Bank Leverage, Capital Requirements and the Implied Cost of (Equity) Capital*

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Abstract

Do heightened capital requirements impose private costs on banks by adversely affecting their cost of capital? And if so, does the effect differ across different groups of banks? Using an international sample of listed banks over the period from 1990 to 2017, I find that equity investors adjust their expected return weakly in accordance with the Modigliani and Miller (1958) Theorem when banks decrease their leverage. The adjustment is stronger for smaller banks, banks that rely more on deposit financing and when debt is reduced rather than deposits, which never triggers a statistically significant adjustment. In any cases, the adjustment is not strong enough to keep banks' cost of capital constant which is estimated to increase by 10 to 40bps, representing a relative increase of 2.8% to 12.6%, when shifting equity from 8% to 16%. When using the 2011 EBA capital exercise as a quasi-natural experiment to identify the impact of capital regulation on bank's cost of capital, results indicate a strong reduction in required returns for the treated banks. However, the reduction is mainly caused by shifts in asset risk, highlighting the importance of differentiating between short-run and long-run effects.

Keywords: Bank Leverage, Implied Cost of Capital, EBA Capital Exercise, Capital Requirements, Bank Regulation, Modigliani-Miller.

JEL Classification: C33, G21, G28, G32

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1 Introduction

"Due to the fact that the authorities have signaled stricter regulation [...] DNB has decided to increase its lending rates" (DNB ASA (2013), largest Norwegian bank).[1]

Ever since the introduction of the Basel I framework in 1988, changes to bank capital regulation have been accompanied by a debate on the associated costs and benefits of heightened capital requirements. The surrounding discussion has gained additional traction in the aftermath of the global financial crisis of 2007-2009, which inter alia triggered further increases in capital requirements for banks.[2] The crisis has ruthlessly revealed banks' vulnerability as many banks were undercapitalized and had to be rescued by their governments, consuming enormous amounts of tax-payer money (among others *Wells Fargo & Co., Citigroup Inc., Commerzbank AG, Lloyds Banking Group*). These incidents reinforced the call for increased capital requirements to improve banks' robustness in future crisis and was answered by the Basel Committee for Banking Supervision (henceforth BCBS) by proposing its latest framework, Basel III. The new framework not only requires banks to hold up to 15.5% of total capital measured against the bank's risk-weighted assets but also to increase the relative fraction of "high quality" loss-absorbing common equity tier-1 (CET1) capital.[3] However, at the same time as these changes were pushed forward, concerns arose that heightened capital requirements might come at the expense of a loss of efficiency in the banking sector by adversely affecting banks' funding costs.[4] If banks were required to rely more on (allegedly) more costly equity, banks' average cost of capital would increase and ultimately raise lending rates (to retail customers). Whether the claim that capital requirements negatively affect banks' funding costs is justified, and if so, determining the magnitude of the expected effect is of high importance to understand and mitigate potential real effects of bank regulation.

In order to contribute to answering this question, I test how changes in capital requirements impact banks' cost of equity and subsequently their overall cost of capital in two ways. First,

[1] DNB ASA justifies the increase of 30bps by the significant increase in risk weights for home mortgages, implying that the bank has to hold more equity against this kind of exposure.

[2] See, for example, the Financial Times (2010a) by Admati and others or The Wall Street Journal (2013) by Cochrane.

[3] A total capital ratio of 15.5% can occur when the conservation buffer of 2.5%, the countercyclical capital buffer of up to 2.5%, and a possible G-SIB Charge of up to 2.5% are added to the minimum capital requirement of 8%.

[4] See, for example, Financial Times (2010b) by Vikram Pandit (Citigroup CEO) or The Wall Street Journal (2010).

I analyzing the relation between bank leverage, differentiated into debt and deposits, and the *implied cost of equity capital*. Second, I study a specific event, the 2011 EBA capital exercise, which exogenously increased capital requirements for a specific group of banks, to establish a direct link between capital requirements and bank's cost of equity capital.

When setting capital requirements, regulators have to weigh both private and social costs that are associated with forcing banks to hold (relatively) more equity capital against the benefit of reducing the probability and magnitude of another financial crisis. The social costs can manifest themselves in the form of adverse effects on loan rates (Kashyap et al. (2010)), the risk of shifting certain activities into to the less regulated "shadow banking sector" (Kashyap et al. (2010)), lower consumption (Van den Heuvel (2008)) and impaired liquidity production (DeAngelo and Stulz (2015)). However, Kashyap et al. (2010) estimate that a ten percentage-point increase in capital requirements would only have a modest long-run steady-state impact on loan rates in the range of 25 to 45 basis points. Similarly, Admati et al. (2013) make a strong case as to why bank equity is not *socially* expensive and conclude that "*[s]etting equity requirements significantly higher than the levels currently proposed would entail large social benefits and minimal, if any, social costs*".

While considering the social costs and benefits of capital regulation is of utmost importance in the policy debate, private costs to banks and their shareholders should not be ignored. In fact, it is probably the private costs in form of a wealth transfer from shareholders to creditors and taxpayers, which explains the banking sectors' resistance to decrease leverage.[5] Besides the costs of issuing new equity[6], one particular focus of the discussion surrounding private costs of capital regulation is the impact it has on banks' cost of capital. At the heart of this debate lies the question whether, or better to which extent, the Modigliani and Miller (1958) Theorem (henceforth MM Theorem) on the capital structure irrelevancy generally applies to banks.

While DeAngelo and Stulz (2015) dismiss the MM Theorem completely on the grounds that it does not take into account the value of liquidity provision by banks and Baker and Wurgler (2015) argue that the MM Theorem fails in the presence of the "low-risk anomaly", several others (e.g.

[5] In this context Admati et al. (2018) suggest the existence of the "leverage ratchet effect", whereby equity holders adjust leverage to maximize the current share price instead of the total firm value. Equity holders will never willingly reduce leverage and even have an incentive to increase it, even if current leverage is already excessive and increasing it will reduce total firm value.

[6] Cohen and Scatigna (2016) find that most banks achieved higher capital ratios since the crisis through the accumulation of retained earnings.

Miller (1995), Pfleiderer (2010), Miles et al. (2013), Admati et al. (2013)) have argued in favor of its applicability. However, a shared view by both sides is that no one believes the MM Theorem to hold exactly due to the many market frictions (e.g. taxes, bankruptcy costs) some of which are specific to the banking sector (e.g. deposit insurance, implicit guarantees). All else being equal, an increase in banks' funding costs (resulting from a decrease in leverage) would be expected as banks (i) can take less advantage of the preferential tax treatment of debt over equity (Célérier et al. (2017)), (ii) can make less use of (implicit) government guarantees (Gandhi and Lustig (2015)) and (iii) forgo some of the premium that investors are willing to pay for the access to liquid financial claims (DeAngelo and Stulz (2015)). Moreover, it is not clear whether banks' shareholders sufficiently adjust their required return on equity downwards as a consequence of having more equity capital as questioned by Goldman Sachs CEO Lloyd Blankfein:

"*The expectation of the market for a ten percent return as the cost of capital was there when the risk-free rate of interest was five percent. And today when the rate of interest is zero, it is the same ten percent when we have more than double the capital, and so [are] consequently much less risky*".[7]

Consequently, it boils down to an empirical question whether and to which extend the MM Theorem applies to banks and how capital requirements actually affect bank's cost of capital. So far, the current literature has investigated the potential impact of higher capital requirements on banks' cost of capital by examining the sensitivity of CAPM estimates for bank's equity beta to leverage and subsequently calculated the consequences for banks' weighted average cost of capital (WACC) in case leverage decreases. Cost of capital estimates derived from the CAPM are subject to some well-known shortcomings, such as criticism about the precision of the estimates, being unable to separate cash-flow from discount rate news and the very long time-series required to detect a positive risk-return relationship. In order to overcome these shortcomings and gain further insights into the relation between banks' cost of capital and capital requirements, I use an alternative measure to estimate banks cost of (equity) capital, the *implied cost of capital* (ICC) as, for example, proposed by

[7] The statement originates from an interview transcript of CNBC with Goldman Sachs Chairman & CEO Lloyd Blankfein in the context of CNBC's "Squawk Box" Today. See https://www.cnbc.com/2016/02/03/cnbc-exclusive-cnbc-transcript-goldman-sachs-chairman-ceo-lloyd-blankfein-speaks-with-cnbcs-squawk-box-today.html, accessed 6-August-2018.

Claus and Thomas (2001) and Gebhardt et al. (2001). Implied cost of capital estimates are derived as the market implied discount rate that equates a bank's future earnings to its current share price. The ICC is a forward looking measure and is therefore well suited to capture expectations (Botosan et al. (2011)). Moreover, the ICC captures large fractions of the (simulation derived) true cost of equity capital (Daske et al. (2010)) and has shown its usefulness in detecting a risk-return relationship already in rather short time periods (Pástor et al. (2008)).[8]

In order to investigate the relation between banks' funding costs and capital requirements, I utilize the ICC estimates in three different ways. The first part of analysis is based on a large scale international bank panel dataset, comprising 1,498 traded banks from 42 countries over the period from 1990 to 2017. Using this dataset, I investigate the relationship between bank leverage and ICC to assess the validity of the MM Theorem in the banking industry and compare with the findings for other financial and non-financial firms.[9] Theory suggests that changes to a firm's (and hence also bank's) capital structure, as forced by increasing capital requirements, should not alter its (pre-tax) WACC (Modigliani and Miller (1958)). Since we are not living in a world that satisfies the assumptions made in the MM Theorem, distortions such as taxes or bankruptcy costs cause the WACC to change with the capital structure. The banking sector in specific has further important factors that distort the MM Theorem, two of which are the provision of liquid financial claims (i.e. deposits) and the presence of implicit (e.g. too-big-to-fail) and explicit (e.g. deposit insurance) government guarantees. How large the impact of these distortions is and whether the magnitude of impact differs among or even within different industries is an empirical question, which I address by analyzing the banking sector and comparing it to other financial and non-financial firms.

In the second part of my analysis, I investigate distortions to the MM Theorem within the banking sector more closely. Specifically, I examine the MM validity in the presence of deposits. The role of bank deposits is often considered to be closer to the custody of funds and to the provision of payment services rather than a source of financing. Therefore, deposits are considered to be remunerated at a lower cost as compared to the risk-free rate and can be considered a economic benefit for banks that is not considered in the MM Theorem (Beltrame and Previtali (2016)).

[8] This paper is not ought to take a definite stance on whether cost of capital estimates derived from ICC methods are superior to CAPM estimates. Especially as the ICC also suffers from certain shortcomings. Nevertheless, ICC has proven its usefulness and is therefore preferred in this work.

[9] For all other financial and non-financial firms I create a similar dataset, comprising 29,305 traded firms from the same 42 countries from 1990 to 2017.

Moreover, these deposits are typically guaranteed by the local government in the form of deposit insurance schemes, marking a further distortion to the MM Theorem, having implications for both, deposit and other debt. In order to take the role of deposits into account, I differentiate between debt and deposit leverage to analyze how equity investors adjust their required return when either of the two kinds of leverage changes. In addition, I distinguish (i) among small and large banks and (ii) among banks with high and low fractions of deposits to total assets, in order to investigate whether required returns differ due to the lower "bail-out" probability for smaller banks and banks with only little deposits.

While these approaches are helpful in establishing a general relationship between bank leverage and the cost of capital, it does not take into account a bank's specific reaction in case they are actually subject to increased capital requirements and the consequences for the cost of capital. In order to gain further insights and to overcome endogeneity concerns, the third part of my analysis is concerned with examining a specific event, the 2011 European Banking Authority (EBA) capital exercise, which exogenously increased capital requirements for some banks while keeping them constant for others. This event has recently been used by Gropp et al. (2018) to identify how banks respond to higher capital requirements in terms of their balance sheet and lending behavior. I complement this research by shifting the scope towards the consequences for banks' cost of capital. The EBA capital exercise was unexpectedly announced on October 26, 2011, shortly after the EBA stress test in June 2011 and required specific European banks to meet a core tier-1 ratio of 9% (up from previously 5%) by June 2012 (EBA (2011a)). The capital exercise comprised the largest EU member state banks in descending order of total asset such that at least 50% of the national banking sector is covered (EBA (2011c)). The economically significant increase in capital requirements, together with the sudden announcement and the EBA's country-specific selection rule makes the capital exercise a suitable candidate for investigating the impact of heightened capital requirements on banks' cost of capital. To the best of my knowledge, previous research has only tried to estimate the impact of heightened capital requirements on the cost of equity by examining the general relationship between leverage and equity beta.

My main findings are as follows. When analyzing the validity of the MM Theorem in the banking versus other sectors, I find that the adjustment of required returns of bank equity investors is three to seven times lower. In order to further investigate the relation between bank leverage and expected returns, I split the leverage into debt and deposit leverage. Estimates show that investors care about three times more about debt leverage than deposit leverage. As these difference might stem from benefits of government guarantees, I split the sample of banks first by size and second by deposit financing. It turns out that large banks and high deposit banks benefit more from implicit government guarantees, whereby equity investors care less about leverage. When moving towards smaller banks and low deposit banks, equity investors start to care more and more about debt leverage, while deposit leverage remains insignificant at all times. The resulting estimates of small and low deposit banks show a similar degree of MM applicability as firms from other sectors. The resulting changes in banks' WACC vary with bank size and deposit financing and range between 10 and 40bps when the equity ratio is increased from 8% to 16%. The increase in WACC is lower for smaller banks and banks with less deposits (relative to total assets) as their implied risk premium adjusts stronger when leverage changes. This implies a larger increase in WACC when deposits are substituted for equity as compared the a scenario where debt is swapped for equity. Lastly, estimates from the EBA capital exercise document a significant decrease in the implied risk premium between 1.2% and 3.3% for treated banks. This reduction is likely caused by increased regulatory capital ratios, which ars achieved through changes in bank asset portfolio composition and not by relatively more equity financing. This finding indicated that in the short-run, banks' WACC might actually slightly decrease as banks hold less risky assets, while in the long-term banks might alter their capital structure, making the first part of my analysis more relevant.

My research fits into the literature on testing the MM Theorem in the banking sector as well as estimating the impact of capital requirements on banks funding costs. The European Central Bank (2011), Tsatsaronis and Yang (2012), Miles et al. (2013) and Clark et al. (2017) all use CAPM approaches in order to estimate the relationship between leverage and banks equity beta in order to estimate the impact on a change in leverage on banks' WACC.[10] All these papers conclude that a sizable MM effect exists in the banking sector, ranging from 41% to 79% relative to a full offset as stated in the MM Theorem, indicating a change in WACC ranging between 10 and 40 basis points when the amount of bank capital is doubled.[11] Cline (2015) uses a more direct approach

[10] European Central Bank (2011) and Tsatsaronis and Yang (2012) both use an international sample of about 50 large traded banks, Miles et al. (2013) conduct their analysis based on the six large UK banks, while Clark et al. (2017) consider 300 U.S. bank holding companies.

[11] Clark et al. (2017) even find a full MM offset for very large banks when ignoring tax effects.

to test the MM Theorem by solving the WACC formula for the cost of equity (as estimated by earnings yield and return on equity) and relate it to leverage. The author finds an MM effect as low as ten percent with an average offset of 45% implying an increase in WACC of 61.5 basis points when leverage (defined as debt over equity) decreases from nine to three. Assuming a ten percentage point increase in capital requirements, Baker and Wurgler (2015) find an increase of 85 basis points (representing a tripling in WACC) when taking into account the "low-risk anomaly" (Baker et al. (2011)) whereby the realized cost of equity is higher for low beta stocks. Neither of the current approaches consider the implied cost of capital, differentiate between different forms of bank leverage nor do they study as specific event that actually increased banks' capital ratios, emphasizing my contribution to the existing literature.

