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An analysis of the potential impact of heightened capital requirements on banks' cost of capital

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Abstract
We provide new estimates of the association between the level of capital and the cost of capital for US banks by using the implied cost of capital as a measure of the cost of equity and by factoring in the effect of the cost of debt. With the important exception of the largest banks, we find that the cost of equity declines when the level of capital increases. This negative association is stronger after the onset of the 2007–2008 financial crisis. Banks' cost of debt also declines when the level of capital increases. However, the weighted average cost of capital (WACC) remains unaltered when capital increases. The analysis of a sample of large banks yields different results: there is no discernible association between the level of capital and the costs of equity and debt for large banks, and their WACC increases with the level of capital.

Keywords Bank capital · Cost of capital · Implied cost of capital · Bank regulation

JEL Classification G28 · G21 · G01

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1 Introduction

We investigate the potential effect of an increase in regulatory capital requirements on the cost of capital for banks. The effect of changes in the capital structure on firms' cost of capital is a core issue in financial economics and has special policy implications in the banking industry. After the recent financial crisis, governments across the globe passed legislation and changed regulation to strengthen the resilience of the financial system. A key piece of this legislation was to raise capital requirements to reduce the effect of distress in the financial sector on the broader economy. However, detractors of this regulation, most prominently large banks, contended that heightened capital requirements increase the cost of doing business for banks, and that part of this increase is passed on to the productive sector in the form of higher borrowing costs and more restricted credit.[1] Thus, an assessment of the impact of an increase in the level of regulatory capital on banks' cost of capital is important for regulators because increasing capital levels can have detrimental effects on economic activity.

Advocates and detractors of proposals to increase capital requirements for banks can find support for their arguments in the literature. Prior studies have shown that financial distress puts downward pressure on banks' capital and that they respond by reducing lending (e.g., Peek and Rosengren 2000; De Haas and van Horen 2012; Huber 2018). The 2007–2008 financial crisis exposed complex interactions between financial institutions that magnified the effects of distress in the financial sector on the real economy. Thus, regulation to increase the level of capital is justified because it is a buffer against negative shocks that hinder the flow of credit to the real economy. However, other theoretical and empirical work has contended that attempts to increase bank capital can increase costs to the financial and industrial sectors of the economy (e.g., Diamond and Rajan 2001, 2002; DeAngelo and Stulz 2015; Berger et al. 2016; Gorton and Winton 2017). These studies argue that a high level of leverage is desirable for banks and that additional capital can have a negative effect on the provision of liquidity. Other costs associated with higher regulatory capital levels mentioned in the literature include weakening the disciplinary role of debt and an increase in the overall risk of the financial sector because higher capital requirements can drive intermediation into the less-regulated shadow banking system.

A main concern with regulation to raise the level of capital voiced by representatives of large banks is that this regulation would increase their overall cost of doing business because debt financing is cheaper than equity financing.[2] However, some scholars have questioned the validity of this argument (e.g., Admati and Hellwig 2014) because it does not consider the effect of additional capital on the cost of equity. Modigliani and Miller (1958) (M-M) prove that under idealized conditions, replacing debt with more expensive equity does not affect the weighted average cost of capital (WACC) because additional equity reduces its cost, and this reduction offsets the increased weight of equity in

[1] The different views of the potential effect of increasing capital requirements can be summarized by the reactions to regulation requiring a risk-based capital surcharge on systemically important U.S. bank holding companies. The Fed Chairwoman Janet Yellen commented that this surcharge was necessary to "bear the costs that their failure would impose on others." Tim Pawlenty, the president of The Financial Services Roundtable, which is a trade group that represents big banks, said: "Regulators should reasonably address risk, but this rule will keep billions of dollars out of the economy.".

[2] For example, according to a former director of JP Morgan, "the first-order effect of increasing the ratio of common equity to total assets from 5 to 30% would clearly be very high. Assume that the annual cost of bank equity is 5 percentage points higher than the after-tax cost of bank deposits and debt…" (Elliott 2013).

the capital structure. However, other studies have argued that the M-M predictions do not apply to the banking industry (see Berger et al. 1995; DeAngelo and Stulz 2015 for a summary of this work).

