Quality versus Quantity: the case of U.S. bank capital buffers

Kiefer de Silva
Department of Banking and Finance, Monash University
Caulfield Campus, Caulfield East, Victoria 3145, Australia
Kiefer.Desilva@monash.edu

Barry Williams*
Department of Banking and Finance, Monash University
Caulfield Campus, Caulfield East, Victoria 3145, Australia
Barry.Williams@monash.edu

Abstract: We find that larger US bank holding companies (BHCs) hold lower quality capital buffers than their smaller peers. US BHCs' capital buffer quality is found to be a function of their operational complexity, risk-weighted assets and profitability. We, however, find no evidence that large US BHCs trade–off capital buffer quality with their liquid asset investments. On average, US BHCs narrow the gap between their actual and target buffer quality by 49.5 per cent per quarter. This (buffer quality) adjustment speed, however, is substantially faster than that observed in pre-GFC US studies of buffer size. The well capitalised US BHCs (top 20 percent) adjust their buffer quality 8 percent faster than poorly capitalised ones. The latter seem to face impediments in raising new capital due to higher reputation costs. The costs of adjusting buffers also seem an important explanation for holding higher quality buffers. Our results shed more light on the trade-offs associated with banks holding higher quality capital buffers.

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* *Corresponding author*

1. Introduction

That banks hold levels of capital in excess of the required regulatory minimum (capital buffers) has been well documented (Santos, 2001; Palia and Porter, 2003; Tanda, 2015). However, the financial crisis of 2007 – 2008 (the Global Financial Crisis, [GFC]) revealed a myopia about this issue, in that the focus was upon the quantity rather the quality of bank capital. In some ways this myopia is surprising, as the initial capital adequacy accord of 1988 explicitly created a division between higher quality capital (Tier 1) and lower quality capital (Tier 2). Despite this established hierarchy of capital, we have no evidence of the manner in which banks adjust the quality of their capital buffers over time. The revision to the capital adequacy accord that followed the GFC has bought the issue of capital quality to the forefront of bank regulatory policy. This motivates our research agenda to address the question: "What factors determine the quality of bank capital buffers?"

Most banks hold 'capital buffers' above the required minimum, despite detailed capital regulations. A key lesson of the GFC is that the size of a bank's capital buffer is of second-order relevance as compared to that of capital quality. Anxiety over banks' soundness during the crisis and the subsequent failure of many institutions, despite maintaining sizeable capital buffers, is attributable in part to the insufficiency of that capital to absorb losses (BCBS, 2011). The BCBS itself acknowledges 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). Consequently, Basel III, the regulatory response to the crisis, elevates the role of *capital buffer quality* in the supervisory agenda.[1]

The significant balance sheet expansion undertaken by the US banks, in the pre-crisis period (2000-2007), was not suitably financed with shareholder equity but rather, short-term debt or debt-like instruments (Acharya, Gujral, Kulkarni, and Shin, 2011). Acharya, Gujral, Kulkarni, and Shin (2011) found that US banks persisted with dividend payments during the crisis, while the capital raised in that period largely took the form of hybrid instruments. The government-

[1] 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. 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.

subsidised capital injections for troubled institutions (under the Troubled Asset Relief Program (TARP)) took the form of preferred equity (Black and Hazelwood, 2013). This combination of sustained dividends and increase in preferred equity led to the proportion of common equity in banks' capital falling at the time when it was most needed. This (overlooked) systemic vulnerability contributed to the severity of the global financial crisis (GFC).[2]

The GFC further exposed how liquidity shortages 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 and Merrouche, 2013). During the crisis when uncertainty was at its peak, interbank lending and broader financial markets froze. Consequently, the risk of bank failure materialised across those with insufficient liquid assets. Thus, in addition to raising capital buffer quality, Basel III also emphasises adequate bank liquidity.[3] Basel III thus encourages coordinated regulation of a bank's capital quality and liquidity channels, to manage systemic risks. The interplay between these channels provides a further motivation for our paper.

The point at which our paper addresses a research gap begins with the existing evidence that larger banks consistently hold smaller capital buffers.[4] Gong, Huizinga, and Laeven (2017), however, find that the effective capitalisation levels of small US BHCs is less than that which is reported, providing evidence of capital arbitrage.[5] 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 and 2013). It is unclear from the paper whether the reduction in the effective capitalisation levels

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[2] Martín-Oliver (2013) similarly finds that Spanish banks favoured issuing cheaper hybrid claims over common equity in the period before the GFC, contributing to that country's extended recession.

[3] 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).

[4] See for instance, Shrieves and Dahl (1992), Rime (2001), Ahmad, Ariff and Skully (2008), Brewer, Kaufman and Wall (2008), Francis and Osborne (2010), Gropp and Heider (2010), Jokipii and Milne (2011).

[5] 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.

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).

Given this new evidence, in this paper, we revisit capital buffer holdings of large US BHCs. Our paper differs from existing studies in several ways. First, we scrutinize the composition of capital buffers (hence, buffer quality) of BHCs as well as magnitude of their aggregate buffers. Second, we focus on the heterogeneity among large US BHCs with particular emphasis on retail intensity, operational complexity and quality of their loan portfolios. This is important as the US BHCs examined in this paper are subject to 'Prompt Corrective Action' (PCA) [required regulatory intervention of increasing severity as a function of decreasing bank capital holdings] under the US Federal Deposit Insurance Corporation Improvement Act (FDICIA).[6] Third, we investigate whether large US BHCs trade–off capital buffer quality with their liquid asset investments. For example, Jokipii and Milne (2011) suggest that banks with greater investments in liquid assets can offset the lowered liquidity risk that follows by holding smaller capital buffers. However, it is currently unclear if this theme persists across the quality of a bank's capital buffer. Fourth, we compute capital buffer quality adjustment speeds for banks with 'extreme' capitalisation levels (*i.e.,* poorly capitalised or well capitalised). In so doing, we explore whether these interactions are as predicted under capital buffer theory.

We find that larger US BHCs hold lower quality capital buffers than smaller banks, confirming the argument that larger banks face lower transactions costs when raising new equity, while also exploiting the implied guarantee that too-big-to-fail status gives to larger banks. Banks with more complex and diversified revenue streams (with more off-balance-sheet exposures and non-interest income) hold higher quality capital buffers to signal financial health and reduce the negative impacts of information asymmetry caused by complexity. Banks with higher levels of credit risk, as measured by risk-weighted assets hold lower quality capital buffers. We suggest that banks may be choosing to buy market share via not fully pricing credit

[6] 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 (FDICIA, 1991; Aggarwal and Jacques, 2001).

risk, or they may be gambling that increased revenue associated with a higher risk portfolio will generate the necessary retained earnings to improve capital buffer quality. Finally, we find that banks in the post GFC period adjust more rapidly toward their preferred quality capital buffer target than they did in the pre-GFC period, indicating that the pre-GFC myopia with respect to capital quality is now diminishing.