The remainder of the paper is structured as follows. Section 2 provides a brief history of the development of bank capital regulation. Section 3 formulates the hypotheses and illustrates the research design and the data. Section 4 presents the results on the the validity of the MM Theorem. and second. In Section 5, I utilize the 2011 EBA Capital Exercise as a quasi-natural experiment to analyze the impact of the capital exercise on banks' cost of capital. Finally, Section 6 concludes.

2 A Brief History of Bank Capital Regulation

The capital levels of banks have long been subject to some form of supervisory scrutiny, going back to the first-known explicit statement on capital policy by the Comptroller of the Currency (1914) which recommended that banks should not "[...] *hold deposits in excess of ten times its unimpaired capital and surplus*".[12] Over time, capital adequacy requirements have become one of the most important types of bank regulation. However, there was significant heterogeneity among the "Group of Ten" (G10) member countries, for example on the treatment of hidden reserves, leading to worries about potential funding-cost advantages (Wagster (1996)). Driven by their joint concern about the stability of the global financial system as well as competitive advantages of banks facing lower capital requirements, the G10 central bank governors founded the Basel Committee on Banking

[12] See Comptroller of the Currency (1914) page 21.

Supervision[13] (BCBS henceforward) in 1974. The BCBS was established with the purpose of enhancing financial stability and improving the quality of banking supervision worldwide. Ever since its foundation, the BCBS has continuously expanded its membership, comprising 45 institutions from 28 jurisdictions as of December 30, 2017.[14] Besides its numerous policy contributions, the Basel Committee is probably most know for its frameworks on international banking regulation and supervision, namely (i) the "Concordat" (1975), (ii) Basel I (1988), (iii) Basel II (2004) and most recently Basel III (2010).[15] The frameworks main objectives are to strengthen the resilience of the financial sector and to reduce the existing source of competitive inequality among international banks. As the Basel Accords only represent standards establishing minimum requirements for member jurisdictions, they have to be transposed into national law as the Basel Accords themselves are not legally-binding.[16]

One of the most significant minimum requirements set out by the Basel Accords was the introduction of a target standard ratio of capital to risk-weighted assets with specific definition as to what qualifies as eligible capital and which risk-weights to apply for which asset group. An outline of the minimum capital requirements under the Basel Accords is depicted in Figure 1. Starting with Basel I, the BCBS (1988) required banks to meet a minimum capital ratio of 8% (of which the tier-1 capital has to be at least 4%) by the end of 1992.[17] The required eligible capital (consisting of tier-1 and tier-2 capital) was defined as a ratio of risk-weighted assets, where each bank asset was assigned to one of several risk buckets, all carrying a different risk-weights. As Basel I was almost exclusively concerned with credit risk, the BCBS (1996) issued the *Amendment to the Capital Accord to incorporate market risk* taking effect at the end of 1997. While the minimum capital ratio remained at 8%, banks now had to apply a different methodology for their trading book securities to incorporate market risk, increasing the required amount of capital. Total bank risk was now defined as credit risk plus market risk, where the later consists of general market risk

[13] Initially named the Committee of Banking Regulations and Supervisory Practices. See http://www.bis.org/bcbs/history.htm for more information on the history of the Basel Committee.

[14] For a complete list of member countries and institutions please see http://www.bis.org/bcbs/membership.htm.

[15] Basel I, II and III will be henceforth jointly referred to as Basel Accords.

[16] See Deutsche Bundesbank (2018) for an overview of the implementation of the Basel Accords into EU and national law. As an example, Basel III was implemented in Europe via the Capital Requirements Directive (CRD) IV, consisting of a regulation and a directive which are then transposed into national law (Deutsche Bundesbank (2013)).

[17] Under Basel I, tier-1 capital consists of paid-up share capital, common stock and disclosed reserves, while tier-1 capital included undisclosed reserves, asset revaluation reserves, general provision/loan loss reserves, hybrid capital instruments and subordinate debt.

and specific market risk. In addition, the definition of eligible capital was extended to include tier-3 capital (consisting of short-term subordinate debt), which was solely eligible to support market risk. As of 1999 the BCBC stated that over 100 countries around the globe have been implementing Basel I (Jackson et al. (1999)).

Figure 1: Development of Basel Capital Requirements

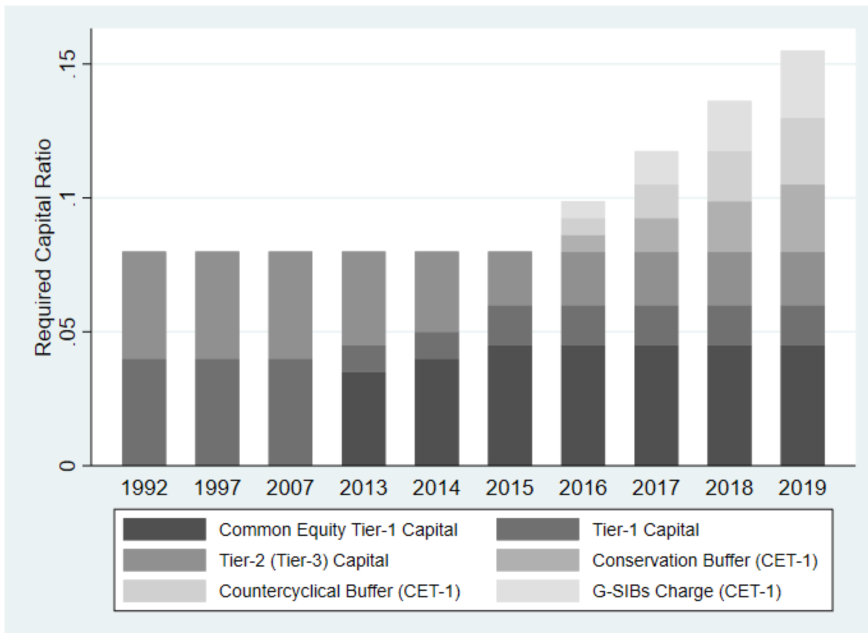

Figure 1 depicts the time-series of capital requirements as demanded by the Basel Accords. The years on the horizontal axis represent the related years of implementation. Basel I had to be implement in 1992, the Market Risk Amendment in 1997, Basel II in 2007 and changes due to Basel III are phased in from 2013 to 2019. Tier-3 capital was introduced in the Market Risk Amendment and again eliminated in Basel III.

Criticism on Basel I's procyclicality and potential for regulatory arbitrage (among other things) led the BCBS (2004) to issue the revised framework of Basel II, taking effect as of the end of 2007. The new framework consisted of three pillars and was much more exhaustive, comprising 251 pages as compared to 26 pages of the Basel I document. The first pillar covered minimum capital requirements (for credit, market and newly operational risk), the second pillar dealt with the supervisory review process and the third pillar was concerned with market discipline (to strengthen disclosure and encourage save banking practices). While the definition of eligible capital and the minimum capital ratio (8%) remained (mostly) unchanged, the calculation of total risk-weighted assets was significantly altered with the introduction of an *Internal Rating Based* (IRB) Approach for credit risk and the *Advanced Measurement Approaches* (AMA) for operational risk. These changes mark a shift away from generally applicable rules towards a more individual review of activities of a specific bank. Basel II was supposed to establish a stronger connection between actual asset risk and capital charges as compared to the "flat tax" feature of Basel I.[18]

The introduction and transition period of Basel II overlapped with the uprise of the global financial crisis, which uncompromisingly revealed the banking sector's further need for fundamental strengthening. Especially, as regulation at that time was said to have an amplifying during the financial crisis due to its pro-cyclical features (see, among others, Kashyap et al. (2004), Gordy and Howells (2006), Heid (2007), Behn et al. (2016)). Accordingly, the BCBS published two new standards in 2010 regarding liquidity risk measurement (BCBS (2010b)) and banking system resilience (BCBS (2010a)), together known as Basel III.[19] Besides two new measures to regulate bank liquidity (LCR) and funding conditions (NSFR), Basel III increased capital requirements by banks in several ways. The definition of eligible capital is changed, separating tier-1 capital into common equity tier-1 (CET1) and additional tier-1 capital, while dropping tier-3 capital completely. Moreover, banks are required (i) to hold more high-quality tier-1 capital which should increase to 6% by 2015 (consisting 4.5% CET1 and 1.5% Addition Tier-1), (ii) to build a capital conservation buffer of 2.5% until 2019, also consisting of CET1, (iii) to build a national countercyclical buffer ranging from zero to 2.5% until 2019, also consisting of CET1 and (iv) to provide an additional capital charge in case the bank is categorized as global systemically important bank (G-SIB) of up to 2.5%, again consisting of CET1.[20]

The frequent changes to banks capital requirements as previously outlined and especially the introduction of Basel III have been accompanied by concerns that forcing banks to hold allegedly

[18]See, for example, Behn et al. (2014) for the impact of IRB introduction on bank credit risk as well as Behn et al. (2016) for the impact of IRB introduction on bank lending.

[19]For completion: in 2009 so called Basel 2.5, consisting of short-term measures, was adopted in response to the financial crisis. It is considered an enhancement of the Basel II framework.

[20]The countercyclical capital buffer is set by the responsible national authority. Each individual banks' countercyclical buffer will be a weighted average of the buffers deployed across all the jurisdictions to which it has credit exposures. With respect to the G-SIB charge the BCBS has published an assessment methodology to calculate a score based on which the bank is assigned to one of five buckets, each carrying different charges. Bucket five carries the highest charge of 3.5% CET1 but is set to be initially empty. An updated list of all G-SIBs is frequently published by the Financial Stability Board.

more costly capital (relative to total assets) would cause banks cost of capital to increase. This in turn could cause a rise in lending rates which ultimately negatively impacts the real economy. In consequence, professionals and academics have accumulated various arguments in favor of an against the idea that heightened capital requirements would significantly increase banks' cost of capital (among others Admati et al. (2013), Baker and Wurgler (2015) or Cline (2015), DeAngelo and Stulz (2015)). Oftentimes, the discussion is centered around the applicability of the MM Theorem in the banking industry, highlighting the importance of further empirical evidence.

3 Hypotheses, Research Design and Data

3.1 Hypotheses Development

In order to test the validity of the MM Theorem across different industries as well as within the banking sector, it is important to formulate why and which deviations we might expect. Under the assumption of perfect capital markets, Modigliani and Miller (1958) have shown that a firm's capital structure does not matter. Their WACC framework is given by

$$WACC = r_E \cdot \frac{E}{A} + r_D \cdot \frac{D}{A}, \tag{1}$$

where r_E is the cost of equity capital, r_D equals the cost of debt and E/A and D/A are the respective sources of equity and debt financing relative to total assets. Changes in leverage cause off-setting changes in the cost of equity, the cost of debt and their respective balance sheet fractions, leaving the overall WACC and thus firm value unchanged. However, as previously stated, there is consensus in the sense that nobody believes the MM Theorem to hold exactly, neither in the banking sector nor in any other industry (Miller (1995)). The questions are rather, to which extent the MM Theorem is expected to hold (or to fail), whether there are differences in its validity among different industries and what the factors for possible deviations could be.

Existing research on optimal capital structure has emphasized the trade-off firms face in their choice of equity versus debt financing. Firms need to weigh the benefits of debt such as tax shields (Kraus and Litzenberger (1973)) and agency benefits (Jensen (1986)) against the cost of debt such as costs of financial distress (Weiss (1990)) and agency costs (Myers (1977)). Balancing these costs and benefits of leverage causes a firm's WACC and in consequence its value to change with its capital structure. However, these distortions are not exclusive to the banking sector but are present in all other sectors alike, so that there is no obvious reason as to why one should expect differences in the degree of validity of the MM Theorem between the banking sector and other industries, solely based on these distortions.

But banks and their role in the economy is special, leading to further distortions such as *implicit* and *explicit government guarantees* which are not present in other sectors. By taking (short-term) deposits and channeling them into (long-term) loans, banks perform the elementary functions of maturity and risk transformation. Besides providing credit and managing the payment system, banks provide liquidity services to market participants, who are willing to pay a premium for access to liquid financial claims (DeAngelo and Stulz (2015)). While providing these liquidity services is socially valuable, at the same time it makes banks vulnerable to bank runs (Diamond and Dybvig (1983)). As these bank (deposit) runs can lead to a failure of the complete financial system, deposit insurance, i.e. an explicit government guarantee on a part of bank's debt, represents a viable solution to mitigate this risk while simultaneously enabling banks to provide liquid claims (Diamond and Dybvig (1986)). In performing their important tasks, the largest banks have even become so essential to the economy that they not only benefit from explicit government guarantees but also from implicit government guarantees (e.g. "too-big-to-fail" (TBTF)) as these banks anticipate that they will not be allowed to go bankrupt due to the enormous damage a failure would inflict on the financial system and subsequently, the real economy. In consequence, investors are willing to accept a lower required rate of return for the bank's securities as they expect that a part of the negative tail risk will be absorbed by the government and ultimately by the taxpayer (Kareken and Wallace (1978)). This arguments holds for the cost of debt, (e.g. Barth and Schnabel (2013), Santos (2014)) as well as the cost of equity (e.g. Brewer and Jagtiani (2013), Gandhi and Lustig (2015), Gandhi et al. (2017)). The presence of these *explicit and implicit government guarantees* are unique to the banking sector and might cause differences in the way how investors perceive leverage when determining their required returns.

Similar to incorporating the effect of taxes into the WACC formula, these distortion can be formalized within the WACC framework in the following way

$$WACC_{Bank} = r_E \cdot \frac{E}{A} + r_D \cdot (1 - \lambda) \cdot \frac{D}{A}, \tag{2}$$

where λ represents the joint effect of the underpricing of deposits due to the presence of deposit insurance and the TBTF subsidy on the cost of debt.[21] With this first formalization of the distortions at hand, I propose the following hypothesis, which I will test in the empirical part of this paper. Hypothesis **H1** relates to an expected difference in the perception and consequently the relation between leverage and the cost of equity capital among banks and other firms.[22] Due to the joint effect of the distortions on bank debt, bank equity investors might evaluate (changes in) leverage differently as compared to equity investors from other sectors, i.e.

H1: *The presence of government guarantees (e.g. deposit insurance) leads to a lower adjustment of the cost of equity in the banking sector as compared to other industries.*

Equity investors might assume that their bank will be bailed-out in case of severe financial distress before the bank is effectively insolvent and equity is wiped out (see, for example, Reuters (2008)). That this is actually the case could be observed in the global financial crisis of 2008-09 as several governments stepped in to save their national banks by providing guarantees and heavy equity injections. [23]

However, the aforementioned distortions are not only relevant among the banking and other industries, but also within the banking sector itself. As previously highlighted, banks funds themselves not only with equity and (market) debt also with deposits. While the distortion due to the presence of deposit insurance is applicable to all banks, the partial downside protection due to any TBTF guarantee only applies to a (small) group of banks. Accordingly, bank's WACC formula

[21] The willingness to pay a premium for access to liquid financial claims as highlighted by DeAngelo and Stulz (2015) is subsumed under λ as it would further contribute to the underpricing of deposits. However, I do not need this assumption for my analysis and in addition, there is evidence that bank deposits might actually be more expensive than capital market debt (Begenau and Stafford (2018).