The divergence in opinions between regulators and bank practitioners and the complex trade-off between the costs and benefits that are associated with equity and debt financing in the academic literature call for empirical analyses on the association between the level of capital and its cost for banks. Our goal is to provide empirical evidence.

Our study differs from prior work in that we measure the cost of equity with the implied cost of capital (ICC). The ICC focuses on the market consensus about the required rate of return that is embedded in stock prices. A weakness of the ICC is that the prediction of future cash flows is model-specific. We demonstrate robustness by using the ICC derived from five different models. We also investigate two different methods to infer future earnings: we use analysts' expectations about earnings per share that we obtained from the Institutional Brokers Estimate System database (IBES-based ICCs), and we follow Hou et al. (2012) who adopt regression models to estimate future earnings (regression-based ICCs).

The analysis of the level of capital and the cost of capital for US banks during the period from 1996 to 2013 reveals a negative association between the level of bank capital and the costs of equity and debt. For instance, the average IBES-based ICC is 90 basis points (bp) lower for banks in the highest Tier-1 capital decile than for those in the lowest decile. Banks in the highest Tier-1 capital decile have a 19 bp lower after-tax cost of debt than banks in the lowest decile. The analysis also demonstrates that there is not a significant association between the level of capital and banks' overall cost of capital. The difference between the WACCs of the best and worst capitalized banks is small: there is a 2 bp difference between the WACC of banks in the highest and in the lowest deciles of the equity-to-assets ratio (ETOA).

Some studies suggest that the association between the level of capital and its cost is different in normal times than in financial crises. For instance, Berger and Bouwman (2013) find that investors earn higher average risk-adjusted stock returns when they invest in banks with relatively more capital, but only in bad times. Calomiris and Nissim (2014) show that prior to the 2007–2008 financial crisis, high leverage was associated with greater value for banks, but this association reversed during the crisis. Motivated by this work, we conduct separate analyses for the periods before and after the onset of the 2007–2008 financial crisis. We find that the outbreak of the financial crisis was associated with a structural shift in the association between the level of capital and banks' cost of capital. The negative association between the level of capital and the ICC was stronger after the outbreak of the financial crisis. However, there is no significant association between the level of capital and banks' WACC before or after the onset of the crisis.

Prior research has also suggested that size is an important determinant of banks' cost of capital. For instance, Ueda and di Mauro (2013) find that government subsidies translate into better credit ratings and cheaper funding for systemically important financial institutions. Gandhi and Lustig (2015) and Gandhi et al. (2020) find that equity is cheaper for large financial institutions. They argue that implicit government subsidies absorb some of the tail risk for large banks that result in lower risk-adjusted returns for larger than for smaller banks, mainly during the financial crisis. Motivated by this work, we perform a separate analysis for banks that participated in the Supervisory Capital Assessment Program (SCAP) or the Comprehensive Capital Analysis and Review (CCAR). This analysis demonstrates that consistent with other studies, large banks have a lower ICC than smaller banks. We also find that the costs of equity and debt remain unaltered when the level of capital increases, and the WACC of the largest banks in our sample increases with the level of equity capital. A possible explanation is that investors perceive that capital is less valuable as a buffer against negative shocks for large banks because implicit government guarantees absorb part of their insolvency risk.

Our study contributes to the literature on the potential consequences of micro- and macro-prudential regulations that seek to reduce the risks in the financial sector by raising regulatory levels of capital. A rich body of theoretical and empirical work analyzes the consequences of capital for lending and liquidity creation (see Thakor 2014; DeAngelo and Stulz 2015 for a summary of this work). We focus on the potential negative effect of raising the regulatory requirements on banks' cost of capital. Supporting the argument that this increase can raise banks' cost of doing business, those studies that have used historical returns find that the cost of equity increases with the level of capital (e.g., Baker and Wurgler 2015; Bouwman et al. 2018). The main difference between these studies and ours is that we measure the cost of equity with the ICC. Consistent with the predictions in M-M, our analysis shows a negative association between the ICC and the level of the banks' capital. This negative association is stronger after the onset of the financial crisis, which is consistent with the studies that argue capital is more valuable during periods of distress (Berger and Bouwman 2013; Calomiris and Nissim 2014; Bouwman et al. 2018). This result provides additional evidence that investors perhaps assign a low value to equity risk during expansions and become more risk-averse during contractions (e.g., Thakor 2016).