These findings have important implications for a number of stakeholders. From a regulator's perspective, studying capital buffer quality is relevant to their supervisory mandate as drafted into Basel III. These findings will assist their understanding of what operating activities drive capital buffer quality at large US 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 depositors' funds 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 promote the role of buffer quality (by prioritising faster adjustments to buffer quality) over buffer size during different economic cycles. This policy implication is heightened by exploring the ease with which poorly-capitalised and well-capitalised banks adjust their buffer quality. Our 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 of poorly capitalised banks to re-establish their buffer. For bank managers, understanding how their peers adjust and target buffer quality across a particularly large group of banks is desirable in setting benchmarks. Enriching bank decision-making in such a way is desirable given the growing supervisory scrutiny.

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

2. Theory and literature review

An unintended consequence of deposit insurance and other state safety nets is the creation of risk-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. Thus, a bank has incentives to maximise 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 or decreased capital holdings. 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. This emphasis is clearly embodied in the Basel Accords and the resulting empirical literature on bank capital holdings.[7]

Bank capital is classified into two categories; Tier 1 and Tier 2.[8] Tier 1 capital – largely composed of shareholder funds and retained earnings – is recognised as superior in terms of its loss-absorbent characteristics (BCBS, 2011).[9] On the other hand, Tier 2 capital (subordinated debt instruments and general provisions) has inferior loss-absorbent qualities but is less costly to raise.[10] Therefore, a bank, in designing its optimal mix of Tier 1 and Tier 2 capital, may trade-off cost considerations with loss-absorbency.

Regulators face the challenging task of stipulating that a bank set aside an 'appropriate' capital base. On the one hand, they must protect against systemic vulnerabilities by requiring banks to hold higher levels of quality capital, and thus minimising the costs of bank failures. On the other hand, they must balance the interests of bank shareholders (and other stakeholders), who desire that their banks avoid holding unnecessarily high levels of costly capital, in order to ensure banks continue to exist as profitable going concerns, as well as fostering the important economic functions that bank provides. Striking a 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 difficult for both regulators and banks.

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7 Santos (2001), Palia and Porter (2003) and Tanda (2015) provide excellent reviews of this prior work.

8 Under Basel II framework, at the discretion of national authorities, banks could issue a third category of regulatory capital, Tier 3 capital. 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.

9 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.

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

2.1 Why do banks hold capital buffers?

Banks have been observed to maintain excess capital above the regulatory minima (Ayuso et al., 2004). The resulting capital buffer enables a bank to absorb unexpected losses (FDIC, 2016), signals its financial health (Berger, Herring, and Szegö, 1995), offers flexibility enabling the bank to exploit growth opportunities (Berger et al., 2008; Francis and Osborne, 2010), shields against supervisory intervention, and reduces costly market disciplinary pressures (Berger et al., 1995). From a systemic perspective, bank capital buffers reduce the probability of taxpayer-funded bailouts (Jokipii and Milne, 2008).[11]

Banks hold capital buffers given the difficulty in raising capital cheaply when needed, especially given likely negative signalling impact of a capital raising (Myers and Majluf, 1984). There is also evidence of a negative association between capital buffers and the economic cycle, such that a bank grows its buffer during economic downswings, and depletes its buffer during upswings (Ayuso, Pérez, and Saurina, 2004; Lindquist, 2004; Jokipii and Milne, 2008; Francis and Osborne, 2010). Basel III introduces a pair of business cycle-dependent capital buffer requirements, which are directed at mitigating this behaviour among banks.[12]

Banks also consider the costs to shareholders of foreclosure (i.e. loss of its 'franchise value' or 'charter value').[13] 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 (Jackson et al., 1999; Jokipii and Milne, 2008).

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[11] The observation that banks hold capital buffers, however, 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, and Tenjo-Galarza, 2012). It is also worth acknowledging the potential that banks' have an internal capital target that differs from the minimum capital ratio set by the regulator (Jokipii and Milne, 2008).

[12] 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. 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.

[13] Franchise value is the value of the bank's future profits that would be lost if it were to be insolvent (Demsetz, Saidenberg, and Strahan, 1996).

2.2 Capital buffer size

It is usually found that capital buffer size falls as bank size increases. Several reasons may explain 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 information asymmetries that accompany equity financing may be particularly burdensome for smaller institutions. In an effort to address investor scepticism, a smaller bank may prefer a higher buffer (Sivarama and 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 "Too Big to Fail" (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 relatively less prohibitive. This finding supports the observation that larger banks have greater access to capital markets.

It is reported by Berger and Bouwman (2013) that well-capitalised banks are more likely to survive banking crises, but also grow market share. They observe that higher aggregate capital benefits small banks always (i.e. during crises and normal times). However, larger banks only benefit from stronger capitalisation during banking crises.[14] Demirguc-Kunt et al. (2013) analogously observe that for larger banks, superior capitalisation is associated with stock market outperformance during crisis times. However, variation in capitalisation across large banks was not found to influence stock market performance prior to crises. The limited utility for larger banks of additional capital outside crises, may explain why they cluster towards lower aggregate capital ratios when compared with their smaller peers.

2.3 Capital buffer quality

The GFC revealed that the regulatory attention toward bank capital was, to that point in time, myopic (Chor and Manova, 2012; Fratzscher, 2012). Basel III addresses some of the regulatory shortcomings exposed during the GFC by raising not only the quantity of required regulatory

[14] See also Laeven, Ratnovski, and Tong (2016) whom similarly suggest that greater capitalisation benefits larger banks mainly during crises.

capital but also its quality.[15] Supporting this emphasis upon quality, 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 associated with the outperformance of individual banks, especially larger banks. Thus, the market was beginning to distinguish between banks based upon the quality of their capital rather than the quantity of their capital. Lubberink and Willett (2016, p.15) reinforce these observations by finding that the book value of equity and Tier 1 capital explain 87% of the variation in market returns for banks.

Market frictions (such as information asymmetries and issuance costs) explain why Tier 1 capital is more expensive to raise than Tier 2 capital (Myers and Majluf, 1984).[16] Consequently, a bank must trade-off the quality and quantity of its capital buffers. 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)).[17] 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) (Dinger and Vallascas, 2016). Thus, judging a bank's financial health based purely on the size of its capital buffer proves inadequate.