[22] At this point, I only consider "raw" leverage, as deposits are not present in other industries.

[23] For example, Germany's Commerzbank AG was provided with more than 18 EURbn in equity via silent participations and a capital increase (see Deutscher Bundestag (2017)). America's Citigroup Inc. received more than 40 USDbn in bailout money (see Reuters (2013)).

need to be adjusted for the presence of deposits, i.e.

$$WACC_{Bank} = r_E \cdot \frac{E}{A} + r_{D,NonDep} \cdot (1-\eta) \cdot \frac{D_{NonDep}}{A} + r_{D,Dep} \cdot (1-\sigma) \cdot \frac{D_{Dep}}{A}, \tag{3}$$

where r_E is the cost of equity capital, $r_{D,NonDep}$ is the cost of (market) debt, $r_{D,Dep}$ is the cost of deposits and $\frac{E}{A}$, $\frac{D_{NonDep}}{A}$ and $\frac{D_{Dep}}{A}$ are the respective balance sheet item fractions from the banks passive side. The variables η and σ represent the TBTF guarantee on (market) debt and deposit insurance, respectively.

Deposits are (almost) completely and explicitly insured, while bank debt is at most implicitly insured (i.e. via TBTF). Accordingly, it is importing to distinguish between the sensitivity of banks' cost of equity with respect changes in debt leverage versus deposit leverage. Deposits are remunerated at a lower cost than bank debt (due to deposit insurance and the willingness to pay a premium for liquid financial claims), whereby equity holders get a larger share of asset returns compared to the case where the same assets are financed with debt. Consequently, the bank's asset risk is spread over a broader equity base in the case of deposit relative to debt financing. In consequence, this leads to hypothesis **H2**, where equity investors demand a lower premium when deposit leverage increases as compared to the case where debt leverage increases, i.e.

H2: *The presence of explicit guarantees on bank deposits leads to a lower adjustment of the cost of equity with respect to changes in deposit leverage as compared to debt leverage.*

In order provide further evidence for the importance of these distortions, I formulate two additional hypotheses. So far, I assumed that equity investors anticipate a future bailout and adjust their required risk-premium as some of this tail-risk is transfered to the government (and ultimately the tax-payer). However, this effect should be more pronounced for very large banks as compared to smaller banks, since the later are less likely to be rescued by the government. Accordingly, hypothesis **H3a** suggests that equity investors of smaller banks should care more about changes in debt leverage as it does not carry a TBTF guarantee, i.e.

H3a: *The adjustment of the cost of equity with respect to changes in debt leverage increase with decreasing bank size.*

Analogously, hypothesis **H3b** suggests that banks who finance themselves with larger fractions of deposits should be less sensitive to changes in debt leverage as compared to banks that rely more on (market) debt financing. The idea is that banks with very high fractions of deposit financing are more likely to be bailed-out as the government would step in anyway because of the explicit guarantee on deposits.[24]

H3b: *The adjustment of the cost of equity with respect to changes in debt leverage increase with decreasing deposit financing.*

For both **H3a** and **H3b**, the sensitivity towards changes in deposit leverage should not change, since deposit insurance exists for all banks alike. What is expected change is the sensitivity towards uninsured and in the best case implicitly guaranteed (market) debt.

With the hypotheses worked out, the next subsections will deal with the estimate of bank cost of equity by illustrating the implied cost of capital and the empirical implementation.

3.2 Bank's Implied Cost of (Equity) Capital

3.2.1 An alternative proxy for expected returns

The usage of the implied cost of capital (henceforth ICC) has evolved in response to the inability of the standard asset pricing models to provide precise estimates of firm-level cost of equity capital (e.g. Fama and French (1997), Elton (1999)) and the very long time-series which is needed to find a positive risk-return relationship (e.g. Lundblad (2007)). In general, the ICC has several desirable qualities as compared to realized returns. By only using information available at the point of the estimation, the estimate potentially much better represents expectations. Moreover, by including earnings forecasts the ICC allows to separate between cash-flow news and news about the discount rate (the actual variable of interest), which is much harder using realized returns.

Pástor et al. (2008) show that using the ICC, the risk-return relationship can already be detected for "short" time-series. Moreover, the authors provide an analytical analysis demonstrating

[24]In **H3b** one possible concern might be that bank with a large fraction of deposit financing have a completely different business model compared to banks who rely only somewhat on deposit financing. While I cannot completely rule out this explanation, I will control for a variety of bank characteristics and fixed effects in order to control for banks' business models.

that the ICC should be a good proxy for the conditional expected stock return given reasonable assumptions.[25] Further validation is provided by Daske et al. (2010) who compare the true cost of equity capital from a model economy (calibrated to the CRSP-Compustat universe) to several implied cost of capital estimates. They find that ICC estimates (single and combined) capture about 90% of the variation in the true cost of equity capital. Botosan et al. (2011) directly compare the performance of realized returns vs. ICC as estimates for firm-specific cost of equity (or expected return). The authors analyze two dimensions namely (i) the association between the estimates and future realized returns and (ii) the association between the estimates and contemporaneous firm risk characteristics. They recommend the use of the ICC and caution against the use of realized returns as proxy for expected returns (even when controlling for cash-flow news).

The previously mentioned literature together with the circumstance that previously research has focused on realized returns as proxies for the cost of equity capital makes encourages me in the believe that the ICC is a useful alternative, promising additional insights into determinants of banks cost of capital.[26]

3.2.2 Computing the Implied Cost of Capital

The literature has brought forward different models to compute the implied cost of capital, which can be categorized into *Residual Income Models* (e.g. Claus and Thomas (2001), Gebhardt et al. (2001)), *Dividend Discount Models* (e.g. Pástor et al. (2008)) and *Abnormal Earnings Growth Models* (e.g. Easton (2004), Ohlson and Juettner-Nauroth (2005)).

In general, the ICC is computed as the discount rate (r_e) the equates the current share price to the present value of all future cash-flows

$$P_t = \sum_{k=1}^{\infty} \frac{\mathbb{E}_t[CF_{t+k}]}{(1+r_e)^k}. \tag{4}$$

For empirical implementation, all models use different assumptions concerning the time period and

[25] The authors assume both the dividend growth as well as the conditional expected return follow on AR(1) process.

[26] However, as with every estimate the ICC comes with certain caveats. One is the reliance on *Clean Surplus Accounting* which does not necessarily apply. Moreover, the computation (and interpretation) relies on the assumption that analyst's earnings forecasts are a good proxy for actual market expectation (Fried and Givoly (1982), O'brien (1988)). As it is a well-known fact that analyst's forecasts are overoptimistic, it is important to control for this bias (Easton and Sommers (2007)). Finally, there are potential issues with measurement errors of ICC estimates as pointed out by Wang (2015)

input parameters. In this paper, I will use an equally weighted average across all five estimates. Mixing the different methods should reduce idiosyncratic measurement errors across the models (Hail and Leuz (2009), Daske et al. (2010)).

Panel A of Table 1 presents the distribution of the average ICC estimate, the ICC estimates among the different estimation methods as well as the assumed long-term growth rate and the analyst forecast bias (FBIAS). The abnormal earnings growth models (AEG) deliver the highest estimates with a mean (median) of above 12% (11%), while the residual income model of Gebhardt et al. (2001) provide the lowest estimates with slightly above 7% (6%). Panel B of Table 1 displays the Pearson correlation coefficients for the same variables as in Panel A. All ICC estimates are highly positively correlated.

Table 1: Cost of Equity Estimates Descriptives

Panel A: Distribution of Implied Cost of Capital Estimates

Variable	N	Mean	Min.	p5	p50	p95	Max.	St. Dev.
ICC (Average)	174,784	10.78%	1.36%	5.59%	9.66%	20.00%	41.56%	4.72%
DDM (Pastor)	167,160	10.88%	3.58%	5.58%	9.65%	21.53%	33.11%	4.76%
RIM (CT)	155,215	10.89%	2.26%	5.60%	9.75%	20.23%	46.12%	4.95%
RIM (GLS)	156,012	7.02%	0.29%	2.85%	6.41%	13.93%	25.91%	3.36%
AEG (OJN)	155,033	12.28%	1.90%	6.26%	11.29%	21.38%	43.02%	4.72%
AEG (Easton)	157,729	12.40%	1.99%	5.72%	11.13%	23.28%	46.65%	5.60%
Long-term Growth	174,784	15.25%	2.00%	2.00%	10.00%	50.00%	100.00%	17.92%
Analyst Forecast Bias	153,496	0.001	-0.377	-0.006	0.000	0.010	0.745	0.018

Panel B: Pearson Correlation Coefficients

Variable	ICC (Average)	DDM (Pastor)	RIM (CT)	RIM (GLS)	AEG (OJN)	AEG (Easton)	LT Growth	FBIAS
ICC (Average)	1.000							
DDM (Pastor)	0.921	1.000						
RIM (CT)	0.932	0.929	1.000					
RIM (GLS)	0.625	0.450	0.490	1.000				
AEG (OJN)	0.921	0.846	0.844	0.467	1.000			
AEG (Easton)	0.897	0.758	0.740	0.463	0.883	1.000		
Long-term Growth	0.609	0.725	0.677	0.076	0.556	0.510	1.000	
Analyst Forecast Bias	0.114	0.077	0.106	0.075	0.106	0.142	0.029	1.000

Table 1 presents the correlation coefficients and distribution of the different ICC models, i.e Pástor et al. (2008) (Pastor), Claus and Thomas (2001) (CT), Gebhardt et al. (2001) (GLS), Ohlson and Juettner-Nauroth (2005) (OJN) and Easton (2004) (Easton).

For illustration purposes, only the model used by Pástor et al. (2008) is outlined in the main text while the detailed computation procedure for all five ICC models can be found in the appendix. Pástor et al. (2008) compute the ICC in the following way

$$P_t = \sum_{k=1}^{3} \frac{FE_{t+k} \cdot (1 - PB_{t+k})}{(1 + r_e)^k} + \sum_{k=4}^{15} \frac{FE_{t+k} \cdot (1 - PB_{t+k})}{(1 + r_e)^k} + \frac{FE_{t+16}}{r_e \cdot (1 + r_e)^{15}}, \tag{5}$$

where P_t is the current share price, FE_{t+k} is the earnings forecasts for year-end $t + k$, PB_{t+k} is the plowback rate (one minus the payout ratio) and ICC is the implied cost of capital. The time horizon T after which a terminal value is computed is equal to 15. For the first three years, explicit analyst forecasts are used, while for the years 4 to 15 earnings forecasts are derived as $FE_{t+k} = FE_{t+k-1} \cdot (1+g_{t+k})$, where g_{t+k} is the earnings growth forecast made by the analyst which is assumed to exponentially mean-revert to the GDP growth rate. As the valuation model from (2) typically does not yield a closed-from solution, the quadratic difference between the right-hand side and the left-hand side is computed where a solution is accepted if the quadratic difference is smaller or equal to 10^{-8}. Finally, an appropriate risk-free rate r is subtracted from the ICC estimate of bank i in order to calculate the implied risk premium (IRP) at time t, i.e.

$$IRP_{i,t} = ICC_{i,t} - r_t. \tag{6}$$

In order to compute the ICC, I combine two kinds of databases. The first is analyst forecasts from *I/B/E/S*, which are used as estimates for banks' future earnings. In addition, *I/B/E/S* provides information on forecasted earnings growth rates and prices which are both utilized in the computation. The data from *I/B/E/S* is then matched to quarterly bank fundamental data, which comes from various sources. For U.S. banks I use information obtained from the banks' quarterly call reports (e.g. FR Y-9C report for bank holding companies) and complement them with quarterly information from *Compustat Bank*, if missing. For international banks I combine information from *Bureau van Dijk's Bankscope* (annual), *Compustat Global* (quarterly) and *S&P's Market Intelligence* (quarterly).[27]

[27] Despite S&P's Market Intelligence, all databases are accessed via the Wharton Research Data Services (WRDS). The matching between I/B/E/S and the call reports was accomplished via the I/B/E/S-CRSP link provided by WRDS. Linking I/B/E/S to the fundamental data for international banks was a blend of matching on security identifiers (e.g. cusip, sedol or isin), name and country as well as hand-matching.

Figure 2: The Global Cost of Bank Equity

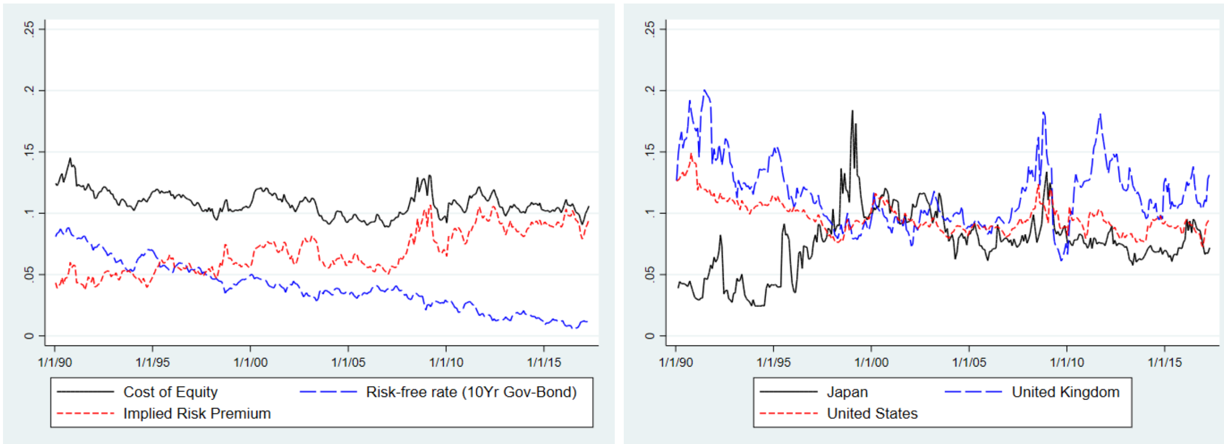

Figure 2 (a) depicts the development of the cost of equity capital (CoE), implied risk premium (IRP) and risk-free rate for listed banks worldwide between 1990 and 2017.

Figure 2 (b) depicts the development of the implied cost of equity capital for banks in the United States, United Kingdom and Japan between 1990 and 2017.

The final dataset is an unbalanced panel consisting of 1,498 from 42 different countries in the period from 1990 to 2017. The corresponding ICC estimates are winsorized at the top and bottom 2% on an annual basis.[28] Finally, I deduct the appropriate risk-free rate as approximated by the yield of 10-year government bonds. As reference I use the U.S. for America, Germany for Europe and Japan for Asia, respectively.

On average (median) the implied cost of equity capital amounts to 10.04% (9.11%) with a corresponding implied risk premium of 5.92% (4.83%). Univariate quintile sorts based on banks' equity ratio, tier-1 ratio, total assets and loan loss reserves over total assets can be found in the appendix (Figure A.3.1). Interestingly, Figure 2 (a) reveals that average cost of bank equity is remarkably stable around 10%, while the implied risk premium has constantly increased over time from as low as 4% up to 10%. Moreover, Figure 2 (b) is consistent with the claim raised by Wagster (1996) that Japanese banks had a substantial funding-cost advantage which Basel I failed to eliminate. The subsequent increase in Japanese banks' implied cost of equity related to the Asian financial meltdown of 1997-98, which US and UK banks were less (or not) exposed to. The impact of global financial crisis of 2007-09 is clearly visible among all three countries, while the sovereign debt crisis starting in 2010 is only pronounced for UK banks.