Some studies find that the overall cost of capital for banks increases with the level of capital. Using a model-based calibration approach, Kashyap et al. (2010) estimate that a 10 percentage point increase in the required level of capital would increase banks' WACC by 25 to 40 bp. Baker and Wurgler (2015) estimate that a 10 percentage point increase in capital would be associated with an 82 to 90 bp increase in banks' WACC. We provide new estimates of the association between the level of capital and the WACC by using the ICC as a measure of the cost of equity and by factoring in the effect of the cost of debt. With the important exception of the largest banks, we find that there is no discernible association between the level of capital and banks' WACC. Thus, our findings do not support the argument that additional capital has a negative effect on credit because it increases banks' cost of capital. These results are robust to alternative econometric techniques such as an instrumental variable approach and a dynamic general method of moments (GMM) panel estimation to account for the potential endogeneity between the level and the cost of capital.

The rest of the paper is organized as follows: In Section 2, we describe the construction and summary statistics of the sample. Section 3 presents the analysis of the association between the level of capital and its cost, and with the cost of debt. In Section 4, we analyze the potential effect of capital on banks' WACC. In Section 5, we address endogeneity concerns. We analyze the effect of size in Section 6. In Section 7, we replicate the analysis using alternative measures of the costs of equity and debt. Section 8 presents the conclusions.

2 Sample construction and descriptive statistics of ICC measures

We analyze a sample of US banks with information from the Wharton Research Data Services (WRDS) and from the Call Reports for the period from 1996 to 2013. Our analysis starts in the first quarter of 1996 when more granular disclosures of data on capital were introduced. This database contains FR Y-9C reports of bank holding companies (BHCs) and the call reports of commercial banks. Data on BHCs were collected from the BHCK series, and data on commercial banks were collected from the RCFD and RIAD series. The sample comprises all BHCs and banks that are not affiliated with a BHC, but it does not include banks that are owned by a BHC (e.g., the sample includes Citigroup but not Citibank). The information needed to compute the ICCs is obtained from the Center for Research in Security Prices (CRSP) and Compustat databases.[3] Combining these databases results in a sample of 1,095 unique banks and 33,150 bank-quarter observations. To avoid a potential survivorship bias, we do not exclude acquired and failed banks from our sample. Table OA1 in the Online Appendix shows the maximum and minimum numbers of banks in each year of the sample as well as the number of acquired and failed banks.

2.1 Measures of capital adequacy

We analyze five measures of capital adequacy that are relevant to regulators and have been used in prior studies. The calculations of these measures and the source of data are shown in Table 1. Panel A of Table 2 presents the summary statistics for these measures. The mean values of the ETOA, tier-1 capital-to-assets (T1CTOA), and risk-based capital-to-assets (RBCTOA) ratios are in the 9% to 10% range. The mean of Tier-1 capital-to-risk-weighted assets ratio (T1CTORWA) is 12.75%. The minimum T1CTORWA for common equity increases from 4% under Basel II to 6% under Basel III. Insured banks in the US are subject to more stringent requirements. A bank is considered "well-capitalized" under The Federal Deposit Insurance Corporation Improvement Act, which was implemented in 1994, if its Tier-1 capital ratio is at least 6%, its total risk-based capital is at least 10%, and its leverage ratio is 5%. In our sample, 97.47% of the banks are well-capitalized. Thus, the capitalization levels are significantly larger than the minimums required by regulators. Many other studies report similar findings (e.g., Berger et al. 2008).[4]

The cross-sectional dispersion is lower for the ETOA than for the T1CTORWA. The standard deviation in the ETOA is 4.64%, and the coefficient of variation (not tabulated) is 48%. The standard deviation in T1CTORWA is 6.91%, and its coefficient of variation is 54.2%.