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[15] Basel III emphasises the importance of CET1 (i.e. shareholder equity) as part of a bank's total capitalisation. 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. (Refer to Basel III: A Global Regulatory Framework for More Resilient Banks and Banking Systems, released in December 2010 and revised in June 2011 by Basel Committee on Banking Supervision).

[16] 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.

[17] 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 (i.e. the GFC) when it was most required to absorb losses.

We argue that bank size should be inversely associated with capital buffer quality. Put differently, we expect larger banks to have more of, less expensive Tier 2 capital (in comparison to more expensive Tier 1 capital, with its superior loss absorbing characteristics) in their capital buffers. This is so because larger banks have greater access and flexibility in issuing hybrid securities, are typically covered by implicit state safety nets such as TBTF concerns and materialise superior economies of scale in the monitoring of risky borrowers. This leads to Hypothesis 1 (H1): *Larger US BHCs hold lower quality capital buffers*.

We investigate further whether there is something more to bank size than size itself, which drives the association with capital buffer quality. In particular, we investigate four bank-specific characteristics (retail intensity, operational complexity, loan quality and investments in liquid assets) in relation to quality of excess capital held by large US banks.

2.2.1 Retail intensity

Hirtle and Stiroh (2007) defines retail intensity as including '*deposit-taking, lending and other financial services provided to consumers and small businesses through all delivery channels…*' (p.1107). Huang and Ratnovski (2009) find that retail intensity of Canadian banks was important in explaining why Canadian banks outperformed other OECD countries' banks during the GFC. Köhler (2015) considers retail-orientated banks as having more stable funding (via 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 reduce retail bank holdings of loss absorbent but costly Tier 1 capital in their buffers.

However, there are competing reasons as to why a retail intensive bank may still favour higher quality buffers. Investigating the characteristics that correspond with retail intensity, Köhler (2014) finds that banks with high degrees of retail exposure tend to have limited market access. This may make raising capital (either Tier 2 capital, or short notice equity raisings) 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 opposing forces. On the one hand, the greater retail exposure (particularly via deposit mobilisation) as a component of total liabilities, the greater the value of deposit insurance to the bank (Berger et al., 1995). If moral hazards drive that bank, then one would anticipate a smaller capital buffer (Dinger and Vallascas, 2016). However, it is found by Berger et al. (2008) that retail banks hold larger capital buffers (quantity) 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 and Milne, 2008). To protect its charter value, a retail bank may be induced to hold additional Tier 1 as a composite of its capital buffers. Hypothesis 2 (H2) therefore is as follows: *Retail intensive US BHCs hold higher quality capital buffers.*

2.2.2 Operational complexity

The extent to which a bank is regarded as operationally complex and opaque may influence the overall composition of its capital buffer. Regulatory reforms in the US – culminating in the passage of the Gramm-Leach-Bliley Act (1999) [18] – permitted banks to engage in an array of previously restricted non-traditional financial services. Consequently, several studies have considered the impact that banks' expansion outside traditional intermediation has on bank characteristics. These include profitability (Stiroh and Rumble, 2006), bank stability (Köhler, 2014), as well as bank-specific and systemic risk (Butzbach, 2016). Although no clear consensus prevails as to whether revenue diversification is beneficial, a recurrent theme is the impact revenue diversification has on the complexity of a bank.[19]

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 and Meckling, 1976). This perspective has been applied to the issue of banks diversifying outside their immediate fields of competence. For example, Milbourn, Boot, and Thakor (1999) find that restructuring of a bank's operations lowers accountability and further aggravates information asymmetries for outsiders. Laeven and Levine (2007) present

[18] Furlong (2000) offers a detailed overview of the Gramm-Leach-Bliley Act (1999).

[19] 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), Acharya, Hasan, and Saunders (2006), Stiroh and Rumble (2006), and Laeven and Levine (2007) find evidence querying revenue diversification's benefits.

evidence that markets ascribe a "diversification discount" to financial institutions. Examining the Tobin's Q scores, the authors find that diversified financial institutions have lower Q scores than the Q scores they would have if the firm separated into individual specialised firms.[20] 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 and Levine, 2007; Williams and Rajaguru, 2013). This complexity translates into pronounced information asymmetry dynamics. Specifically, these banks may prioritise reliance upon retained earnings to finance their activities (Gropp and Heider, 2010). Greater information asymmetry at operationally complex banks implies that alternative sources of finance such as equity raising will be costlier (Myers and Majluf, 1984).

Furthermore, operational complexity is found to be associated with uninformed funding sources (due to greater information asymmetry) and this uncertainty can result in sudden and unpredictable funding withdrawals (Huang and Ratnovski, 2011). To mitigate the impact that such withdrawals could have, operationally complex banks may hold a greater proportion of loss-absorbent Tier 1 capital in their buffers. Similarly, by doing so, an operationally complex bank may wish to signal to the market its ongoing viability. This leads to Hypothesis 3 (H3): *Operationally complex US BHCs hold higher quality capital buffers.*

2.2.3 Credit risk

Credit risk is connected to capital holdings via the capital buffer theory (Kleff and Weber, 2008)[21], which predicts that banks deliberately maintain a buffer above the regulatory capital minimum. There is thus on-going adjustments between regulatory capital holdings and loan portfolio risk. Such behaviour has been confirmed in a series of US studies (Shrieves and Dahl, 1992; Aggarwal and Jacques, 2001).

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[20] Tobin's q measures the present value of future cash flows divided by the replacement costs of tangible assets (Laeven and Levine, 2007).

[21] See Jokipii and Milne (2011) for further discussion on the capital buffer theory.

The buffer-risk adjustment has also been observed to vary according to the degree of bank capitalisation. There is evidence of a pronounced negative relationship between the capital buffer size and credit risk for less capitalised banks (Heid, Porath, and Stolz, 2004; Jokipii and Milne (2011). 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 (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.[22] 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 and Rob, 1999; Jokipii and 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) that the overall relationship between bank risk and capital is U-shaped.[23] Williams (2014) finds that the intensity of risk-seeking behaviour lessens 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).

Where the causality runs between credit risk and capital is a significant empirical consideration. In addressing this, Jokipii and Milne (2011) analyse 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 argue 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 capital buffer theory (Kleff and Weber, 2008; Jokipii and Milne, 2011).

[22] Buser, Chen, and Kane (1981) provides a detailed discussion on the implicit costs of falling below the regulatory minimum.