[28]When winsorizing the ICC estimates, the bank estimates are combined with equivalent estimates for non-bank firms.

3.3 Research Methodology & Descriptive Statistics

In general, the (pre-tax) weighted average cost of capital (WACC) is defined as

$$WACC = r_E \cdot \frac{E}{A} + r_D \cdot \frac{D}{A}, \tag{7}$$

where r_E is the cost of equity capital, r_D equals the cost of debt and E/A and D/A are the respective sources of equity and debt financing relative to total assets. According to the MM Theorem, increasing reliance on relatively more costly equity is offset by decreasing expected returns on equity as well as on debt, keeping the overall WACC constant. This is of course only true if taxes and (implicit) government guarantees are disregarded. If taxes are considered, the WACC actually decreases in leverage.[29] The same is true for (implicit) government guarantees (e.g. deposit insurance) as depositors do not demand an appropriate risk-premium from the bank whereby deposits are underpriced and WACC decreases when a bank finances itself more and more with deposits relative to equity (and other debt).

In order to account for the differential treatment of deposits and debt, I consider a restated formula for WACC formula as proposed by Beltrame and Previtali (2016), taking into account the role of deposits

$$WACC = r_E \cdot \frac{E}{A} + r_{D,NonDep} \cdot \frac{D_{NonDep}}{A} + r_{D,Dep} \cdot \frac{D_{Dep}}{A}, \tag{8}$$

where r_E is the cost of equity capital, $r_{D,NonDep}$ is the cost of debt (non deposit), $r_{D,Dep}$ is the cost of debt (deposit) and $\frac{E}{A}$, $\frac{D_{NonDep}}{A}$ and $\frac{D_{Dep}}{A}$ are the respective balance sheet item fractions from the banks passive side.

In order to test how investors adjust their expected return on equity, the previously stated WACC formula can be solved for r_E, giving the following representation for the "general"

$$r_E = WACC + (WACC - r_D) \cdot \frac{D}{E}, \tag{9}$$

[29]Bankruptcy costs are not considered here. For a theoretical model of the impact of bankruptcy costs on banks' capital structure decisions, see Allen et al. (2015).

and the alternative WACC formula of Beltrame and Previtali (2016)

$$r_E = WACC + (WACC - r_{D,NonDep}) \cdot \frac{D_{NonDep}}{E} + (WACC - r_{D,Dep}) \cdot \frac{D_{Dep}}{E}. \tag{10}$$

In empirical terms, this can be tested by regressing a bank's implied cost of equity capital on bank leverage for the "general" case as well as a bank's debt leverage and deposit leverage for the alternative case. Accordingly, I utilize the follow panel regression

$$IRP_{i,t} = \alpha + \beta_1 \cdot \frac{D_{t-1}}{E_{i,t-1}} + \epsilon_{i,t}, \tag{11}$$

where α corresponds to the bank's WACC and β_1 is the difference between the WACC and the cost of debt. Finally, the panel regression is extended by including (i) vector $\mathbf{Z}_{i,t-1}$ of lagged time-varying bank variables to control for the impact of differences in asset risk and business models across banks and over time, (ii) bank fixed effects (η_i) to capture unobservable bank specific impacts which are constant over time and (iii) country times quarter fixed effects ($\mu_t \cdot \mu_c$) to capture changes in the economic environment in which banks operate as well as average changes in bank's asset risk. Adding the further variables yields the final panel regression in the form of

$$IRP_{i,t} = \alpha + \beta_1 \cdot \frac{D_{t-1}}{E_{i,t-1}} + \delta \cdot \mathbf{Z}_{i,t-1} + \mu_i + \mu_t \cdot \mu_c + \epsilon_{i,t}, \tag{12}$$

where δ represents the vector of coefficients of lagged bank characteristics and all other variables defined as stated before. Analogously, the alternative case that differentiates between deposit and debt leverage is tested by

$$IRP_{i,t} = \alpha + \beta_1 \cdot \frac{D_{NonDep,i,t-1}}{E_{i,t-1}} + \beta_2 \cdot \frac{D_{Dep,i,t-1}}{E_{i,t-1}} + \epsilon_{i,t}, \tag{13}$$

where α corresponds to the bank's WACC and β_1 and β_2 are the difference between the WACC and the cost of debt (non-deposit) and cost of debt (deposit), respectively. Similar to equation (12), lagged bank characteristics, bank fixed effects and country times quarter fixed effects are added, yielding the final regression equation

$$IRP_{i,t} = \alpha + \beta_1 \cdot \frac{D_{NonDep,i,t-1}}{E_{i,t-1}} + \beta_2 \cdot \frac{D_{Dep,i,t-1}}{E_{i,t-1}} + \delta \cdot \mathbf{Z}_{i,t-1} + \mu_i + \mu_t \cdot \mu_c + \epsilon_{i,t}. \tag{14}$$

The data used in the regression analysis consist of my ICC estimates on the left hand side and of bank characteristics from varying data source on the right hand side.

Table 2: Descriptive Sample Statistics

	N	mean	sd	p5	p50	p95
Cost of Equity	61,310	0.108	0.047	0.057	0.097	0.200
Implied Risk Premium	61,310	0.068	0.052	0.010	0.056	0.172
Total Assets (USDbn)	46,722	31.549	51.437	0.422	6.395	163.700
Total Deposits / Total Assets	44,996	0.727	0.149	0.433	0.765	0.891
Total Net Loans / Total Assets	44,094	0.624	0.163	0.286	0.652	0.837
Commercial Loans / Total Assets	28,846	0.124	0.090	0.006	0.105	0.309
Consumer Loans / Total Assets	27,681	0.068	0.071	0.001	0.046	0.198
Loan Loss Provisions / Total Loans	31,447	0.002	0.002	0.000	0.001	0.005
Loan Loss Reserves / Total Loans	37,888	0.016	0.011	0.003	0.014	0.038
Liquidity	28,687	0.247	0.123	0.057	0.236	0.483
Equity Ratio	46,660	0.090	0.060	0.039	0.082	0.145
Tier-1 Ratio	35,134	0.118	0.032	0.072	0.114	0.181
Total Capital Ratio	35,962	0.140	0.032	0.102	0.134	0.202
Leverage (Debt / Equity)	46,712	12.014	4.912	5.810	11.084	22.950
Total Debt / Total Equity	44,949	2.457	2.316	0.242	1.606	8.048
Total Deposits / Total Equity	44,803	9.480	3.567	4.727	8.892	17.013
RWA / Total Assets	27,317	0.690	0.133	0.432	0.706	0.879
CAPM Beta	33,574	0.712	0.538	-0.015	0.650	1.666
FF3 Beta	33,574	0.712	0.486	-0.015	0.717	1.515
Return on Assets	44,675	0.009	0.011	-0.002	0.009	0.019
Std.Dev. of ROA	31,077	0.001	0.001	0.000	0.001	0.003
Return on Equity	43,219	0.099	0.087	-0.024	0.108	0.208
Dividend Payout Ratio	12,926	0.350	0.247	0.000	0.322	0.867

Table 2 displays several bank characteristics (quarterly or annually, depending on availability) for all 1,498 banks from 42 different countries over the period form 1990Q1 to 2016Q4. Detailed definitions of all variables can be found in Table A.2.1 in the appendix.

As previously mentioned, data for U.S. banks is obtained from the banks' quarterly call reports (e.g. FR Y-9C report for bank holding companies) and complemented with quarterly information from *Compustat Bank*, if missing. For international banks I combine information from *Bureau van Dijk's Bankscope* (annual), *Compustat Global* (quarterly) and *S&P's Market Intelligence* (quarterly). Table 2 displays the ICC estimates (quarterly average) as well as various bank characteristics for which data was available in the quarter prior of the ICC estimation. A detailed description of all variables definitions can be found in Table A.2.1 in the appendix. Bank size in terms of total assets ranges from 400 USDm up to over 300 USDbn. Moreover, there is significant variation in capitalization, funding in terms of deposits as well as the lending on the asset side. Finally, there is substantial variation across banks (and over time) regarding leverage, deposits over equity and total debt over equity.[30] This variation is exploited in order to investigate whether leverage can explain banks' implied cost of capital.

4 Modigliani-Miller and Banks

4.1 Validity across Sectors

Do bank equity investors actually perceive changes in leverage differently than equity investors in other sectors? Based on the distortions mentioned in Subsubection 3.1, I stated in **H1** that due to the distortions unique to the banking sector, bank equity investors will be less sensitive to changes in leverage. In order to provide evidence for **H1**, I test the panel regressions as stated in equation (12) among bans, other financial firms and non-financial firms.

All specification in Table 3 show a statistically significant impact of leverage on the required return on equity at the 1% level. Economically however, there is a large variation in the size of coefficients. Columns (1) to (3) represent the coefficient estimates on leverage, defined as debt over equity, while including firm and country times quarter fixed effects as well as ICC controls (analyst forecast bias and assumed growth rate). The estimates indicate that bank equity investors increase their required return on equity by 5bps if leverage increases by one unit. Compared to

[30] The MM Theorem is actually stated in market values of equity and debt. However, since I want to investigate the relationship between regulatory leverage and banks' cost of capital, I use book values. Regulators care about capital components as stated on the balance sheet (after applying several prudential filters) and not the market value of equity. In addition, market value of debt is not available so that I would need to relate book value of debt and market value of equity. Therefore, I utilize book values of equity and debt throughout the paper. Nevertheless, for robustness I provide the results for equation (12) and (14) in the appendix.

the non-financial and other financial sector, the increase is roughly three to five times lower as indicated by the coefficients of 14bps and 28bps. When including some commonly available control variables, the coefficient for banks actually decreases while those in the non-banking sector increase, leading to five to seven times lower sensitivity of equity investors' required return in the banking sector.

Table 3: Implied Risk Premium and Leverage

	(1) Banks	(2) Other Fin.	(3) Non-Fin.	(4) Banks	(5) Other Fin.	(6) Non-Fin.
Debt / Equity	4.8296***	27.6228***	13.9658***	4.2778***	30.1070***	20.8291***
	(1.4389)	(4.7251)	(1.2749)	(1.5234)	(4.9025)	(1.3411)
ln(Total Assets)				52.8443***	-25.1763***	-5.7274**
				(9.5740)	(8.8385)	(2.4822)
Book-to-Market				68.1404***	243.0660***	206.0844***
				(9.6854)	(12.7882)	(3.8097)
ICC Controls	Yes	Yes	Yes	Yes	Yes	Yes
Firm FE	Yes	Yes	Yes	Yes	Yes	Yes
Country-Time FE	Yes	Yes	Yes	Yes	Yes	Yes
Observations	45721	52114	612993	43943	51011	612180
Adjusted R^2	0.8215	0.7726	0.7410	0.8282	0.7851	0.7533

Table 3 presents the coefficient estimates for testing the MM-Theorem among banks, other financial and non-financial firms. Columns one to three show the estimates of equation (12) of the standard MM for banks, other financial firms and non-financial firms without the inclusion of bank/firm specific controls. The regressions in columns four to six represent the estimates from equation (12), additionally controlling for lagged bank/firm characteristics. The analyst forecast bias (FBIAS) and the assumed long-term growth rate (LT Growth) are included as ICC control variables. Bank/firm controls include the natural logarithm of total assets and the book-to-market ratio. Standard errors are clustered at the bank (firm) level. *, **, and *** indicate statistical significance at the 10%, 5%, and 1%. level respectively.

What would this now imply for banks' WACC? Taking the sample medians of the implied risk premium (5%) and the equity ratio of (8%) together with an average risk-free rate of 3% and an assumed credit spread of 1%, the WACC would amount to 4.32% $[0.08\cdot(3\%+5\%)+0.92\cdot(3\%+1\%)]$. If we take the estimate of column (1) and assume that the equity ratio regulation increase the ratio to 16% (equaling a decrease in leverage by 6.25 units) the cost of equity would decrease by 30bps [4.8bps $\cdot(-6.25)$]. Supposing that the cost of debt is not affected by the increase in the capital ratio, the pre-tax WACC would increase by 27.2bps $[0.16 \cdot (3\% + (5\% - 0.048\% \cdot 6.25) + 0.84 \cdot (3\% + 1\%)]$ marking a relative increase in WACC of 6.3%.[31] The same calculation can be done including the tax-benefits of debt financing, leading to an increase on WACC of 36.8bps, implying a relative increase in WACC of 11.4%.[32]

For the MM-Theorem to hold exactly, the cost of equity would need to decrease to 6% as compared to 7.7% based on the estimates in column (1). Relative to the initial cost of equity of 8%, this implies an MM offset of only 15%.[33] However, as previously mentioned, the expectation was never to find a full MM offset, although 15% is an astonishingly low offset, especially when comparing it to estimates for non-financial firms and other financials.[34] Using the estimates from columns (2) and (3) in a similar exercise as previously outlined for banks, the MM offset amounts to 43% and even 86% for non-financial and other financials, respectively. This finding is in line with hypothesis **H1** and indicates that the distortions unique to the banking sector play a significant role in how equity investors perceive leverage.

Based on these findings alone, one might suggest that there is only little support for the applicability of the MM Theorem in the banking industry. The estimated changes in WACC range from 27 to 37bps, which might sound economically small but based on the assumptions made to calculate them, they represent a relative increase in WACC of 6.3% to 11.4%. Interestingly, the increase in lending costs as stated by DNB ASA falls into the estimated range of WACC changes, providing at least some justification for such an action. However, one should not forget that bank debt differs significantly from debt in other industries due to the role of deposits. This calls for a closer analysis of the relationship between bank leverage and the cost of equity capital. Accordingly, the following subsection will analyze bank debt more thoroughly.

[31] The assumption that the cost of debt does not appreciate the capital increase is not in accordance with the MM Theorem as debt should get less risky as capital increases. While no cost of debt appreciation might be a reasonable assumption for very large banks, it might be questionable for smaller banks. However, in unreported regression results I do not find a statistically significant relationship between CDS spreads and leverage. Unfortunately, CDS Spreads were only available for a small subsample of (mostly large) banks from 2007 onwards.

[32] This estimate relates to an assumed tax rate of 30% and is calculated as $0.08 \cdot (3\% + 5\%) + 0.92 \cdot (3\% + 1\%) \cdot (1 - 0.3)$. The after-tax WACCs amount to 3.21% as start value and 3.58% after the decrease in leverage.

[33] The MM offset is calculated as the actual change in banks' cost of equity of 30bps over the required change of 200bps that would be needed to keep the WACC constant.

[34] A graphical illustration of the development of the cost of equity / implied risk premium of banks, other financials and non-financials can be found in Figure A.3.2 the appendix.

4.2 Validity within the Banking Sector

The previous section showed that changes in bank leverage are associated with much lower adjustments in the required return on equity as compared to other industries. One possible explanation is the special role of bank deposits, which can not be seen as conventional debt but are often considered to be closer to the custody of funds and to the provision of payment services rather than a source of financing. In addition, they are explicitly insured by the government and are, in combination with investors' willingness to a pay a premium, a cheaper source of financing than debt. In consequence, bank equity investors might perceive deposit debt differently from other debt (e.g. banks issuing bonds), which is formulated in hypothesis **H2**. In order to test this hypothesis, I run the panel regressions as state in equations (13) and (14) with and without including lagged bank characteristics.