2.2 Measures of the cost of equity

We use the ICC as the measure of the cost of equity. The ICC is the discount rate that equates market values to the present value of all expected future cash flows generated by securities. Thus, the ICC is the assessment of investors' expected return that is embedded in stock prices. A growing number of studies use the ICC as a measure of firms' cost of equity (e.g., Pastor et al. 2008; Chava and Purnanandam 2010; Campbell et al. 2012; Chen et al. 2013, 2015). These studies often motivate the use of the ICC as an alternative to realized returns because those returns are "a very poor measure of expected returns"

[3] We eliminate 24 banks that have a CRSP's permanent company identifier corresponding to more than one RSSD code. As in Baker and Wurgler (2015), we exclude Federal Reserve banks, foreign banks, functions related to deposit banking, non-depository credit institutions, and federal credit agencies.

[4] However, these high levels of capital do not imply that regulatory capital is not binding for the majority of banks in our sample. We only observed the constrained choice of the level of capital. The optimal level may be lower, but banks may maintain capital above the regulatory level as a buffer against negative shocks that can push their regulatory capital below the minimum level. These shocks would force banks to raise additional equity or to cut dividends (for a more detailed discussion, see Berger et al. 1995).

Table 1 Descriptions of the variables

Variable Name	Description	Source
Panel A. Measures of Capital Adequacy		
Equity to Assets	The ratio of total equity capital (BHCK3210) to average of total assets (BHCK 3368)*	Bank Regulatory
Tier-1 capital-to-assets	The ratio of Tier-1 capital (BHCK8274) to average of total assets (BHCK 3368)	Bank Regulatory
Risk-based capital-to-assets	The ratio of total qualifying capital allowable under the risk-based capital guidelines (BHCK3792) to average of total assets (BHCK 3368)	Bank Regulatory
Tier-1 capital-to-risk-weighted assets	The ratio of Tier-1 capital (BHCK8274) to total risk-weighted assets (BHCK a223)	Bank Regulatory
Risk-based capital-to-risk-weighted assets	The ratio of total qualifying capital allowable under the risk-based capital guidelines (BHCK3792) to total risk-weighted assets (BHCK a223)	Bank Regulatory
Panel B. Measures of the implied cost of capital (ICC) and the cost of debt**		
GLS	ICC estimated using the model in Gebhardt et al. (2001): $P_t = BPS_t + \sum_{k=1}^{11} \frac{E_t[(ROE_{t+k}-R)\times BPS_{t+k-1}]}{(1+R)^k} + \frac{E_t[(ROE_{t+12}-R)\times BPS_{t+11}]}{R\times(1+R)^{11}}$	IBES/CRSP/Compustat
CT	ICC estimated using the model in Claus and Thomas (2001): $P_t = BPS_t + \sum_{k=1}^{5} \frac{E_t[(ROE_{t+k}-R)\times BPS_{t+k-1}]}{(1+R)^k} + \frac{E_t[(ROE_{t+5}-R)\times BPS_{t+4}](1+g)}{(R-g)\times(1+R)^5}$	IBES/CRSP/Compustat
OJ	ICC estimated using the model in Ohlson and Juettner-Nauroth (2005): $R = A + \sqrt{A^2 + \frac{E_t[EPS_{t+1}]}{P_t} \times (g - (\gamma - 1))}$ where $A = 0.5\left((\gamma - 1) + \frac{E_t[D_{t+1}]}{P_t}\right), g = 0.5\left(\frac{E_t[E_{t+3}]-E_t[E_{t+2}]}{E_t[E_{t+2}]} + \frac{E_t[E_{t+5}]-E_t[E_{t+4}]}{E_t[E_{t+4}]}\right)$	IBES/CRSP/Compustat
MPEG	ICC estimated using the model in Easton (2004): $P_t = \frac{E_t[E_{t+2}]+R\times E_t[Div_{t+1}]-E_t[E_{t+1}]}{R^2}$	IBES/CRSP/Compustat
Gordon	ICC estimated using the model in Gordon and Gordon (1997): $R = \frac{E_t[EPS_{t+1}]}{P_t}$	IBES/CRSP/Compustat
Composite	The average of the GLS, CT, OJ, MPEG, and Gordon models	