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

It is desirable from a regulator's perspective that a bank with high loan portfolio risk maintains a higher quality capital buffer. Otherwise, should the riskier loans of this bank sour, insufficient quality capital increases 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 ratios 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 buffer is better placed to weather losses as a going-concern. To date, this consideration has not been addressed and current evidence leaves unanswered how banks adjust the quality of their buffers as credit risk changes.

As credit risk increases, so too does the need to signal ongoing viability provided that charter values influence bank manager decision-making (Jokipii and Milne, 2011). It follows that banks should signal their viability in the composition of their capital buffers. Furthermore, it could be that capital buffer quality reflects managerial risk-aversion (Ho and Saunders, 1981). If this is the case, then a bank with high credit risk will compensate for this by growing the quality of its capital buffers. Therefore, Hypothesis 4 (H4) is as follows: *US BHCs with greater credit risk exposures hold higher quality capital buffers.*

2.2.4 Investments in liquid assets

Jokipii and Milne (2011) rationalise that greater investments in liquid assets reduce the need for insurance against falling below the minimum capital requirements. This behaviour is consistent with the precautionary motive for holding liquid assets. The authors posit that the '*risk weight associated with liquid assets means that banks can increase their capital buffers by liquidating assets*' (p.170). 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 evidence to date finds that a bank with high liquidity, targets lower capital buffers (Berger et al., 2008; Jokipii and Milne, 2011). This may be through risk minimization, as suggested by Jokipii and Milne (2011) or higher liquid assets being indicative of market access restrictions (Bates et al., 2009). Current evidence is yet to isolate how the composition (quality) of capital buffers varies across the level of liquid assets held by banks. This leads to Hypothesis 5 (H5): *US BHCs with greater investments in asset liquidity hold lower quality capital buffers.*

3. Sample and empirical framework

3.1 Sample

Our sample is an unbalanced panel of US Bank Holding Companies (BHC), Financial Holding Companies (FHC), and Savings and Loan Holding Companies (SLHC) (collectively referred to as BHCs). Data cover the quarterly periods from 2001 to 2016. 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 heterogeneity enhances understanding as to the drivers of capital buffer quality amongst these 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. 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 are 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. We focus on BHCs, as opposed to individual commercial banks (which are in turn owned by BHCs). This approach is steeped in the regulator's "source of strength" doctrine, which leaves BHCs financially responsible for their subsidiary banks.[24] 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. Thus, capital management is best investigated at the BHC level.

The US banking system is also complicated by cross-ownership interests across some BHCs. To eliminate double counting of the same activities, only top-tiered BHCs are included in the sample (Stiroh and Rumble, 2006; Shim, 2013). 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

[24] 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.*"

$1 billion are automatically required to file the quarterly FR Y-9C report.[25] BHCs with asset sizes that do not meet this threshold must file the *bi-annual* FR Y-9SP report. The data required for this study, especially, the components of regulatory capital are only captured by the FR Y-9C filings. Thus, only large BHCs filing FR Y-9C reports are considered.

Further, including only large BHCs 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 in our sample 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.[26]

In relation to mergers and acquisitions, the target and acquirer are treated as unique observations for as long as the data are 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. This approach mitigates sample-selection bias (Kashyap, Rajan, and 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 several 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.[27] Care is also taken to address typographical errors that appear during some stages of the reports being filed.

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[25] 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. Before March 2006, it was $150 million.

[26] Gong et al. (2017) conduct their calculation of effective bank capitalisation ratios by two methods: The 'decompression' method and the 'deduction' method. The former involves pro forma consolidation of the minority-owned affiliates onto the balance sheet of the parent BHC. While the latter deducts from the parent BHC its investments in affiliates from its own equity. FDIC currently uses a version of the latter approach. It should be acknowledged that (Gong et al., 2017) prefer the 'decompression' method for its accuracy. However, we follow 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.

[27] Please refer to Appendix A for the data item codes utilised to construct the variables used.

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, and Holzhäuser, 2010). The final data set holds 78,963 observations over the 64 quarters commencing Quarter 1 2001 and ending Quarter 4 2016. Table 1 presents the breakdown of the observations included in the data sample.

<Insert Table 1 about here>

3.2 Empirical framework

We utilise a partial adjustment model, consistent with the existing literature on bank capital buffer (Ayuso et al., 2004; Jokipii and Milne, 2008; Pereira and Saito, 2015). Our approach is predicated on banks being thought of as (1) having a pre-determined optimal capital buffer target, and (2) adjusting towards their target over time. Thus, 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 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 (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 and Saito, 2015). The speed at which banks move towards their target buffer is denoted by an adjustment term, θ. Thus,

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

or,

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

where, θ is the speed of adjustment, and ε is a stochastic error term. The speed of adjustment term, θ, should lie 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 and 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 a set of $\boldsymbol{N}$ explanatory variables:

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

where, X is a vector of N explanatory variables and δ is a vector of parameters. Our empirical estimation thus takes the form:

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

Table 2 provides detailed variable definitions and data sources used in Equation 5.

<Insert Table 2 about here>

3.2.1 Dependent variables

Buffer size[28] is defined as the amount of total capital held (quarterly) in excess to the regulatory minimum (Fonseca and González, 2010; Jokipii and Milne, 2011).[29] Thus,

$$BUFSIZE = \frac{\frac{TIER1 + TIER2}{RWA} - REGMIN}{REGMIN} \tag{6}$$

[28] 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.

[29] 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.

where, *BUFSIZE* is the capital buffer; *TIER1* and *TIER2* are the total Tier 1 and Tier 2 capital respectively; *RWA* is the total risk weighted assets of the bank; *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 Basel III (i.e. Quarter, 1 2014), at least half of the 8% must have been Tier 1 capital. Our 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 banks hold discretionarily as either Tier 1 or Tier 2 capital:

$$BUFQUAL = TOTAL\ TIER1\ CAPITAL - MINIMUM\ TIER1\ CAPITAL, \tag{7}$$

where,

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

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

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

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

Equation (10) serves as 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 capital 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 explicit capital buffer requirements. The combination of the two buffer requirements 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.

<Insert Table 3 about here>

These adjustments introduce 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 our 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 in 2016, 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 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 quarters as:

$$BUFQUAL16 = \frac{TIER1}{RWA} - \left(\frac{6.625}{8} \times \frac{TIER1 + TIER2}{RWA}\right) \qquad (11)$$

A second buffer measure introduced in 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.[30] Importantly though, to this point the Federal Reserve Board has left the CCyB at 0%.[31] Therefore, as the CCyB is dormant during the sample period, no adjustment is necessary in this regard to our buffer quality measure.

