weighted assets to total assets	BHCWA223	Independent Variable - Credit Risk - Alternative'
Credit Risk	Non-performing loans to total loans	BHCK5525	Independent Variable - Credit Risk - Alternative'
Credit Risk	Non-performing loans to total loans	BHCK5526	Independent Variable - Credit Risk - Alternative'

Credit Risk	Provisions to total assets	BHCK4230	Independent Variable - Credit Risk - Alternative'
Credit Risk	Commercial loans	BHCK1763	Independent Variable - Credit Risk - Alternative'
Credit Risk	Commercial loans	BHCK1764	Independent Variable - Credit Risk - Alternative'
Bank Size	Bank Size	BHCK2170	Natural log of Total Assets is used as proxy for bank size. Total Assets is also used in calculation of primary credit risk variable - risk-weighted assets to total assets
Retail Intensity	Fixed Assets to total assets	BHCK2145	Independent Variable - Retail Intensity - Primary
Retail Intensity	Retail loan exposure to total loans	BHCKB538	Independent Variable - Retail Intensity - Alternative
Retail Intensity	Retail loan exposure to total loans	BHCKK207	Independent Variable - Retail Intensity - Alternative
Retail Intensity	Retail loan exposure to total loans	BHCK2011	Independent Variable - Retail Intensity - Alternative
Retail Intensity	Retail loan exposure to total loans	BHCKF158	Independent Variable - Retail Intensity - Alternative
Retail Intensity	Retail loan exposure to total loans	BHDM1797	Independent Variable - Retail Intensity - Alternative
Retail Intensity	Retail loan exposure to total loans	BHDM5367	Independent Variable - Retail Intensity - Alternative
Retail Intensity	Retail loan exposure to total loans	BHDM5368	Independent Variable - Retail Intensity - Alternative
Retail Intensity	Retail deposit exposure to total deposits	BHCB3187	Independent Variable - Retail Intensity - Alternative
Retail Intensity	Retail deposit exposure to total deposits	BHCB2389	Independent Variable - Retail Intensity - Alternative
Retail Intensity	Retail deposit exposure to total deposits	BHCB6648	Independent Variable - Retail Intensity - Alternative
Retail Intensity	Retail deposit exposure to total deposits	BHOD3187	Independent Variable - Retail Intensity - Alternative
Retail Intensity	Retail deposit exposure to total deposits	BHOD2389	Independent Variable - Retail Intensity - Alternative
Retail Intensity	Retail deposit exposure to total deposits	BHOD6648	Independent Variable - Retail Intensity - Alternative
Retail Intensity	Retail deposit exposure to total deposits	BHDM6631	Independent Variable - Retail Intensity - Alternative
Retail Intensity	Retail deposit exposure to total deposits	BHDM6636	Independent Variable - Retail Intensity - Alternative