Table 1 (continued)

Variable Name	Description	Source
Cost of debt	The explanation of this variable (VM010) in Bloomberg is: "After-tax weighted average cost of debt is calculated using government bond rates, a debt adjustment factor, the proportions of short and long-term debt to total debt, and the stock's effective tax rate. The debt adjustment factor represents the average yield above government bonds for a given rating class. The debt adjustment factor is only used when a company does not have a fair market curve. When a company does not have a credit rating, an assumed rate of 1.38 (the equivalent rate of a BBB + Standard & Poor's long-term currency issuer rating) is used."	Bloomberg
Ln Book value	The natural logarithm of total equity capital (BHCKG105) in 2007 constant dollars	Bank Regulatory
Panel C. Banks' characteristics		
Beta	Beta computed by regressing a minimum of 24 months and a maximum of 60 months of prior HPRs on the CRSP value-weighted market HPRs	CRSP
Market to book	The natural logarithm of the market to book ratio of equity. Book value of equity equals common stock (BHCK3230) + surplus (BHCK3240) + retained earnings (BHCK3247)	CRSP/Bank Regulatory
ROE	Return on equity computed as the net income before extraordinary items (BHCK4300) divided by total equity capital (BHCK3210)	Bank Regulatory
Efficiency ratio	The ratio of non-interest expense (BHCK4093) to the sum of net interest income (BHCK4107) plus non-interest income (BHCK4079)	Bank Regulatory
Liquid assets	The ratio of liquid assets (BHCK0081 + BHCK0395 + BHCK0397 + BHCK1773) to total assets (BHCK2170)	Bank Regulatory
Ln Z	The natural logarithm of the return on assets plus equity-to-assets ratio that is scaled by the standard deviation in the return on assets. The calculation of the standard deviation in the return on asset is based on a rolling window of 12 quarters	Bank Regulatory
Deposits to assets	The ratio of deposits to total assets	Bank Regulatory
Core deposits	The sum of transaction deposits, savings deposits, and small (denominations less than $100,000) time deposits scaled by total assets. (BHDM6631 + BHDM6636) / BHCK2170	Bank Regulatory
Loan concentration	Herfindahl–Hirschman Index (HHI) of the following six loan categories: commercial real estate, residential real estate, construction and industrial, consumer, agriculture, and other	Bank Regulatory
Real estate loans	Loans secured by 1–4 family residential construction (BHCKF158) + loans secured by other construction loans and all land development and other land loans (BHCKF159) + real estate loans secured by farmland (BHDM1420) divided by total loans and leases, net of unearned income (BHCK2122)	Bank Regulatory

Table 1 (continued)

Variable Name	Description	Source
Nonperforming loans	Nonperforming loans / total loans. Total nonperforming loans equal the sum of total loans and lease finance receivables, nonaccrual (BHCK1403) and total loans and lease finance receivables, past due 90 days and more and still accruing (BHCK1407). Total loans equal total loans and leases, net of unearned income (BHCK2122)	Bank Regulatory
Panel D. Market-wide variables		
TED spread	Computed as the difference between the 3-month LIBOR and the 3-month T-bill rate	Bloomberg
High VIX	Equals one for months in which the Chicago Board Options Exchange Volatility Index (VIX) is greater than its 80^{th} percentile	CBOE
Bond Liquidity	Bond liquidity premiums	Fontaine and Garcia (2012)***
Yield curve	A yield curve factor defined as the change in the 10-year Treasury constant maturity yield minus the 1-year Treasury constant maturity yield	St. Louis Fed
T-10 ret	Excess return of the US 10-year Government Bond Total Return Index over the 1-month T-bill rate	Bloomberg
Corporate bond ret	Excess return of the Dow Jones Corporate Bond Return Index over the 1-month T-bill rate	Bloomberg
Financial crisis	A dummy variable that identifies observations during the period July 2007 to December 2013	