3.2.2 Hypotheses variables

We calculate our size variable (Hypothesis 1) ($SIZE_{i,t}$) as the natural log of total assets. 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 excess capital. A negative association with buffer quality could indicate an ability of larger banks to raise external Tier 1 capital with lower transaction costs (Kleff and Weber, 2008). To measure retail intensity (Hypothesis 2) we employ a measure of fixed assets. We calculate $FIXASSETS_{i,t}$ as the ratio of fixed assets to total assets. Retail intensive banks should have higher values, reflecting their investment in bank branches and product distribution networks such as ATMs. A restricted capacity to tap capital markets at short notice may limit retail intensive banks' ability to raise Tier 2 capital at short notice. Hence, as retail intensity increases we expect capital buffer quality to increase.

Operational complexity (Hypothesis 3) is measured by revenue diversification. We construct a measure of revenue concentration, $HHI_{i,t}$, using an Herfindahl-Hirschman index specification. A bank with diversified revenue lines (including off balance sheet exposures) is structurally more complex and prone to agency problems. 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 and Milne, 2008).

Conceptually, $HHI_{i,t}$ is given by:

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

30 Under Basel II, approved banks can use internal models to calculate the capital requirements 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 and 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.

31 https://www.federalreserve.gov/newsevents/pressreleases/bcreg20161024a.htm

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

$$SH_{INT} = \frac{INT}{INT + NON}$$
$$SH_{NON} = \frac{NON}{INT + NON} \qquad (13)$$

A lower *HHI* indicates a bank with a less diversified revenue base. For example, a value of zero indicates 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. If operationally complex banks signal their ongoing viability with higher quality capital buffers, a positive relationship between *HHI* and capital buffer quality is expected. [32]

To measure credit risk (Hypothesis 4) we employ the proportion of risk-weighted assets to total assets (RWA). This ratio is acknowledged as a reliable proxy for credit portfolio risk (Jokipii and 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 be made to hold higher quality capital buffers to mitigate their risk of failing (BCBS, 2013).

We explore the intertemporal dynamic between capital and risk by taking a two-period lag of risk-weighted assets ($RWA_{i,t-2}$). This structure mitigates potential endogeneity problems and has been previously used for that purpose (Laeven and Majnoni, 2003; Francis and Osborne, 2010). It also recognises that a bank requires time to make a desired capital adjustment following realisation of its credit risk exposure. In addition to mitigating potential endogeneity problems, our structure allows identification of the causality direction of interest. 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 supports the risk aversion

[32] Greater exposure to off-balance sheet activities, similarly to revenue diversification, is also closely related to firm opacity (Laeven and Levine, 2007; Williams and 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 employed ($\frac{OBS}{SIZE_{i,t}}$).

argument whereby banks with a higher risk loan portfolio hold higher quality buffers to signal their ongoing viability.

We measure liquidity holdings (Hypothesis 5) using cash and marketable securities to total assets ($CASHMKTSEC_{i,t}$). A bank with greater investments in low yielding, liquid assets is expected to hold a smaller proportion of Tier 1 capital in its buffer. 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 capital buffers because there is less need for costly equity in the presence of low risk, 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 safe liquid assets (Pereira and Saito, 2015). Greater investment in liquid assets could lower the liquidity premium on raising equity and this may encourage banks to raise equity while the cost of Tier 1 capital is cheaper (Angbazo, 1997; Ahmad et al., 2008).

3.2.3 Interaction terms

Capital buffer theory suggests that undercapitalised banks are expected to improve their capitalisation toward an internally optimal target (Peura and 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 well capitalised banks (Jokipii and Milne, 2011). To capture these variations, a pair of interaction terms are introduced into the regressions. Thus, $DQUAL_{LOW}$ is a dummy variable that equals unity if $BUFQUAL$ is in the bottom 20th percentile of observations, and zero otherwise. $DQUAL_{HIGH}$ is a dummy variable 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 speed varies depending on the degree of bank capitalisation.

3.2.4 Control variables

A measure of profitability is consistently utilised in the existing literature to proxy for the opportunity cost of capital. In this study, $ROE_{i,t}$ is used, consistent with prior research, 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 argued that financially sound banks may substitute earnings for capital, particularly Tier 1 capital. 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. Thus, a positive association with buffer quality is expected.

The share of subordinated debt to total liabilities is termed $SUBORD_{i,t}$. A bank which has a greater proportion of uninsured funding is likely to be more exposed to market discipline (Francis and Osborne, 2010). If banks are responsive to market disciplinary effects, then to signal their ongoing viability, higher quality capital buffers may be desirable. Thus, a positive coefficient is expected.

3.3 Econometric considerations

The capital-risk decision is widely regarded as a two-way relationship (Ayuso et al., 2004; Shrieves and 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 (Rime, 2001; Jokipii and Milne, 2011). 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 (Fiordelisi, Marques-Ibanez, and Molyneux, 2011; Pereira and Saito, 2015). The second approach is to address endogeneity issues directly within the econometric model adopted (Alfon, Argimon, and Bascuñana-Ambrós, 2004; Francis and Osborne, 2010; Lindquist, 2004). We utilise the latter approach as our 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) becomes our primary econometric specification. 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 and 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) and Roodman (2006). In addition to limiting and collapsing instruments (which both mitigate this downward 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 utilising 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). The FE panel model addresses the endogeneity problem encountered in pooled least squares estimates by removing fixed effects and addressing unobserved heterogeneity (Kenward and 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 our primary model. This is achieved by using lagged structures for endogenous terms (Blundell and Bond, 1998).

4. Results

4.1 Summary statistics and correlations

Despite the sample consisting of 'large' BHCs, the dispersion of the *SIZE* variable, which ranges from a natural log of total assets of 11.92 to 20.62 with a mean of 13.62, reveals material variation in bank size (Table 4). Of note is a high correlation (0.612) between off-balance sheet activities and bank size (Table 5). This is hardly surprising, given that larger banks extensively utilise off-balance sheet contracts for additional income generation. The negative correlation between buffer quality and bank size is preliminary evidence of the largest banks holding lower quality buffers.

<Insert Table 4 about here>

<Insert Table 5 about here>

4.2 Regression results

The empirical estimations from equation (5) covering the entire sample period (Quarter 1 2001 – Quarter 4 2016) are presented in Table 6 for all banks (Bank Holding Companies, Finance Holding Companies, and Savings and Loan Holding Companies) and in Table 7 for the truncated sample of Bank Holding Companies. Models (1) and (2) are estimated using two-way fixed effects panel (FE) regressions and Models (3) and (4) are estimated using the two-step Blundell and Bond (1998) system GMM (Francis and Osborne, 2010; García-Suaza et al., 2012; Pereira and Saito, 2015). The autocorrelation tests indicate that the condition of the absence of second-order serial correlations is met for the system GMM models. The Hansen statistic does not imply over-identification restrictions on the estimated equations for Models (3) and (4).