Retail Intensity	Retail deposit exposure to total deposits	BHFN6631	Independent Variable - Retail Intensity - Alternative
Retail Intensity	Retail deposit exposure to total deposits	BHFN6636	Independent Variable - Retail Intensity - Alternative
Operational Complexity	Herfindahl hirschman index	BHCK4107	Independent Variable - Operational Complexity - Primary - 2002-2016
Operational Complexity	Herfindahl hirschman index	BHCK4070	Independent Variable - Operational Complexity - Primary - 2007-2016
Operational Complexity	Herfindahl hirschman index	BHCK4483	Independent Variable - Operational Complexity - Primary - 2007-2016
Operational Complexity	Herfindahl hirschman index	BHCKA220	Independent Variable - Operational Complexity - Primary - 2007-2016
Operational Complexity	Herfindahl hirschman index	BHCKC888	Independent Variable - Operational Complexity - Primary - 2007-2016
Operational Complexity	Herfindahl hirschman index	BHCKC887	Independent Variable - Operational Complexity - Primary - 2007-2016
Operational Complexity	Herfindahl hirschman index	BHCKC386	Independent Variable - Operational Complexity - Primary - 2007-2016
Operational Complexity	Herfindahl hirschman index	BHCKC387	Independent Variable - Operational Complexity - Primary - 2007-2016
Operational Complexity	Herfindahl hirschman index	BHCKB491	Independent Variable - Operational Complexity - Primary - 2007-2016
Operational Complexity	Herfindahl hirschman index	BHCK4070	Independent Variable - Operational Complexity - Primary - 2003-2006
Operational Complexity	Herfindahl hirschman index	BHCK4483	Independent Variable - Operational Complexity - Primary - 2003-2006
Operational Complexity	Herfindahl hirschman index	BHCKA220	Independent Variable - Operational Complexity - Primary - 2003-2006
Operational Complexity	Herfindahl hirschman index	BHCKB490	Independent Variable - Operational Complexity - Primary - 2003-2006
Operational Complexity	Herfindahl hirschman index	BHCKB491	Independent Variable - Operational Complexity - Primary - 2003-2006
Operational Complexity	Herfindahl hirschman index	BHCKC386	Independent Variable - Operational Complexity - Primary - 2003-2006
Operational Complexity	Herfindahl hirschman index	BHCKC387	Independent Variable - Operational Complexity - Primary - 2003-2006
Operational Complexity	Herfindahl hirschman index	BHCK4070	Independent Variable - Operational Complexity - Primary - 2001-2002
Operational Complexity	Herfindahl hirschman index	BHCK4483	Independent Variable - Operational Complexity - Primary - 2001-2002

Operational Complexity	Herfindahl hirschman index	BHCKA220	Independent Variable - Operational Complexity - Primary - 2001-2002
Operational Complexity	Herfindahl hirschman index	BHCKB490	Independent Variable - Operational Complexity - Primary - 2001-2002
Operational Complexity	Herfindahl hirschman index	BHCKB491	Independent Variable - Operational Complexity - Primary - 2001-2002
Operational Complexity	Herfindahl hirschman index	BHCKB494	Independent Variable - Operational Complexity - Primary - 2001-2002
Operational Complexity	Herfindahl hirschman index	BHCK4107	Independent Variable - Operational Complexity - Primary - 2001-2002
Operational Complexity	Natural log of off-balance sheet activities to the natural log of total assets	BHCK3814	Independent Variable - Operational Complexity - Alternative
Operational Complexity	Natural log of off-balance sheet activities to the natural log of total assets	BHCK3816	Independent Variable - Operational Complexity - Alternative
Operational Complexity	Natural log of off-balance sheet activities to the natural log of total assets	BHCK6550	Independent Variable - Operational Complexity - Alternative
Operational Complexity	Natural log of off-balance sheet activities to the natural log of total assets	BHCK3817	Independent Variable - Operational Complexity - Alternative
Operational Complexity	Natural log of off-balance sheet activities to the natural log of total assets	BHCK6566	Independent Variable - Operational Complexity - Alternative
Operational Complexity	Natural log of off-balance sheet activities to the natural log of total assets	BHCK3820	Independent Variable - Operational Complexity - Alternative
Operational Complexity	Natural log of off-balance sheet activities to the natural log of total assets	BHCK6570	Independent Variable - Operational Complexity - Alternative
Operational Complexity	Natural log of off-balance sheet activities to the natural log of total assets	BHCK3822	Independent Variable - Operational Complexity - Alternative
Operational Complexity	Natural log of off-balance sheet activities to the natural log of total assets	BHCK3411	Independent Variable - Operational Complexity - Alternative
Operational Complexity	Natural log of off-balance sheet activities to the natural log of total assets	BHCKA126	Independent Variable - Operational Complexity - Alternative
Operational Complexity	Natural log of off-balance sheet activities to the natural log of total assets	BHCKA127	Independent Variable - Operational Complexity - Alternative
Operational Complexity	Natural log of off-balance sheet activities to the natural log of total assets	BHCK8723	Independent Variable - Operational Complexity - Alternative
Operational Complexity	Natural log of off-balance sheet activities to the natural log of total assets	BHCK8724	Independent Variable - Operational Complexity - Alternative