* BHCK represents the BHC series; Commercial banks series have the same numerical component, but they start by RCFD

Variable description is from the Fed's Micro Data Reference Manual. https://www.federalreserve.gov/apps/mdrm/data-dictionary

** P_t is the market equity in year t, R is the implied cost of capital (ICC), BPS_t is the book equity, $E_t[]$ denotes market expectations based on information available in year t, ROE_t is the return on equity, g is the estimated growth rate, γ is the perpetual growth rate in abnormal earnings beyond the forecast horizon, Div_t is the dividend, and EPS_t is the earnings per share

*** http://jean-sebastienfontaine.com/wp-content/uploads/2016/04/FundingLiquiditFactor_19862015Q4.txt

Table 2 Summary statistics of banks' capital adequacy and their implied cost of capital (ICC). Panel A presents sample statistics of five measures of bank capital adequacy: equity-to-assets ratio (ETOA); Tier-1 capital-to-assets ratio (T1CTOA); risk-based capital-to-assets ratio (RBCTOA); Tier-1 capital-to-risk-weighted assets (T1CTORWA); and risk-based capital-to-risk-weighted assets ratio (RBCTORWA). The sample expands from the first quarter of 1996, when granular capital data disclosure requirements were introduced, to 2013. Panel B shows the sample characteristics of the five ICC measures described in Table 1 computed using analysts' earnings forecast from I/B/E/S (IBES-based ICCs); IBES-based ICC is the average of these five estimates. Panel C shows the sample characteristics of the five ICC estimates based on cross-sectional regression models; regression-based ICC is the average of the five ICC estimates. Capital level measures and ICC estimates are described in detail in Table 1

Variable	Mean	Median	Standard deviation	5th percentile	95th percentile
Panel A. Bank capital adequacy					
ETOA	0.0970	0.0911	0.0464	0.0597	0.1419
T1CTOA	0.0905	0.0874	0.0394	0.0613	0.1329
RBCTOA	0.1020	0.0988	0.0393	0.0723	0.1441
T1CTORWA	0.1275	0.1203	0.0691	0.0819	0.2018
RBCTORWA	0.1429	0.1352	0.0678	0.1042	0.2156
Panel B. ICCs computed using analysts' earnings forecast from I/B/E/S					
GLS	0.0952	0.0909	0.0235	0.0680	0.1359
CT	0.0965	0.0878	0.0484	0.0625	0.1456
MPEG	0.1104	0.1003	0.0421	0.0628	0.1951
OJ	0.0744	0.0714	0.0275	0.0423	0.1126
GORDON	0.0691	0.0672	0.0232	0.0348	0.1080
Composite IBES-based ICC	0.0892	0.0838	0.0255	0.0622	0.1334
Panel C. ICCs computed using cross-sectional regression models					
GLS	0.1060	0.0966	0.0435	0.0574	0.1841
CT	0.1301	0.1109	0.0718	0.0569	0.2694
MPEG	0.1642	0.1430	0.0898	0.0663	0.3385
OJ	0.0927	0.0769	0.0722	0.0270	0.2056
GORDON	0.0819	0.0678	0.0659	0.0199	0.1895
Composite regression-based ICC	0.1137	0.0978	0.0634	0.0508	0.2311

(Elton 1999). The ICC explains some puzzling findings in the association between risk and return. For instance, Pastor et al. (2008) introduce the ICC because asset pricing models, such as the CAPM and the intertemporal CAPM of Merton (1973), predict a positive time-series relation between the conditional mean and variance of returns. However, the association between realized returns and systematic risk is either flat or negative (e.g., Fama and French 1992). Using the ICC as a proxy for the conditional expected return, Pastor et al. (2008) find the positive relation predicted by theory in the US and in several other countries.[5]