<Insert Table 6 about here>

<Insert Table 7 about here>

Hypothesis 1 is tested using the coefficient for *SIZE*. We obtain consistently negative and statistically significant coefficients for *SIZE* across the models (Tables 6 and 7). This persistent evidence extends the existing wisdom (that larger banks hold smaller capital buffers) by indicating that larger US 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 excess capital) (Kleff and Weber, 2008). It may also be a product of larger banks operating under implicit TBTF expectations.

We do not find evidence to support Hypothesis 2 (for *FIXASSET* in Tables 6 and 7), that retail intensive banks in the US hold more (or less) of loss absorbent but costly Tier 1 capital in their buffers. An explanation for this may be that retail intensive banks, due to the 'stable' nature of their traditional banking services, are considered less exposed to shock funding withdrawals and net deposit drains. This stable funding structure may deter retail banks from holding more of costly T1 capital in their buffers (Köhler, 2015). This is also consistent with moral hazard behaviour by retail intensive banks (Berger et al., 2008; Berger et al., 1995).

The positive coefficients for *HHI* (Tables 6 and 7) are suggestive of more operationally complex, diversified banks holding higher quality capital buffers, supportive of Hypothesis 3. 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 health (Jensen and Meckling, 1976; Laeven and Levine, 2007). As operational complexity is also associated with the potential for uninformed funding sources, this uncertainty can result in sudden and unpredictable funding withdrawals (Huang and Ratnovski, 2011). Mitigating the impact that such withdrawals could have on a bank's operations may encourage operationally complex banks to hold more of loss-absorbent *T1* capital in their buffers. This finding supports *H3*.

Opposite to our expectations expressed in Hypothesis 4, our measure of credit risk, RWA_{t-2} presents consistently negative coefficients at the 1% significance level (Tables 6 and 7). Model (3)'s estimate (in Table 6) 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 could 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 and Milne, 2011). This finding is also in line 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 maintaining a level of overall bank risk).

We find only limited support for Hypothesis 5, in that the estimates for *CASHMKTSEC* are statistically insignificant in our primary GMM Models (in both Tables 6 and 7). This is in contrast to the fixed effects panel regression estimates, which are positive and statistically significant. Thus, we do not offer convincing evidence to suggest a robust association between US banks' investments in liquid assets and the composition (quality) of their capital buffers.

The coefficient on the lagged buffer quality ($BUFQUAL_{t-1}$) is statistically significant across all models. These estimates are bounded between the values of 0 – 1 and can therefore be thought of as reflecting the speed of adjustment towards the desired buffer quality (Jokipii and Milne, 2011). The system GMM estimate in Model (3) in Table 6 indicates that on a quarterly basis, banks narrow the gap between their actual and target buffer quality by 51.6%, on average. The same is 49.5% for the truncated sample of US bank holding companies (Table 7). Thus, the costs of adjusting buffers seem an important explanation for holding a better quality buffer (Francis and Osborne, 2012).

Comparing to prior studies on *buffer size*, this adjustment speed is faster than that observed by Jokipii and Milne (2011) of 9% (for the size of capital buffers), studying US banks between 1986 and 2008. In our study, half the sample observations are in the post-GFC period. Comparing the results to Jokipii and Milne (2011) indicate that banks may have learnt a lesson post-GFC. This lesson translates into faster adjustment speeds of buffer quality. The observed adjustment speeds in our study are 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).

In Models (2) and (4), we interact adjustment speeds with degrees of bank capitalisation. Both iterations for $DQUAL_{HIGH} * BUFQUAL_{t-1}$ indicate that well-capitalised banks can adjust their buffer quality toward the desired value faster than the average bank. Model (4) reports that well-capitalised banks adjust their buffer quality 8% faster, when evaluated at the mean as compared to the average bank. The statistically significant negative estimates for $DQUAL_{LOW} * BUFQUAL_{t-1}$ in Model (2) (in Tables 6 and 7) indicate that poorly capitalised banks face impediments in raising new capital effectively. This is consistent with Berger et al. (2008) who ascribe this to the reputational costs of poor capitalisation.

Bank profits (*ROE)* is found to be positively associated with capital buffer quality. This highlights the importance of retained earnings for building Tier 1 capital. Our finding is 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 and Majluf, 1984; Pereira and Saito, 2015). Our result is also counter to the trade-off theory predicting a negative coefficient due to the high cost of idle capital. Our measure of market discipline, subordinated debt issues (*SUBORD)*, has ambiguous estimates across the models. It is therefore unclear whether market discipline has succeeded in encouraging banks to hold higher quality capital buffers.

We note that prior to 2014, large US 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). During the period from 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% was deducted from the BHC's regulatory capital using the deduction approach and the amount below 10% threshold was 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. From Quarter 1 2015 these distinctions were abolished and a new methodology applied irrespective of whether a BHC used the Advanced Approaches methodology or not (FDIC, 2016).

Thus, Table 8 reports system GMM regression estimates on equation (5) for the period commencing Quarter 1 2001 and ending Quarter 4 2013. In Model (2), we interact adjustment speed with degrees of bank capitalisation. Consistent with our main results, the coefficient for $DQUAL_{HIGH}$ * $BUFQUAL_{t-1}$ indicate that well-capitalised banks (in comparison to poorly capitalised ones) have adjusted their buffer quality significantly quicker during this period as well. Of the hypothesis variables previously estimated, *HHI* and RWA_{t-2} have statistically significant coefficients. Consistent with the main results in Table 6, operationally complex banks (with higher *HHI*s) held more loss absorbent capital buffers while banks with higher credit risk (i.e. higher RWA_{t-2}) held lower quality buffers.

<Insert Table 8 about here>

In addition to investigating determinants of buffer quality (as reported in Tables 6, 7 and 8), Table 9 presents results for determinants of buffer size. Although the prior literature suggests larger banks hold smaller capital buffers, we do not observe similar evidence for US BHCs after controlling for lag buffer size, capital buffer adjustment speeds and other bank-specific characteristics. This functions as further evidence that there are other operational qualities more important to a large bank that determine the size of its capital buffer, beyond the mere size affect.

<Insert Table 9 about here>

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 in this study 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 affected by the difficulty of comparing small BHCs to large BHCs.