In Table 4, I report the regression results for testing the MM-Theorem when differentiating between debt and deposit leverage as compared to overall leverage. Columns (1) and (2) again show the sensitivity of required equity returns to changes in leverage if leverage is not differentiated. AS compared to the previous subsection, column (2) controls for a broader vector of lagged bank characteristics, which, however, does not alter the outcome as the coefficient remains relatively low at 4.6bps.

Columns (3) and (4) present the estimates for the restated MM formula, splitting leverage into deposit and debt leverage. The resulting estimates in column (3) of 3bps and 9.5bps indicate that bank equity investors adjust their required return more than three times as strong if debt leverage changes as compared to changes in deposit leverage. Moreover, the coefficient on deposit leverage is only barely statistically significant at the 10% level, while the one on debt leverage is statistically significant at the 1% level. When controlling for lagged bank characteristics in column (4), the coefficient on deposit leverage even becomes insignificant while the one on debt leverage remains significant at the 1% level.

Table 4: Bank's Implied Risk Premium and Leverage

	(1) MM	(2) MM	(3) MM (Dep. adj.)	(4) MM (Dep. adj.)
Debt / Equity	4.8296***	4.5990**		
	(1.4389)	(1.7872)		
Total Deposits / Equity			3.2723*	2.6157
			(1.8413)	(2.0347)
Total Debt / Equity			9.4945***	9.1664***
			(2.5306)	(3.5386)
ln(Total Assets)		57.7980***		55.3558***
		(10.0210)		(9.9979)
Total Loans / Total Assets		-53.1652		-48.8137
		(35.9705)		(36.5444)
Loan Loss Reserves / Total Loans		-1939.9881***		-1924.2953***
		(593.9544)		(609.7695)
Liquidity		-109.1696***		-110.5299***
		(39.7220)		(40.6218)
Book-to-Market		41.5233***		41.9273***
		(11.0497)		(11.0741)
ICC Controls	Yes	Yes	Yes	Yes
Bank FE	Yes	Yes	Yes	Yes
Country-Time FE	Yes	Yes	Yes	Yes
Observations	45721	26201	43429	26117
Adjusted R^2	0.8215	0.8407	0.8257	0.8406

Table 4 presents the coefficient estimates for testing the MM-Theorem. Columns one and two show the estimates of equation (12) for the standard MM without and with bank controls. The regressions in columns three and four represent the estimates resulting from equations (14) for the adjusted MM without and with controlling for lagged bank characteristics. The analyst forecast bias (FBIAS) and the assumed long-term growth rate (LT Growth) are included as ICC control variables. Bank controls include the natural logarithm of total assets, loans over total assets, loan loss reserves over total loans, liquidity and book-to-market ratio. Standard errors are clustered at the bank level. *, **, and *** indicate statistical significance at the 10%, 5%, and 1%. level respectively.

These findings are in line with hypothesis **H2** and are consistent with the idea that equity investors might care less about government guaranteed deposits than debt. While the coefficient on debt leverage (which is probably much closer to debt in other industries) is still smaller than those for firms in other financial or non-financial sectors, it is now twice as large as the coefficient on overall leverage displayed in columns (1) an (2). Using the estimates from column (3) in a similar exercise as before, but now accounting for debt and deposits, the coefficient implies that the cost of equity decreases by 59.4bps and 20.1bps in equity is exchanged for debt and deposits, respectively. In terms of funding costs (after-tax), decreasing debt would lead to an increase of 22.5bps (32.1bps), equaling a relative increase in WACC of 5.2% (9.9%), while decreasing deposits yields an increase of 28.7bps (38.3bps), equaling a relative increase in WACC of 6.6% (11.9%). The MM offset for deposits amounts to 10.3%, while the offset amounts to 29.69% for debt.

In summary, it appears to be the case that an increase in the required return on equity correlates with an increase in a bank's debt leverage while the relation with deposit leverage is not statistically significantly. However, the adjustment in IRP is still not as large as for non-banks which might be due to the joint effect of implicit and explicit government guarantees, which does not only affect how deposit leverage is perceived but also how debt leverage is perceived. In order to further disentangle this idea, I will further dissect the banking sector in the following.

Implicit versus Explicit Government Guarantees

The previously performed analysis pooled all banks into one regression to estimate the impact of leverage on IRP. However, an often mentioned criticism about regulation is the "one-size fits all" approach. In addition, the previously stated argument regarding government guarantees might be more suitable to large banks (TBTFl) than to small ones, as the later are less likely to be bailed-out. Accordingly, equity investors of smaller banks might care more about leverage, specifically debt leverage, compared to equity investors of very large banks as lined out in hypothesis **H3a**.

In order to shed some light on the question whether the cost of capital of banks of different sizes might be affected differently, I sort banks into for size buckets based on their average size throughout the sample period. I distinguish between small (< 4USDbn in total assets), medium (4 to 25USDbn), large(25 to 100USDbn) and very large (> 100USDbn) banks. Table 5 reports the result from an panel regression (similar to column (4) of Table 4) for each size-bucket separately.[35]

The results indicate an almost linear increase in the coefficient of debt leverage from very large, where the coefficient is also statistically insignificant, to small banks, reaching coefficients of 13.8bps and 15.4bps for the smallest and second smallest group of banks, which statistically

[35] I did not perform quartile sorts with respect to the size buckets because these would yield "too similar" size buckets due to the distribution of bank total assets.

significant at the 5% and 1% level. Interestingly, the coefficient for the two smallest groups of banks are now of similar size as the coefficients obtained in the non-financial sector. Deposit leverage is statistically insignificant among all four size-buckets. For very large banks neither deposit nor debt leverage seems to impact IRP significantly, which is in line with **H3a** and the notion of explicit and implicit government guarantees distorting the relation between leverage and required returns. For the changes in WACC (after-tax) this means that smallest banks experience an increase of 18bps (28bps) while very large banks are subject to an increase of 30bps (40bps). The changes translate into a relative increase in WACC of 4.2% (8.6%) and 7.0% (12.4%), for small and large banks, respectively. The corresponding MM offsets are 43.1% and 5.6%.

Table 5: Bank Size Buckets, ICC and Leverage

	(1)	(2)	(3)	(4)
	SIZE $<$ 4bn	4bn $<$ SIZE $<$ 25bn	25bn $<$ SIZE $<$ 100bn	SIZE $>$ 100bn
Total Deposits / Equity	1.7775	1.0515	8.9078	5.5485
	(3.0937)	(3.2784)	(6.3962)	(5.1447)
Total Debt / Equity	13.7861**	15.3627***	2.4310	1.8098
	(5.8531)	(5.0000)	(9.7977)	(6.9728)
ICC Controls	Yes	Yes	Yes	Yes
Bank Controls	Yes	Yes	Yes	Yes
Bank FE	Yes	Yes	Yes	Yes
Country-Time FE	Yes	Yes	Yes	Yes
Observations	14080	7330	3103	1860
Adjusted R^2	0.7887	0.8701	0.8995	0.8743

Table 5 resents the coefficient estimates for testing the adjusted MM-Theorem including deposits as specified in equation (14). All banks are sorted into four size buckets based on their average size throughout the sample period. The analyst forecast bias (FBIAS) and the assumed long-term growth rate (LT Growth) are included as ICC control variables. Bank controls include the natural logarithm of total assets, loans over total assets, book-to-market ratio, liquidity and loan loss reserves over total loans. Standard errors are clustered at the bank level. *, **, and *** indicate statistical significance at the 10%, 5%, and 1%. level respectively.

Under similar reasoning one might expect that banks that rely more on deposit financing are also more likely to be rescued by their local government in case of severe financial distress. As formulated in hypothesis **H3b** this implies that equity holders of banks with a large fraction of deposits relative to total assets might be less sensitive to changes in leverage, i.e. adjust their expected return on equity less if debt leverage increases. As banks have less deposits, equity investors should "start" caring more about changes in debt leverage. To test this hypothesis, I perform quartile sorts based on the average fraction of deposits over total assets a bank has throughout the sample period.

Table 6: Bank Deposit Buckets, ICC and Leverage

	(1) DEP < p25	(2) p25 < DEP < p50	(3) p50 < DEP < p75	(4) DEP > p75
Total Deposits / Equity	4.8398	-0.0160	4.8580	0.5767
	(3.3697)	(4.7258)	(3.7004)	(3.6209)
Total Debt / Equity	19.7170***	22.7744***	4.4861	0.9585
	(4.2688)	(7.7503)	(7.1909)	(12.5360)
ICC Controls	Yes	Yes	Yes	Yes
Bank Controls	Yes	Yes	Yes	Yes
Bank FE	Yes	Yes	Yes	Yes
Country-Time FE	Yes	Yes	Yes	Yes
Observations	6577	6338	6670	6650
Adjusted R^2	0.8532	0.7883	0.8378	0.8553

Table 6 presents the coefficient estimates for testing the adjusted MM-Theorem including deposits as specified in equation (14). All banks are sorted into four buckets based on their average fraction of deposits over total assets throughout the sample period. The analyst forecast bias (FBIAS) and the assumed long-term growth rate (LT Growth) are included as ICC control variables. Bank controls include the natural logarithm of total assets, loans over total assets, book-to-market ratio, liquidity and loan loss reserves over total loans. Standard errors are clustered at the bank level. *, **, and *** indicate statistical significance at the 10%, 5%, and 1%. level respectively.

The results in Table 6 show that the coefficient on deposit leverage is again statistically insignificant among all four buckets. However, the coefficient on debt leverage is only statistically insignificant for the two buckets with the highest fraction of deposit financing, which is in line with **H3b**. The higher fraction of deposits to total assets might cause equity investors of these banks to presume a higher bailout probability, leading them to be less sensitive to changes in debt leverage. With respect to the two groups of banks with the smallest fractions of deposit financing, the estimated coefficients amount to 19.7bps and 22.8bps for the smallest and second smallest deposit bucket. Comparing banks in the buckets with the smallest and largest fraction of deposits (columns (1) and (4), the change in WACC (after-tax) amounts to 12.1bps (21.9bps) and 31.0bps (40.6bps). The changes translate into a relative increase in WACC of 2.8% (6.8%) and 7.2% (12.6%), for low and high deposit banks, respectively. The corresponding MM offsets are 61.6% and 3.1%. One concern of this analysis might be than high and low deposit banks have significantly different business models and the identified effect is due to this differences. In order to mitigate this concern I again control for a variety of bank control variables. In addition, the banks in the deposits buckets are not the same ones as in the size buckets as the mean (median) total assets among the four buckets are 55.3 (38.1), 19.3 (6.8) , 18.1 (3.9) and 17.7 (3.1) (all in USDbn) from column (1) to (4), i.e. in ascending order of the fraction of deposits over total assets.

What can we now conclude for the applicability of the MM-Theorem in the banking sector? Miller (1995) answered this question in a brief paper and stated that some will suggest

"*[...]that the M&M Propositions really don't apply to banking. But, of course, taken literally, they would not apply anywhere else either. Much of the research focus in finance in the last 30 years has been precisely on those departures from the strict M&M assumptions[...]*".

Thinking back to the very first analysis in this paper, this is exactly what I found. Due to several distortions, the MM Theorem does not hold for banks but neither does it hold in any other sector. The underlying mechanism whereby investors change their expected return on equity in response to changes in leverage does existing but as expected, is not sufficiently to keep any firm's WACC constant. Consequently, it is the degree of applicability across different sectors that is of major interest and which is depending on the present frictions. Those frictions unique to the banking sector, i.e. the preferential treatment of deposits and the existence of government guarantees, add to the frictions present in all sectors. The presented results indicate that these frictions contribute to a lower applicability of the MM Theorem in the banking sector as compared to other industries, whereby forced changes to a bank's capital structure inflict stronger changes in WACC as for similar changes for other firms. However, this is not true for all banks as distortions such as implicit government guarantees do not have the same weight across all banks. My findings indicate that the degree of applicability for small banks and banks less financed with deposits is very well on the same level as the degree in other sectors. However, for very large banks and banks mainly financed with deposits, there is little evidence to support the applicability of the MM Theorem and consequently, these banks are those who might face the strongest increase in WACC if they were to unwillingly change their capital structure.

One caveat of the previously performed analysis is that I have to make the implicit underlying assumption that other bank variables that impact the required return on equity are either included in the regression or do not change. For example, it could well be that at the same time as bank leverage increases there is a simultaneous increase in asset risk which is not (completely) captured by the control variables and several fixed effects. In this case, the effect of leverage on banks' required return on equity would be upwards biased. Nevertheless, it is import to take banks' behavior into account when they are forced to change their funding structure as changes to their cost of capital might be only part of the story. In order to gain further insights into the effect increased capital requirements, the following subsection entails the setting of a quasi-natural experiment in order to estimate the joint effect of the changes in bank behavior, due to increased capital requirements, on the required return on equity.

5 The 2011 EBA Capital Exercise

5.1 Institutional Background

The EBA capital exercise was announced on October 26, 2011 with the goal of restoring the confidence in the EU banking sector by ensuring that banks are sufficiently capitalized. More specifically, banks were asked to build up an exceptional and temporary capital buffer against sovereign debt exposures to reflect market prices as at the end of September. At the time of the announcement European banks had just been subject to the mid-2011 EBA stress test, which eight banks failed after accounting for the capital-raising actions (EBA (2011e)), whereby the timing and the magnitude of this increase in capital requirements was unexpected.[36] The exercise did not coincide with other changes to capital requirements for European banks, in particular changes due to Basel III, which only became effective as of January 1, 2013.[37]. Moreover, the EBA assured compliance by stating that "*[i]n accordance with Article 16(3) of the EBA Regulation, competent authorities must make every effort to comply with the Recommendation*" (EBA (2011d)).

In line with the exercise, the EBA required 71 banks (from 19 EU-countries) to reach a 9%

[36] See, for example, Financial Times (2011): "Europe's banks face 9% capital rule" by Jenkins, P. and Spiegel, P., October 11, 2011.

[37] The revised capital requirements under Basel III piecewise introduced under the transitional agreement, starting on January 1, 2013 and becoming fully effective as of January 1, 2018.

core tier-1 ratio by the end of June 2012 (EBA (2011b)) up from the previously required 5%.[38] The scope was similar to the previously conducted EU-wide stress test, which was designed to include at least 50% of each EU member state's national banking sector in terms of consolidated total assets as of end of 2010 (EBA (2011c)). In each country, banks were selected in descending order of their total assets until at least half of the countries banking sector (in terms of total assets) was included. Banks subject to the capital exercise were required to submit their capital plans, outlining how they intend to meet the new requirements, to their national supervisors before the end of year 2011. In order to achieve the newly set target ratio, the EBA recommended that banks should increase their capital base, by, for example, retained earnings or reduced bonus payments, rather than meeting the requirements by shrinking assets (EBA (2011b)). However, since the EBA did not provide any specific information how they would enforce this recommendation, the EBA left discretion to the banks in terms of how to meet the new requirements.

Due to the country-specific selection mechanism of the EBA, the capital exercise exemplifies an ideal laboratory for investigating the impact of heightened capital requirements on specific group of banks, while there was no change for others.

5.2 Data & Methodology

The setup of the 2011 EBA capital exercise naturally lends itself to a difference-in-differences research design as for some banks the EBA imposed higher capital requirements while at the same time leaving them unchanged for other European banks. The treatment, however, was not random as the EBA selected banks based on a specific rule based on bank size. As pointed out by Gropp et al. (2018) this would compromise any causal inference if large banks differ from small banks.