Operational Complexity	Natural log of off-balance sheet activities to the natural log of total assets	BHCK8725	Independent Variable - Operational Complexity - Alternative
Operational Complexity	Natural log of off-balance sheet activities to the natural log of total assets	BHCK8726	Independent Variable - Operational Complexity - Alternative
Operational Complexity	Natural log of off-balance sheet activities to the natural log of total assets	BHCK8727	Independent Variable - Operational Complexity - Alternative
Operational Complexity	Natural log of off-balance sheet activities to the natural log of total assets	BHCK8728	Independent Variable - Operational Complexity - Alternative
Liquid Assets	Cash and marketable securities to total assets	BHCK0081	Independent Variable - Liquid Assets - Primary
Liquid Assets	Cash and marketable securities to total assets	BHCK0395	Independent Variable - Liquid Assets - Primary
Liquid Assets	Cash and marketable securities to total assets	BHCK0397	Independent Variable - Liquid Assets - Primary
Liquid Assets	Cash and marketable securities to total assets	BHDMB987	Independent Variable - Liquid Assets - Primary/Alternative
Liquid Assets	Cash and marketable securities to total assets	BHCKB989	Independent Variable - Liquid Assets - Primary/Alternative
Liquid Assets	Cash and marketable securities to total assets	BHCK1350	Independent Variable - Liquid Assets - Primary/Alternative
Liquid Assets	Cash and marketable securities to total assets	BHCK0213	Independent Variable - Liquid Assets - Primary/Alternative
Liquid Assets	Cash and marketable securities to total assets	BHCK1287	Independent Variable - Liquid Assets - Primary/Alternative
Liquid Assets	Cash and marketable securities to total assets	BHCK1290	Independent Variable - Liquid Assets - Primary/Alternative
Liquid Assets	Cash and marketable securities to total assets	BHCK1293	Independent Variable - Liquid Assets - Primary/Alternative
Liquid Assets	Cash and marketable securities to total assets	BHCK1295	Independent Variable - Liquid Assets - Primary/Alternative
Liquid Assets	Cash and marketable securities to total assets	BHCK1298	Independent Variable - Liquid Assets - Primary/Alternative
Liquid Assets	Cash and marketable securities to total assets	BHCK8496	Independent Variable - Liquid Assets - Primary/Alternative
Liquid Assets	Cash and marketable securities to total assets	BHCK8499	Independent Variable - Liquid Assets - Primary/Alternative
Liquid Assets	Marketable securities to total assets	BHDMB987	Independent Variable - Liquid Assets - Primary/Alternative
Liquid Assets	Marketable securities to total assets	BHCKB989	Independent Variable - Liquid Assets - Primary/Alternative

Liquid Assets	Marketable securities to total assets	BHCK1350	Independent Variable - Liquid Assets - Primary/Alternative
Liquid Assets	Marketable securities to total assets	BHCK0213	Independent Variable - Liquid Assets - Primary/Alternative
Liquid Assets	Marketable securities to total assets	BHCK1287	Independent Variable - Liquid Assets - Primary/Alternative
Liquid Assets	Marketable securities to total assets	BHCK1290	Independent Variable - Liquid Assets - Primary/Alternative
Liquid Assets	Marketable securities to total assets	BHCK1293	Independent Variable - Liquid Assets - Primary/Alternative
Liquid Assets	Marketable securities to total assets	BHCK1295	Independent Variable - Liquid Assets - Primary/Alternative
Liquid Assets	Marketable securities to total assets	BHCK1298	Independent Variable - Liquid Assets - Primary/Alternative
Liquid Assets	Marketable securities to total assets	BHCK8496	Independent Variable - Liquid Assets - Primary/Alternative
Liquid Assets	Marketable securities to total assets	BHCK8499	Independent Variable - Liquid Assets - Primary/Alternative