In considering the other hypothesis variables, credit risk has been found to play a significant role in predicting the size of the capital buffer (*BUFSIZE*) maintained by a bank. According to Model (1), a one percent increase in RWA_{t-2} implies a 9% reduction in the size of the buffer *ceteris paribus*. Bank investment in liquid assets (*CASHMKTSEC*) is positively associated with capital buffer size. This is consistent with banks using their liquid assets and capital buffers to capitalise upon growth opportunities (Pereira and Saito, 2015). Similarly, the coefficient for *ROE* is positive and statistically significant across both models. The finding is consistent with the pecking order theory that retained earnings are an important source for banks to grow their capital buffers as well as the quality of their buffers (Ayuso et al., 2004; Myers and Majluf, 1984).

5. Conclusion

In this study, we examine the capital buffer quality held by large US bank holding companies (BHCs) over 2001-2016. The data sample comprised 2,885 BHCs with 78,963 observations directly obtained from quarterly reports (FR Y-9C) published by the Federal Reserve Bank of Chicago. By exploiting variations across institutions, quarterly periods and different components of regulatory capital, we document the first evidence that larger US BHCs hold lower quality buffers. Our evidence suggest that large US BHCs are met with less market scepticism when raising capital, and so can afford to hold lower quality buffers. This outcome may also be a product of larger BHCs operating under implicit 'Too-Big-To-Fail' guarantees.

On average, large US BHCs narrow the gap between their actual and target buffer quality by 49.5 percent on a quarterly basis. This adjustment speed, however, is substantially faster than that observed in previous pre-GFC US studies on buffer size. It seems that US BHCs have learnt a lesson over the post-GFC period and thus now place a greater emphasis on capital buffer quality. When disaggregated and evaluated at the mean, the top 20% of US BHCs based on total capitalisation adjust their buffer quality 8 percent faster than poorly capitalised ones (bottom 20% of BHCs based on total capitalisation). The latter seem to face impediments in raising new capital perhaps due to higher reputation costs. The significance of the lagged buffer quality indicates that the costs of adjusting buffers are an important explanation for holding a better quality buffer.

We also find that operational complexity, credit risk and profitability consistently influence the quality of capital buffers. The observed positive association between the operational complexity and capital buffer quality may be indicative of the increased agency problems associated with complex institutions and the resulting utility of signalling effects. As operational complexity is also associated with the potential for uninformed funding sources, this uncertainty can result in sudden and unpredictable funding withdrawals. Mitigating the impact that such withdrawals could have on a bank's operations may encourage operationally complex banks to hold more of loss-absorbent Tier 1 capital in their buffers. The strongly negative lag effect of credit risk on capital buffer quality could be consistent with such a BHC gambling on elevated credit risk as a means of re-establishing their buffer quality via greater expected earnings. The consistent positive association between return on average assets and capital buffer quality highlights the importance of retained earnings for building T1 capital in banks' buffers. Our finding is consistent with the pecking order theory predicting that retained earnings are a cost-effective and preferable source of funding.

Discovering that poorly-capitalised banks have difficulty re-establishing their capital buffer quality suggests that perhaps a greater regulatory emphasis needs to be placed upon earlier intervention. Regulators desire preventing 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 former, the finding that operationally complex banks hold 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. The implication of these results is that restrictions placed upon operationally complex banks should be predicated upon both the quality of the individual bank's capital buffers as well as the overall level of its credit risk.

Table 1 – Sample data breakdown

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

Table 2 Variable definitions for Equation 5

This table defines all variables used in Equation 5. The authors using FR Y-9C reports calculated all measures.

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: Hypothesis variables			
SIZE	Bank size	Natural log of bank total assets	Nier and Baumann (2006); Jokipii and Milne (2011)
FIXASSETS	Retail intensity	Fixed assets to total assets	Williams (2014)
HHI	Operational complexity	Diversification between total interest income and non-interest income (using Herfindahl-Hirschman Index (*HHI*))	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); Jokipii and Milne (2011); Shim (2013)
CASHMKTSEC	Investments in liquid assets	Cash and marketable securities to total assets	Kashyap et al. (2002); Berger and Bouwman (2013); Shim (2013)
Panel C: 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)

Panel F: Control variables			
ROE	Opportunity cost of capital	Ratio of earnings to 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	Francis and Osborne (2010); Pereira and Saito (2015)

Table 3 – Capital Conservation Buffer phase-in

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

Table 4 – Descriptive statistics

This table presents the summary statistics for the main regression variables used in equation 5. *BUFQUAL* is the proportion of Tier 1 regulatory capital discretionarily held by a bank. *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. *HHI* measures the revenue diversification between non-interest income and total interest income. *OBS/SIZE* is the natural log of the notional value of off-balance sheet activities to total 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. A full description of each variable is presented in Table 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
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
HHI	78963	0.2527	0.1096	0.0110	0.4996
OBS/SIZE	78963	0.7923	0.0849	0.4168	1.0926
RWA_{t-2}	73396	0.7162	0.1148	0.3334	1.0189
CASHMKTSEC	78963	0.1794	0.1047	0.0128	0.5799
ROE	78963	0.0483	0.1918	-8.6523	0.6873
SUBORD	78963	0.0093	0.0136	0.0000	0.0812

Table 5 – Correlation matrix

This table presents the correlations between the variables used in Equation 5. *BUFQUAL* is the proportion of Tier 1 regulatory capital discretionarily held by a bank. *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. *HHI* measures the revenue diversification between non-interest income and total interest income. *OBS/SIZE* is the natural log of the notional value of off-balance sheet activities to total assets. RWA_{t-2} is a two-period lag of risk-weighted assets to total assets. *CAMKTSEC* 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. A full description of each variable is presented in Table 2. All variables are estimated quarterly for each bank. *, **, *** denote significance at the 10, 5 and 1% levels, respectively.