In order to cope with this potential selection problem I exploit the country-specific selection thresholds of the EBA whereby (i) banks are included in descending of their total assets such that (ii) at least 50% of total assets of the nation banking sector is covered. While the first criteria causes capital exercise banks to be larger than non-capital exercise banks on average, the second criteria leads to a considerable size overlap.[39] Similar to Gropp et al. (2018) I use this circumstance to

[38] For Greek banks no new benchmarks have been set in order not to conflict with the EU/IMF program.

[39] The smallest capital exercise bank was *Nova Kreditna banka Maribor* (Slovenia) with total assets of nearly 6 billion euro as of 2010 while the largest non-capital exercise bank was *Crédit Mutuel* (France) with about 591 billion euro in total assets.

combine the difference-in-difference framework with matching methodology of Abadie et al. (2002) to match capital exercise banks (treatment group) to similar non-capital exercise banks (control group).

While there is a considerable size overlap between the treatment and control group, substantial differences in the covariates could make regression methods sensitive to (minor) specification changes. This concern is addressed by the bias-corrected matching estimator developed by Abadie et al. (2002).[40] In order to capture differences between the size-matched in terms of capital structure, funding strategy, business model and profitability, I additionally match banks on bank characteristics as of 2010. These are total customer deposits to total assets, total net loans to total assets, return on average assets, core tier-1 ratio and net interest income to total operating revenue as in Gropp et al. (2018). The difference in banks' cost of capital is computed by calculated the difference between the pre-treatment period, ranging from 2010Q3 to 2011Q2, and the post-treatment period, ranging from 2012Q3 to 2013Q2, leaving out the adjustment period.

In order to create the capital exercise sample, I start with all European banks for which I/B/E/S analysts forecasts are available, which are necessary for computing a banks implied cost of capital. These banks are all located in countries subject to the capital exercise plus Greece and Switzerland. Next, I drop those banks which do not have sufficient IRP observations in the pre- and/or post-treatement period leaving me with 113 banks (31 capital exercise banks and 82 non-capital exercise banks). Subsequently, I drop banks which are not at the highest consolidation level as well as banks that were undergoing restructuring as pointed out by Gropp et al. (2018).[41] This procedure results in a final sample consisting of 31 capital exercise banks and 58 control group banks.

Figure 3 display the distribution of all remaining banks from countries there where subject to the EBA capital exercise, plus Switzerland and Greece. On average, capital exercise banks are significantly larger than banks that were not included in the exercise. This might raise the concern that treated and untreated bank differ also with respect to other aspects than size. In fact, when comparing the two groups of banks unfiltered, capital exercise banks have significantly lower ratios

[40] Subsequent to the matching based on covariates, some of the remaining bias is removed through regression on a subset of continuous covariates.

[41] The banks excluded due to ongoing restructuring are Dexia (Belgium), Osterreichische Volksbank AG (Austria), West LB Germany, EFG Eurobank Ergasias S.A., National Bank of Greece, Alpha Bank, Piraeus Bank Group, ATE bank, TT Hellenic Postbank S.A. (all Greece) and Bankia (Spain).

of deposits to total assets, of total loans to total assets and hold more liquid assets relative to total assets. In addition, they differ with respect to their equity ratio, non-performing loans to total loans (see (Table A.5.1 in the appendix for more details)).

Figure 3: Distribution of (listed) Banks' Total Assets by Country

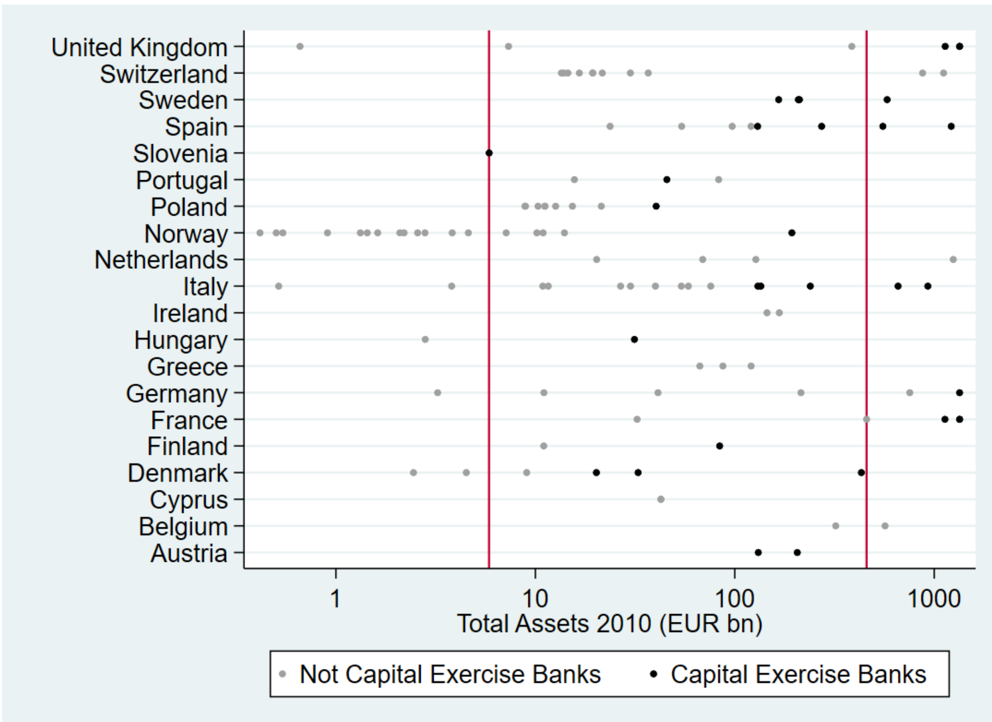

Figure 3 displays the distribution of total bank assets (as of end of 2010) of all listed banks from countries who where subject to the 2011 EBA Capital Exercise plus banks from Switzerland (not part of the capital exercise). Malta and Luxembourg were also part of the capital exercise but they either do not have listed banks or the computation of ICC was not possible in the desired time period.

In order to make the two groups more comparable and alleviate concerns that any effects might solely be attributable to the different characteristics of the two groups, I employ the overlap strategy of Gropp et al. (2018). Accordingly, I remove capital exercise banks larger than the largest non-capital exercise bank and eliminate non-capital exercise banks smaller than the smallest capital exercise banks.[42] The cutoff values are indicated by the two red lines in Figure 3.

[42]For determining the smallest / largest bank I do not include banks from Switzerland. However, even when the two large Swiss banks (UBS Group AG, Credit Suisse AG) are included, results stay qualitatively and quantitatively similar.

That reducing the full sample to the overlap sample is effective in making banks more comparable based on their observable characteristics is illustrated in Table 7. The table shows that after dropping banks outside the cutoff, the two groups become much more similar in terms of their observable characteristics.[43]

Table 7: Descriptive Statistics Overlap Sample

	Capital Exercise Banks	Control Group Banks	Difference in means	p-value
N =	*18*	*22*		
Total Assets (EURm)	131.1481	30.1207	101.0274***	0.0000
Total Deposits / Total Assets	0.4553	0.4877	-0.0324	0.4741
Total Net Loans / Total Assets	0.6480	0.6517	-0.0037	0.9613
Liquid Assets / Total Assets	0.2243	0.2067	0.0176	0.6843
Governemt Debt / Total Assets	0.0680	0.0854	-0.0174	0.4587
Securities / Total Assets	0.2000	0.2209	-0.0209	0.4438
Total Equity / Total Assets	0.0741	0.0801	-0.006	0.4831
Total Capital Ratio	0.1352	0.1286	0.0066	0.5910
Tier-1 Ratio	0.1127	0.1046	0.008	0.4803
Common Equity Tier-1 Ratio	0.1022	0.0964	0.0058	0.6285
RWA / Total Assets	0.5703	0.6171	-0.0468	0.4775
Cost-to-Income Ratio	0.5680	0.6202	-0.0522	0.2406
NPLs / Total Loans	0.0768	0.0587	0.0181	0.3178
Non-Interest Expense / Total Assets	0.0176	0.0216	-0.0039	0.2858
Market Risk	0.0708	0.0691	0.0017	0.7201
Return on Average Assets	0.0061	0.0065	-0.0004	0.7603

Table 7 displays several bank characteristics (quarterly) for capital exercise banks (18) and control group banks (22) included in the overlap sample as of 2010Q4 (i.e. prior to the capital exercise). Banks in the overlap sample are located in Austria, Denmark, Finland, France, Germany, Hungary, Italy, Netherlands, Norway, Poland, Portugal, Spain, Sweden, Switzerland (not part of the capital exercise but added as controls) and the United Kingdom. The p-value result from a t-test for a difference in means between the two groups, where *, **, and *** indicate statistical significance at the 10%, 5%, and 1%.

Compared to the full sample the only difference remaining statistically significant is total assets.

[43] The displayed bank characteristics deviate from those shown in the previous section due to data availability reasons. For the capital exercise quarterly data from SNL Financial (now: Market Intelligence) could be used. Unfortunately, their coverage only goes back until 2008. In order to not loose too many observations, the previous section uses more available variables from the other data sources.

Capital exercise banks are now only four-times larger than banks from the control compared to 15-times in the full sample. Removing the differences between the treatment and control groups makes me confident going forward with the analysis of how heightened capital requirements impact bank's cost of capital relative to banks who do not face an increase.

For robustness purposes, I also perform a standard difference in difference analysis in addition to the matching estimator of Abadie et al. (2002). I perform a regression of the following form

$$IRP_{i,t} = \alpha + \beta_1 \cdot \text{CE Bank} + \beta_2 \cdot \text{Post CE} + \delta \cdot \mathbf{Z}_{i,t-1} + \mu_i + \mu_t \cdot \mu_c + \epsilon_{i,t}, \tag{15}$$

where $IRP_{i,t}$ is the implied risk premium of bank i at time t, CE Bank is a dummy taking a value of one for capital exercise banks in the post-treatment period, $\delta\mathbf{Z}_{i,t-1}$ is a vector of lagged time-varying bank characteristics, μ_i and $\mu_t \cdot \mu_c$ are bank fixed effects and country times quarter fixed effects, respectively.

5.3 Results

As briefly outlined in the previous subsection, plausible exogenous variation in capital requirements is needed in order to make a statement about the impact of increased capital requirements on banks' cost of capital. The unexpected announcement of the 2011 EBA capital exercise together with specific bank selection rule represent such an environment. Comparing capital exercise banks (CE banks) to a group of control group banks from the same countries (plus Switzerland) that were not subject to the capital exercise allows for such a statement.

Table 8 presents the results for the Abadie et al. (2002) estimator (given by the average treatment effect on the treated (ATT)) for the difference between capital exercise and matched control group banks. First, column (1) to (3) establishes that capital exercise banks actually significantly increased their capital ratios relative to untreated banks. This holds true when using all available banks in Panel A as well as in the overlap sample in Panel B. For further illustration, Figure A.5.2 in the appendix shows the evolution of mean CET1 ratios relative to 2010 for capital exercise and control group banks. This result has already been established by Gropp et al. (2018) and is only restated here as my sample deviates from the one of the authors as I can only use listed banks. Interestingly, column (4) indicated that the overall equity ratio did not increase but even slightly decrease for CE banks. Jointly interpreted with columns (5) and (6) this hints at the fact that treated banks increased their capital ratios by decreasing (risk-weighted) assets instead of issuing new capital, which is line with Gropp et al. (2018).

Table 8: EBA Capital Exercise and Cost of Equity

	(1) Δ CET1 Ratio	(2) Δ Tier-1 Ratio	(3) Δ Total Capital Ratio	(4) Δ Equity Ratio	(5) Δ Log(RWA)	(6) Δ RWA/ TA	(7) ΔIRP
Panel A: Full Sample Matching							
Observations	31	31	31	31	31	31	31
CE Banks	0.0213	0.0187	0.0157	-0.0031	-0.0882	-0.0621	0.0036
Control Banks	0.0095	0.0110	0.0087	0.0015	0.0538	-0.0278	0.01538
Estimator (ATT)	0.0019	0.0098***	0.0118***	-0.0022	-0.2022***	-0.0213***	-0.0328***
Panel B: Overlap Sample Matching							
Observations	22	22	22	22	22	22	22
CE Banks	0.0250	0.0217	0.0179	-0.0033	-0.0811	-0.0736	0.0081
Control Banks	0.1322	0.1204	0.0121	0.0008	0.0430	-0.0296	0.0182
Estimator (ATT)	0.0080**	0.0107***	0.0134***	-0.0072**	-0.1939***	-0.0431***	-0.0248***

Table 8 presents the Abadie et al. (2002) estimates of changes, as given by the ATT, in capital ratios, risk-weighted assets and IRP surrounding the 2011 EBA capital exercise for treated and control group banks. The pre-treatment period covers the four quarters prior to the capital exercise (2010Q3 to 2011Q2), while the post-treatment period covers the four quarters subsequent to the end of the capital exercise (2012Q3 to 2013Q2). The lines titled "CE Banks" (analogously "Control Banks") represent the average change in the outcome variable before and after the capital exercise. Banks are matched based on pre-treatment levels (2010Q4) of total assets, common equity tier-1 ratio, deposits over total assets, net loans over total assets, net income over operating revenue, return on average assets and the assumed long-term growth rate. *, **, and *** indicate statistical significance at the 10%, 5%, and 1%. level respectively.

The impact of the capital exercise on banks' IRP is presented in column (7). In the full sample, capital exercise banks have a 3.28% lower change IRP compared to their matched control group. This difference is economically and statistically significant. In the overlap sample the change in IRP is 2.48% lower. In combination, these findings indicate that bank equity investors lower their required returns not because banks finance themselves with more equity but because banks reduce asset risk whereby they increase their regulatory capital ratios. Of course, if banks shifted from risky assets into government debt, which carries a zero risk-weight, the decrease in asset risk is only present on paper or at least overstated. Nevertheless, investors appear to perceive CE banks as less risky due to their actions, which they actually are from a regulatory point of view, and lower their required return accordingly. In unreported results I find that a one percentage point increase in tier-1 ratio is associated with a decrease of almost 20bps decrease in required returns, which might explain a part of the observed decrease in IRP.[44] One additional factor that might play into the size of the estimated change in required returns is an increase in the value of the implicit government guarantee. Investors might believe that due to the inclusion into the capital exercise, the government might consider the bank to be of specific importance, which could increases the probability of a future bailout and consequently lowers the required return. In light of the sovereign debt crisis, this effect might be much more pronounced than in "regular" times. However, there are also very large banks in the control group which would potentially benefit from the same increase in value of the implicit guarantee. In unreported findings I try to control for the exposure towards sovereign debt by including the share of government debt over total assets as a matching variable, which does not alter the results.[45].

For further robustness in terms of methodology, Table 9 reports the results from a standard difference-in-difference framework as described in equation (15) of Section 3. In the full sample, the change in IRP amounts to a decrease of −1.7% and −1.2% when bank controls are included. For the overlap sample, capital exercise banks have a lower IRP of −1.9% and −2.8%, which are of similar size thant those estimated in Table 8.

Comparing the findings with those of Subsubection 4.2, it appears to be the case that banks do not react to increased capital requirements by decrease leverage but by changing their asset composition in order to comply with regulatory capital ratios. While this was not the primary intention of the EBA capital exercise as retaining earnings and issuing new equity was preferred to selling assets, it achieved the goal of making banks safer, at least in the understanding of regulatory capital ratios. This makes the second part of my analysis of particular importance, as judging the impact of increased requirements based on the general relationship between leverage and the cost of equity does not take into account how banks react. While it is reasonable to state that on

[44] This estimates is obtained from a similar analysis as in Subsubection 4.2 for banks larger than USDbn 100.

[45] Using government debt over total assets is an imperfect measure as the exposure with respect to countries like Greece, Ireland, Italy, Portugal and Spain were the main drivers of stress (Popov and Van Horen (2014)) but it should provide some more robustness especially in light of the home bias

average better capitalized banks enjoy a lower risk premium, the large sample analysis does not allow to isolate the change in WACC due to a change in requirements. The EBA capital exercise is much more suitable for this kind of task as it allows to estimate the joint impact of higher capital requirements and banks response to said requirements on bank equity investors IRP and subsequently bank's WACC.

Table 9: Difference-in-Difference

	(1) Full Sample	(2) Full Sample	(3) Overlap Sample	(4) Overlap Sample
CE Bank x Post CE	-0.0174**	-0.0127**	-0.0195**	-0.0283***
	(0.0072)	(0.0062)	(0.0081)	(0.0075)
ICC Controls	Yes	Yes	Yes	Yes
Bank Controls	Yes	No	No	Yes
Bank FE	Yes	Yes	Yes	Yes
Country-Time FE	Yes	Yes	Yes	Yes
Observations	551	676	427	342
Adjusted R^2	0.8477	0.8520	0.8873	0.8891

Table 9 presents the coefficient estimate for the treatment variable (banks subject to the capital exercise in the post capital exercise period) as specified in equation (15). The pre-treatment period covers the four quarters prior to the capital exercise (2010Q3 to 2011Q2), while the post-treatment period covers the four quarters subsequent to the end of the capital exercise (2012Q3 to 2013Q2). The dummy variables for being a capital exercise bank (*CE Bank*) and the post capital exercise period (*Post CE*) are dropped due to inclusion of bank as well as country. The analyst forecast bias (FBIAS) and the assumed long-term growth rate (LT Growth) are included as ICC control variables. Bank controls include the natural logarithm of total assets, deposits over total assets, loans over total assets, risk-weighted assets over total assets, total securities over total assets, total equity over total assets, government debt over total assets, total capital ratio, cost income ratio, non-performing loans over total loans, non-interest expense over total assets, return on average assets, liquid assets over total assets, market risk (difference between short-term assets and short-term debt divided by total assets) and net income over operating revenue. Standard errors (in parentheses) are clustered at the bank level. *, **, and *** indicate statistical significance at the 10%, 5%, and 1%. level respectively.

So what do the findings of the analysis of the 2011 EBA capital exercise imply for banks' WACC? As highlighted before, CE banks did not react to the higher requirements by increasing the share of equity financing on their balance sheets but rather adjust the composition of their assets in order to comply with the increased requirements. Thinking in terms of the initial idea of

Modigliani and Miller (1958), asset returns are divided among equity and debt holders. How much each investor receives depends on the capital structure for the firm but does not alter to overall amount that is distributed. Relating this to the change in bank behavior induced by the capital exercise, the distributable amount is altered as banks shift to less risky assets (assuming that risk-weighted assets are a reliable measure for asset risk, which is of course debatable). Moving to less risky assets should lead to a less dispersed distribution of future equity values causing a decrease the required return of equity investors. Taking the back-of-the-envelope calculation used in the previous section, the average bank faced a return on assets of 4.32%, with a required return on equity of 8% $[0.08 \cdot (3\% + 5\%) + 0.92 \cdot (3\% + 1\%)]$. Given the estimate in column (7) of Table 8, the return on equity decreases to 5.52%, leading to an implied decreases in the return on assets of 20bps to 4.12% $[0.08 \cdot 5.52\% + 0.92 \cdot 4\%)]$. This indicates that the increased capital requirements actually caused banks WACC to decrease but not due to any changes in the composition of their capital structure but by causing a shift in asset risk.

One important remark with respect to the previously presented findings is that one has to keep in mind that CE banks had to comply with the increased capital requirements within a relatively short period of time, which might make asset sales the preferred option for compliance.[46] The change in WACC is then predominantly caused by shifts in bank asset portfolios towards less (regulatory) risky assets and not changes in capital structure.[47] However, in the long run banks might as well adjust their capital structure to comply with increased capital requirements, for example to regain the same level of asset risk as before. This then brings back the discussion about the validity of the MM Theorem for banks as analyzed in Subsubection 4.2.

6 Concluding Remarks

I investigate the impact of heightened capital requirements on banks' cost of capital. Using a large scale international sample I test the applicability of the MM Theorem for the banking sector and find mixed evidence. Compared to other sectors, bank equity investors seem to care less about

[46]Another explanation for the preference of asset sales as compared to issuing new equity is provided by the "leverage ratchet effect" of Admati et al. (2018).

[47]As already mentioned, on additional effect might have been an increase in the value of implicit government guarantees which would further reduce impact on leverage on bank equity investors' require return, i.e. the same amount of leverage might be perceived less risky.

changes in leverage due to the benefit of lower funding costs and the presence of implicit and explicit government guarantees. When analyzing the banking sector more closely, two things emerge. First, investors' required return on equity is less sensitive to changes in deposit leverage than in debt leverage as deposits funding is cheaper and benefits from a explicit government guarantee. Second, the benefit of implicit government guarantees (e.g. TBTF) is unevenly distributed in the banking sector. While a larger fraction of the increase in WACC due to reliance on relative more expensive equity is offset by reduced required returns for small banks and banks that rely only little on deposit financing, there is only moderate evidence for a similar mechanism for very large banks and banks relying heavily on deposit financing. This hints at the fact that market frictions like the underpricing of deposits, deposit insurance as well as implicit government guarantees might distort the MM Theorem applicability more for large and/or high deposits banks as compared to small and/or low deposit banks.

Furthermore, I exploit the EBA capital exercise as a quasi-natural experiment to examine the impact of heightened capital requirements on bank investors' required returns. Applying the matching strategies suggested by Gropp et al. (2018), I find that banks which were subject to the increased requirements reduced their implied risk premium on average about 2.8% relative to untreated banks. One of the advantages of using the capital exercise is that it takes into account how banks change their behavior after an increase in capital requirements, which is not considered when analyzing large sample correlations between leverage and cost of capital estimates. However, it is important to take banks' reaction into account as the reaction and the increased capital jointly determine banks' funding costs. The result from the EBA capital exercise indicates that banks that banks' WACC actually decreased as banks shifted to less risky assets to comply with the higher capital ratios instead of raising more equity so that their capital structure remained unchanged. While selling (risky) assets might be the preferred method for compliance in the short-run, in the long-run banks' might consider raising relatively more equity capital, which would lead to moderate increases in banks' WACC as outlined in the first paper of this paper.

There are two insight for policy makers. First, if capital requirements actually demand a decrease in leverage, the impact on banks' funding costs appear to be moderate, especially if the decrease in leverage is achieved by reducing debt instead of deposits. Second, it is of great importance to consider the joint actions taken by banks when setting capital requirements. As shown by Gropp et al. (2018) and collaborated by this research, banks might not comply by increasing their equity base via issuance of new equity but rather by shrinking and shifting assets. These changes in bank behavior should be carefully assessed when comparing the associated social costs and benefits of higher capital standards.

However, the provided evidence only represents a short-term impact and the long-run consequence are yet to analyze, especially as Basel III will not become fully effective before 2019.

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Appendices

A.1 ICC Estimation Methods

A.1.1 ICC Estimation based on Gebhardt et al. (2001)

Gebhardt et al. (2001) use a *Residual Income Model* derived from the Dividend Discount Model

$$P_t = \sum_{k=1}^{\infty} \frac{\mathbb{E}_t[D_{t+k}]}{(1+r_e)^k}, \tag{16}$$

using clean surplus accounting (CSA). CSA requires that losses and gains affecting book value of equity are included in earnings whereby the change in book value is equal to

$$B_t = B_{t-1} + NI_t - DIV_t. \tag{17}$$

Solving for DIV_t and substituting into the Dividend Discount Model yields

$$P_t = B_t + \sum_{k=1}^{\infty} \frac{\mathbb{E}_t[NI_{t+k} - ICC \cdot B_{t+k-1}]}{(1+r_e)^k} = B_t + \sum_{k=1}^{\infty} \frac{\mathbb{E}_t[(ROE_{t+k} - r_e) \cdot B_{t+k-1}]}{(1+r_e)^k}. \tag{18}$$

For empirical implementation, a two-stage approach is undertaken whereby explicit earnings forecasts are used for the first three years after which the earnings are implicitly computed by assuming that the period ROE converges linearly to an 3-year rolling industry median $ROE^{Industry}$.[48]

$$FE_{t+k} = \frac{FE_{t+k-1}}{B_{t+k-1}} + \left(\frac{t+k-3}{9}\right) \cdot \left(ROE^{Industry}_{t+k-1} - \frac{FE_{t+k-1}}{B_{t+k-1}}\right) \cdot B_{t+k-1}. \tag{19}$$

After period $T = 12$ any earnings growth is assumed to be value neutral, leading to the following representation

$$P_t = B_t + \sum_{k=1}^{3} \frac{FE_{t+k} - r_e \cdot B_{t+k-1}}{(1+r_e)^k} + \sum_{k=4}^{12} \frac{FE_{t+k} - r_e \cdot B_{t+k-1}}{(1+r_e)^k} + \frac{FE_{13} - r_e \cdot B_{12}}{r_e \cdot (1+r_e)^{12}}, \tag{20}$$

[48] Industry classificaiton is done using SIC codes and the industries as definded by Campbell (1996).

which is then estimated minimizing the squared difference between the right-hand side and left-hand side of the equation.

A.1.2 ICC Estimation based on Claus and Thomas (2001)

Claus and Thomas (2001) similarly use a *Residual Income Model* approach which relies on CSA. Their model deviates from the one by Gebhardt et al. (2001) as it consideres a time horizon T of only five years after which the residual income growth is assumed to be equal to the expected inflation, leading to the following representation

$$P_t = B_t + \sum_{k=1}^{5} \frac{FE_{t+k} - r_e \cdot B_{t+k-1}}{(1+r_e)^k} + \frac{(FE_6 - r_e \cdot B_5) \cdot (1+g^{inf})}{(r_e - g^{inf}) \cdot (1+r_e)^5}. \tag{21}$$

Earnings forecasts for year four and five are computed as $FE_{t+k} = FE_{t+k-1} \cdot (1+g)$ where g is the growth rate forecasted by the analyst. The model is then estimated minimizing the squared difference between the right-hand side and left-hand side of the equation.

A.1.3 ICC Estimation based on Easton (2004)

Easton (2004) derives the implied cost of equity capital from an *Abnormal Earnings Growth Model* using one- and two-year ahead earnings. Dividends are set equal to a constant fraction of earnings derived as the average dividend payout ratio over the past three years. The estimated model equals

$$P_t = \frac{FE_{t+2} + r_e \cdot DIV_{t+1} - FE_{t+1}}{r_e^2}. \tag{22}$$

The model assumes that the growth in abnormal earnings persists in perpetuity. Moreover, the model requires a positive change in forecasted earnings (including re-invested dividends) to yield a numerical solution which is again derived as minimizing the squared difference between the two sides of the equation.

A.1.4 ICC Estimation based on Ohlson and Juettner-Nauroth (2005)

Ohlson and Juettner-Nauroth (2005) also use an *Abnormal Earnings Growth Model*. Using one–year ahead earnings, dividends as well as short-term and long-term earnings growth they derive the implied cost of capital from the following valuation model

$$P_t = \left(\frac{FE_{t+1}}{r_e}\right) \cdot \frac{\left(g^{st} + r_e \cdot \frac{DIV_{t+1}}{FE_{t+1}} - g^{inf}\right)}{(r_e - g^{inf})}, \tag{23}$$

where the short-term abnormal earnings growth g^{st} is equal to the average between the growth forecasted by the analysts and $t+1$ to $t+2$ earnings growth. The long-term abnormal earnings growth is equal to the expected inflation. Dividends are set equal to a constant fraction of earnings derived as the average dividend payout ratio over the past three years. Moreover, the model requires a positive change in forecasted earnings to yield a numerical solution which is again derived as minimizing the squared difference between the two sides of the equation.

A.1.5 ICC Estimation based on Pástor et al. (2008)

ICC is the internal rate of return that is implied by equating the price on the left hand side to the valuation formula on the right hand side

$$P_t = \sum_{s=1}^{T} \frac{FE_{t+s}(1 - PB_{t+s})}{(1+r_e)^s} + \frac{FE_{t+T+1}}{r_e(1+r_e)^T}. \tag{24}$$

The right hand side will be divided into three parts: (i) concrete forecasts ($t = 1, 2, 3$), (ii) computed forecasts ($t = 4, .., 15$) and (iii) terminal value

$$P_t = \sum_{s=1}^{3} \frac{FE_{t+s}(1 - PB_{t+s})}{(1+r_e)^s} + \sum_{s=4}^{15} \frac{FE_{t+s}(1 - PB_{t+s})}{(1+r_e)^s} + \frac{FE_{t+16}}{r_e(1+r_e)^{15}}. \tag{25}$$

The computed earnings forecasts (FE_{t+s}), the growth rate of earnings (g_{t+s}) and the plowback rate (PB_{t+s}) are derived in the following manner

$$FE_{t+s} = FE_{t+s-1}(1 + g_{t+s}) \tag{26}$$

$$g_{t+s} = g_{t+s-1} exp\left(\frac{\log\left(g/g_{t+3}\right)}{T-1}\right) \tag{27}$$

$$PB_{t+s} = PB_{t+s-1} - \frac{PB_{t+2} - PB}{T-1}. \tag{28}$$

Furthermore, it is assumed that the current plowback rate affects subsequent earnings growth, i.e. $g = ROI \times PB$. If one now assumes that the cost of capital is driven to ROI, it can be substituted into the former equation and we have an expression for the steady-state plowback rate (PB)

$$PB = \frac{g}{r_e} \tag{29}$$

Hence, in order to compute the ICC for a firm at a specific day one needs to solve (2) under the conditions (3),(4),(5) and (6). Since solving equation (2) with the given constraints does usually not yield a closed-form solution, one needs to minimize the squared difference and set a value (e.g. 10^{-8}) for the allowed difference

$$\min\left[\left(p_t - \left(\sum_{s=1}^{3}\frac{FE_{t+s}(1-b_{t+s})}{(1+r_e)^s} + \sum_{s=4}^{15}\frac{FE_{t+s}(1-b_{t+s})}{(1+r_e)^s} + \frac{FE_{t+16}}{r_e(1+r_e)^{15}}\right)\right)^2\right]. \tag{30}$$