	BUF QUAL	BUF $QUAL_{t-1}$	BUF SIZE	SIZE	FIX ASSET	HHI	OBS/SIZE	RWA_{t-2}	CAMKTSEC	SUBORD
BUFQUAL	1									
$BUFQUAL_{t-1}$	0.963***	1								
BUFSIZE	0.862***	0.853***	1							
SIZE	-0.206***	-0.196***	-0.0587***	1						
FIXASSET	-0.0845***	-0.0879***	-0.126***	-0.198***	1					
HHI	-0.0469***	-0.0483***	0.0359***	0.325***	0.119***	1				
OBS/SIZE	-0.342***	-0.335***	-0.263***	0.612***	-0.101***	0.265***	1			
RWA_{t-2}	-0.514***	-0.521***	-0.513***	0.101***	0.0584***	-0.0714***	0.340***	1		
CAMKTSEC	0.418***	0.413***	0.396***	-0.238***	-0.0228***	0.0603***	-0.364***	-0.525***	1	
ROE	0.133***	0.109***	0.144***	-0.0307***	-0.0177***	0.0619***	0.0141***	-0.0478***	0.0442***	
SUBORD	-0.327***	-0.329***	-0.160***	0.317***	0.0373***	0.0838***	0.273***	0.270***	-0.244***	1

Table 6 – Capital buffer quality determinants (total sample; Q1 2001 – Q4 2016)

Specifications (1) and (2) are estimated using fixed effects panel regressions and specifications (3) and (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. *FIXASSET* is fixed assets to total assets. *HHI* measures diversification between total interest income and non-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 total assets. *ROE* is the return on average 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. Robust *t*-statistics are presented in parentheses. *, **, *** indicate significance at the 10, 5 and 1% levels, respectively.

	(1)	(2)	(3)	(4)
VARIABLES	FE	FE	GMM	GMM
$BUFQUAL_{t-1}$	0.846***		0.516***	
	(416.70)		(6.97)	
$DQUAL_{LOW}$ * $BUFQUAL_{t-1}$		-0.448***		0.3160
		(-43.12)		(0.64)
$DQUAL_{HIGH}$ * $BUFQUAL_{t-1}$		0.377***		0.559***
		(42.57)		(2.62)
SIZE	-0.0013***	-0.0031***	-0.0162**	-0.0293**
	(-10.52)	(-7.500)	(-2.173)	(-2.575)
FIXASSET	-0.0283***	0.0029	2.4530	-0.2170
	(-4.549)	(0.10)	(1.48)	(-0.116)
HHI	0.00302***	-0.00684***	0.0526**	0.0961***
	(6.29)	(-3.193)	(2.28)	(3.03)
RWA_{t-2}	-0.00303***	-0.0286***	-0.0820***	-0.0652
	(-6.054)	(-10.42)	(-4.505)	(-1.466)
CASHMKTSEC	0.0111***	0.0114***	0.0642	0.0842
	(20.94)	(4.50)	(0.87)	(0.99)
ROE	0.00516***	0.0106***	0.00479***	0.0173**
	(38.48)	(15.78)	(4.11)	(2.03)
SUBORD	-0.0277***	-0.0723***	0.2780	0.483**
	(-8.524)	(-3.619)	(1.61)	(2.38)
Constant	0.0245***	0.115***	0.234*	0.450***
	(14.83)	(18.00)	(1.89)	(2.58)
# Observations	73,388	73,388	73,388	73,388
R-squared	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

Table 7 – Capital buffer quality determinants (Bank Holding Companies; Q1 2001 – Q4 2016)

Specifications (1) and (2) are estimated using fixed effects panel regressions and specifications (3) and (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. *FIXASSET* is fixed assets to total assets. *HHI* measures diversification between total interest income and non-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 total assets. *ROE* is the return on average 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. Robust *t*-statistics are presented in parentheses. *, **, *** indicate significance at the 10, 5 and 1% levels, respectively.

VARIABLES	(1) FE	(2) FE	(3) GMM	(4) GMM
$BUFQUAL_{t-1}$	0.846***		0.495***	
	(357.7)		(6.3)	
$DQUAL_{LOW} * BUFQUAL_{t-1}$		-0.417***		0.6670
		(-34.52)		(-0.56)
$DQUAL_{HIGH} * BUFQUAL_{t-1}$		0.371***		0.689***
		(37.1)		(2.7)
SIZE	-0.0013***	-0.0026***	-0.0212***	-0.0374***
	(-8.864)	(-4.492)	(-3.568)	(-2.838)
FIXASSET	-0.0419***	-0.0217	-0.0336	3.3460
	(-5.805)	(-0.643)	(-0.0292)	-1.012
HHI	0.00343***	0.0090***	0.0659***	0.125***
	(6.1)	(3.668)	(3.0)	(2.9)
RWA_{t-2}	-0.0031***	-0.0300***	-0.0786***	-0.0953
	(-5.247)	(-9.998)	(-4.092)	(-0.994)
CASHMKTSEC	0.0113***	0.0107***	0.0565	-0.0163
	(18.3)	(3.7)	(1.0)	(-0.157)
ROE	0.00487***	0.0100***	0.00281***	0.0134
	(33.6)	(12.8)	(3.0)	(1.1)
SUBORD	-0.0271***	-0.103***	0.317***	0.846**
	(-7.044)	(-4.324)	(3.9)	(2.4)
Constant	0.0253***	0.109***	0.341***	0.512**
	(12.7)	(13.2)	(3.9)	(2.6)
# Observations	55,063	55,063	55,063	55,063
R-squared	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

Table 8 – Capital buffer quality determinants (truncated sample; 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 fixed assets to total assets. *HHI* measures diversification between total interest income and non-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 total assets. *ROE* is the return on average 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. Robust *t*-statistics are presented in parentheses. *, **, *** indicate significance at the 10, 5 and 1% levels, 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

Table 9 – Determinants of capital buffer size (Q1 2001 – Q4 2016)

Specifications (1) and (2) are estimated using fixed effects panel regression and specifications (3) and (4) 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 fixed assets to total assets. *HHI* measures diversification between total interest income and non-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 total assets. *ROE* is the return on average 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. Robust *t*-statistics are presented in parentheses. *, **, *** indicate significance at the 10, 5 and 1% levels, respectively.

VARIABLES	(1) GMM	(2) GMM
$BUFSIZE_{t-1}$	0.442*	
	(1.89)	
$DSIZE_{LOW} * BUFSIZE_{t-1}$		0.843**
		(2.28)
$DSIZE_{HIGH} * BUFSIZE_{t-1}$		0.4830
		(1.37)
SIZE	-0.0233	-0.0380
	(-0.473)	(-0.794)
FIXASSET	13.0700	6.9120
	(1.27)	(0.84)
HHI	0.0939	0.1260
	(0.79)	(1.02)
RWA_{t-2}	-0.0945***	-0.0772**
	(-2.767)	(-2.412)
CASHMKTSEC	0.449**	0.507**
	(2.18)	(2.25)
ROE	0.0240***	0.0199**
	(2.83)	(2.28)
SUBORD	2.9710	2.4700
	(1.55)	(1.42)
Constant	0.0451	0.3460
	(0.06)	(0.47)
# Observations	73,388	73,388
R-squared		
# Banks	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

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