A.2 Variable Definitions

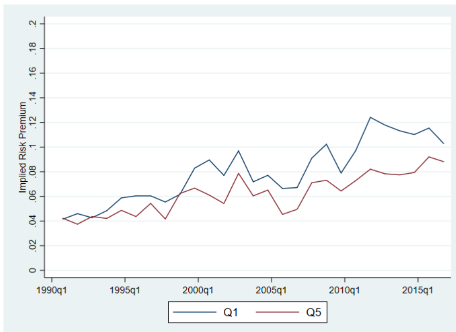
Table A.2.1: Variable Definitions

Name	Definition	Source
Cost of Equity	The Cost of equity is computed as the equally-weighted average of the five different ICC models (detailed derivation of all five models is provided in the appendix)	
Implied Risk Premium	Cost of equity minus the respective risk-free rate (10-year government bond yields; U.S. for North America, Germany for Europe and Middle East/Africa, Japan for Asia)	
Long-term Growth Rate (LT Growth)	The 5-year earnings forcast as provided by I/B/E/S. If the variable is missing, it is inferred from given earnings forecasts (FE) as FE(2-year ahead) / FE (1-year ahed) - 1. If the 2-year ahead forecasts is missing the growth is inferred from the 1-year ahead foreacst and the most recent actual earnings. Growth rates below 0.02 or above 1 are set to the respective boundries.	Own Computation
Analystr Forecast Bias (FBIAS)	FBIAS is calcualted as the difference between the foreacsted earnings of a certain year and the actual earnings of the same year divided by lagged total assets.	
Total Assets (USDbn)	Total Assets	
Equity Ratio	Book value of equity over total assets	
Total Deposits / Total Assets	Total Deposits over total assets	
Total Net Loans / Total Assets	Total net loans over total assets	
Commercial Loans / Total Assets	Commercial loans over total assets	
Consumer Loans / Total Assets	Consumer loans over total assets	
Loan Loss Provisions / Total Loans	Loan Loss Provisions over total net loans	
Loan Loss Reserves / Total Loans	Loan Loss Reserves over total net loans	
Tier-1 Ratio	Tier-1 Capital over total risk-weighted assets	Bureau van Dijk's Bankscope,
Total Capital Ratio	Total capital over total risk-weighted assets	S&P Market Intelligence,
Leverage	Total liabilities over total (book value of) equity	Compustat Global & North America,
Total Debt / Total Equity	Total debt over total equity	FR Y-9C Reports (Federal Reserve Bank,
Total Deposits / Total Equity	Total deposits over total equity	I/B/E/S
RWA / Total Assets	Risk-weighted assets over total assets	
Std.Dev. of ROA	Standard deviation of Return on Assets over 12 (at least 5) quarters	
Liquidity	Cash and bank balances plus available for sale securities over total liabilities minus total equity	
ROA	Return on assets (quarterly)	
ROE	Return on equity (quarterly)	
Dividend Payout Ratio	Paid dividends over net income	
Book-to-Market	Book value of equity over market value of equity	
CAPM Beta	CAPM Betas (rolling 250-day basis)	CRSP,
FF3 Beta	Fama & Frech 3-Factor Betas (rolling 250-day basis)	Thomosn Reutres Eikon

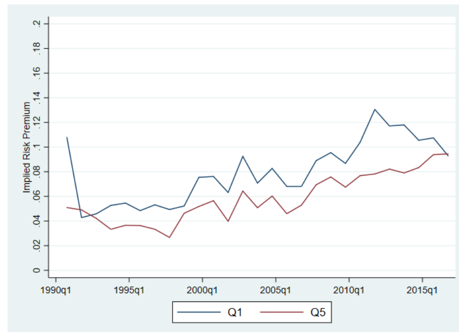
A.3 Testing the M&M Theorem

A.3.1 IRP Quintile-Sorts based on Bank Characteristics

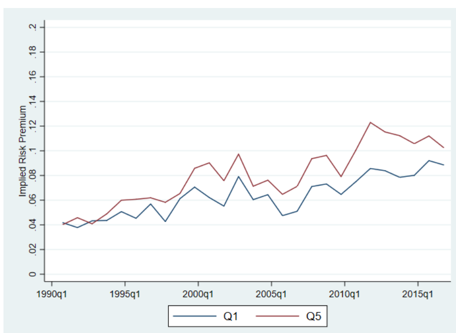
Figure A.3.1: IRP Quintile-Sorts



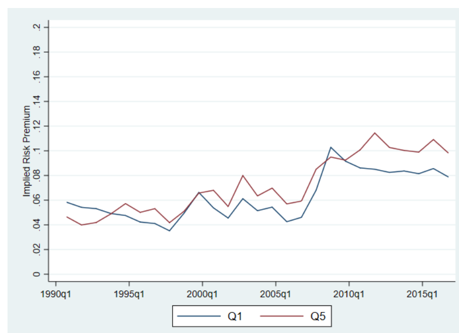
(a) Equity Ratio



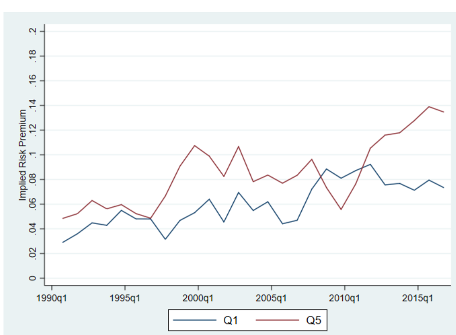
(b) Tier-1 Ratio



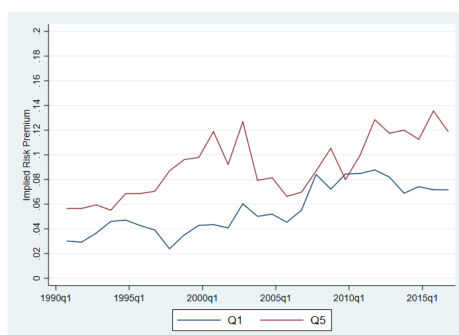
(c) Leverage



(d) Total Assets



(e) Loan Loss Provisions



(f) Market-to-Book

A.3.2 Cost of Equity by (broad) Sectors

Figure A.3.2: Cost of Equity (IRP) for different Sectors over Time

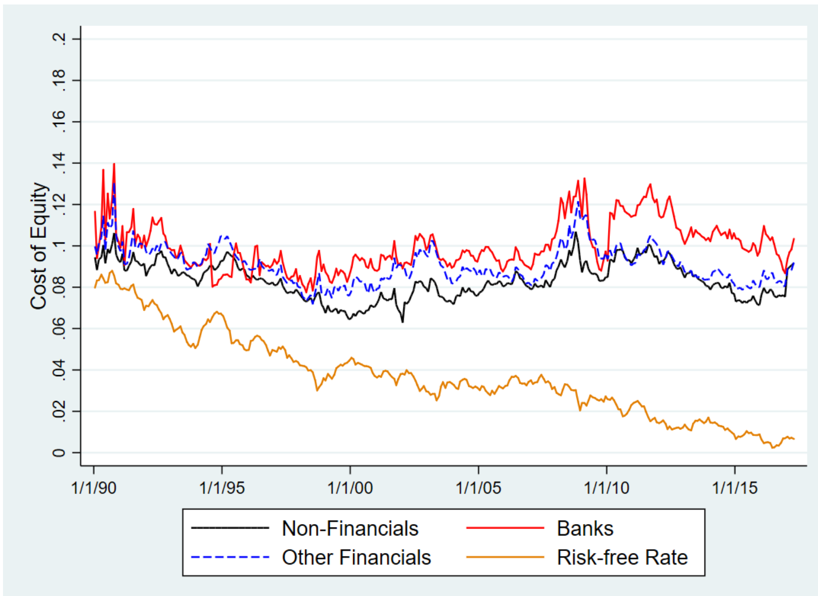


Figure A.3.2 (a) depicts the cost of equity for non-financial firms, banks and all other financial firms over time.

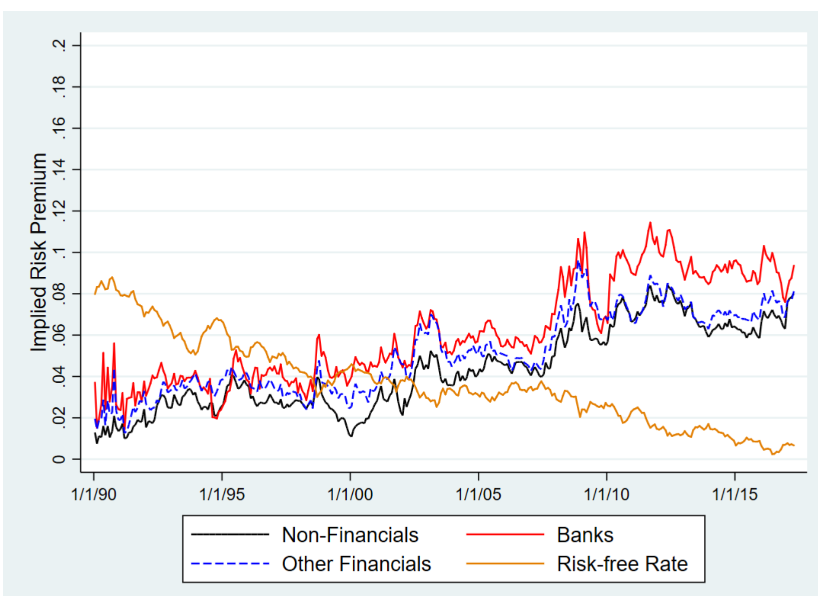


Figure A.3.2 (b) depicts the implied risk premium for non-financial firms, banks and all other financial firms over time.

A.4 Robustness Test using Market Leverage

Table A.4.1: Bank's Implied Risk Premium and Market Leverage

	(1) MM	(2) MM	(3) MM (Dep adj.)	(4) MM (Dep adj.)
Debt / MV Equity	5.1435***	3.1205**		
	(0.7697)	(1.5517)		
Total Deposits / MV Equity			3.4470***	-0.6678
			(1.0120)	(1.7752)
Total Debt / MV Equity			9.3733***	12.8406***
			(2.2626)	(3.5219)
ln(Total Assets)		58.4223***		54.8891***
		(10.0796)		(9.9935)
Total Loans / Total Assets		-58.9707		-53.4128
		(36.0771)		(35.7776)
Loan Loss Reserves / Total Loans		-1939.6670***		-1999.5006***
		(599.0328)		(611.1818)
Liquidity		-112.4479***		-118.5203***
		(39.9994)		(40.4151)
Book-to-Market		3.8072		18.6786
		(19.3879)		(19.6768)
ICC Controls	Yes	Yes	Yes	Yes
Bank FE	Yes	Yes	Yes	Yes
Country-Time FE	Yes	Yes	Yes	Yes
Observations	43530	26201	41811	26117
Adjusted R^2	0.8270	0.8407	0.8303	0.8413

Table A.4.1 presents the coefficient estimates for testing the MM-Theorem using market leverage defined as book value of debt over market value of equity. Columns one and two show the estimates of equation (12) for the standard MM without and with bank controls. The regressions in columns three and four represent the estimates resulting from equations (14) for the adjusted MM without and with controlling for lagged bank characteristics. The analyst forecast bias (FBIAS) and the assumed long-term growth rate (LT Growth) are included as ICC control variables. Bank controls include the natural logarithm of total assets, loans over total assets, loan loss reserves over total loans, liquidity and book-to-market ratio. Standard errors are clustered at the bank level. *, **, and *** indicate statistical significance at the 10%, 5%, and 1%. level respectively.

A.5 EBA Capital Exercise - Additional Statistics

A.5.1 Descriptive Statistics - Capital Exercise and Control Group Banks

Table A.5.1: Descriptive Statistics Full Sample

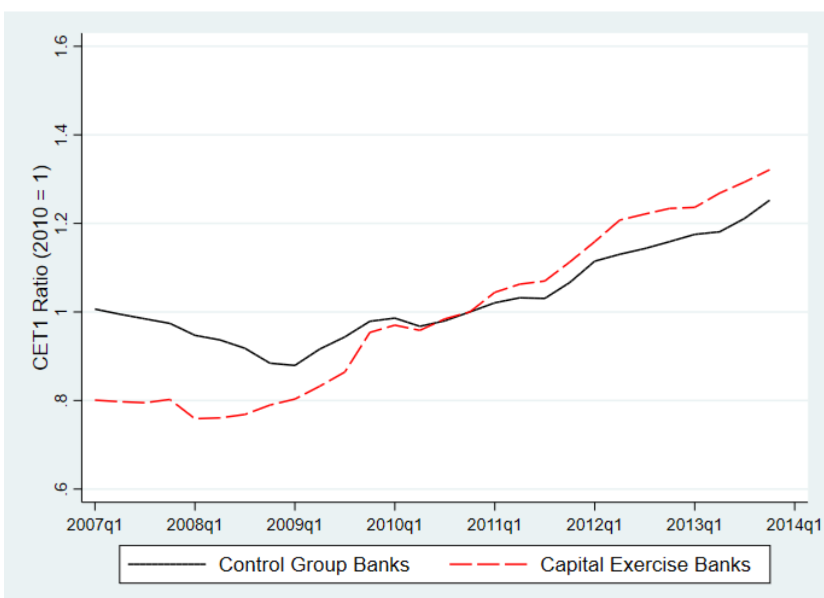
	Capital Exercise Banks	Control Group Banks	Difference	p-value
$N =$	*33*	*44*		
Total Assets (EURm)	491.5500	25.4945	466.0555***	0.0000
	210.8914	8.1042	202.7872	
Total Deposits / Total Assets	0.4135	0.5142	-0.1007***	0.0042
	0.3974	0.5129	-0.1155	
Total Net Loans / Total Assets	0.5601	0.6661	-0.106***	0.0091
	0.5757	0.7455	-0.1698	
Liquid Assets / Total Assets	0.3195	0.2150	0.1045***	0.0043
	0.2973	0.1636	0.1337	
Governemt Debt / Total Assets	0.0663	0.0670	-0.0007	0.9674
	0.0655	0.0466	0.0189	
Securities / Total Assets	0.2767	0.2056	0.0711**	0.0289
	0.2366	0.1497	0.0869	
Total Equity / Total Assets	0.0642	0.0801	-0.0159**	0.0144
	0.0633	0.0737	-0.0104	
Total Capital Ratio	0.1378	0.1453	-0.0076	0.3091
	0.1336	0.1420	-0.0084	
Tier-1 Ratio	0.1119	0.1229	-0.0109	0.1436
	0.1094	0.1252	-0.0158	
Common Equity Tier-1 Ratio	0.0971	0.1112	-0.0141*	0.0581
	0.0923	0.1091	-0.0168	
RWA / Total Assets	0.4911	0.5936	-0.1024**	0.0102
	0.4894	0.6033	-0.114	
Cost-to-Income Ratio	0.5762	0.6021	-0.0259	0.3468
	0.5974	0.6148	-0.0174	
NPLs / Total Loans	0.0818	0.0515	0.0303**	0.0257
	0.0631	0.0319	0.0312	
Non-Interest Expense / Total Assets	0.0160	0.0214	-0.0054**	0.0324
	0.0147	0.0166	-0.0019	
Market Risk	0.0670	0.0737	-0.0067	0.6554
	0.0593	0.0533	0.006	
Return on Average Assets	0.0047	0.0078	-0.0032**	0.0272
	0.0049	0.0071	-0.0023	

Table A.5.1 depicts several bank characteristics of capital exercise and control group banks. The first number refers to the average within the respective group while the number below represents the median. The p-value result from a t-test for a difference in means. level respectively.

A.5.2 Development of CET1 Ratios - Capital Exercise and Control Group Banks

Figure A.5.2: Development of CET1 Ratios over Time

[Figure A.5.2](#) (a) depicts the development of CET1 ratios among capital exercise banks and the full sample of control group banks.



[Figure A.5.2](#) (b) depicts the development of CET1 ratios among capital exercise banks and the overlap sample of control group banks.