A caveat with the ICC is that the prediction of future cash flows is model-specific. Without clear evidence that one model is superior to others, Hou et al. (2012) propose

[5] Chava and Purnanandam (2010) contend that the ICC is by construction a forward-looking measure that captures the time variation in expected stock returns better than ex-post realized returns. Contrary to the negative cross-sectional relation between expected default risks and stock returns found in other studies that use realized returns, Chava and Purnanandam (2010) find a positive relation using the ICC.

constructing a composite index that averages the estimates of the five models of Gebhardt et al. (2001), Claus and Thomas (2001), Ohlson and Juettner-Nauroth (2005), Easton (2004), and Gordon and Gordon (1997). We closely follow this methodology.[6,7]

The cash flows necessary to estimate the ICC can be inferred from analysts' predictions about future earnings-per-share (EPS) that we obtained from IBES (IBES-based ICCs). However, small firms and firms that are financially distressed are underrepresented in IBES. Analysts' forecasts can also be tainted by over-optimism (Easton and Sommers 2007). The 2007–2008 financial crisis provides an example of analysts and investors failing to forecast the large losses that resulted in an underestimation of the ICC before the crisis. To reduce these concerns, Hou et al. (2012) propose using a pooled cross-sectional model to forecast cash flows (regression-based ICCs). We use both ICC estimates in this study. The sample of IBES-based ICCs consists of 16,227 bank-quarter observations and the sample of regression-based ICCs of 24,012 bank-quarter observations. Panels B and C of Table 2 show that the average of IBES-based statistics, 8.92%, is significantly smaller than the average of the regression-based ICCs, 11.37%. We provide an example of the calculation of the ICC for JP Morgan Chase in the Online Appendix Table OA2.

Figures 1A and B compare the five ICC estimates. All the estimates follow the same pattern, but there are significant differences in their magnitudes. The composite IBES-based ICC increases from an average of 8.2% in the third quarter of 1997 to 10.4% by the end of 1999, when it starts a protracted decline up to 2006. IBES-based ICCs increase by 200 bp during the crisis and then decline to their pre-crisis level, 8.4%, by the end of 2013. Regression-based ICCs follow a similar pattern prior to the financial crisis, but they increase sharply after the financial crisis and remain 700 bp above the pre-crisis level until 2013.

Figure 1C depicts the time series of Tier-1 capital and the ICC. The level of bank capital declines during the period from 1996 to 2008 and increases after the onset of the financial crisis in a context of increasing regulatory pressure to recapitalize the banking system. The pattern of a negative relation between the cost of equity and capital level emerges in the time series depicted in this figure, and this association is more evident in IBES-based than in regression-based ICCs.

Figure 1D displays the evolution of the cost of debt and the WACC. The figure does not include the years 1996–1999 because the after-tax cost of debt is only available after 2000. The WACC closely follows the cost of debt, as expected in highly leveraged firms. The time series of cost of debt and of the ICC move in tandem, which indicates the presence of common factors that affect both sources of funding. The decline in banks' WACC after

[6] Negative ICCs, which account for about 0.52% of the observations, are excluded from the sample. Other studies have matched earnings forecasts with market values at the end of an arbitrary month. For example, Gebhardt et al. (2001) use the end of April, while Hou et al. (2012) use the end of June. The choice does not take into account firms' fiscal year. More importantly, using only one month per year imposes a significant loss of information. To ameliorate these concerns, we utilize monthly information from IBES, and then compute the average ICC for each quarter.

[7] A concern with the ICC is that the potential of mergers in the banking industry can be reflected in market prices, which may impact the ICC. This concern is more relevant before the 2007–2008 financial crisis, which was a period of significant consolidation in the banking industry. Furthermore, in the earlier stages of the financial crisis, investors and analysts failed to anticipate the magnitude of the crisis. Thus, market prices and analysts' EPS forecasts were overstated, which can affect the accuracy of the ICC as a measure of the cost of equity.

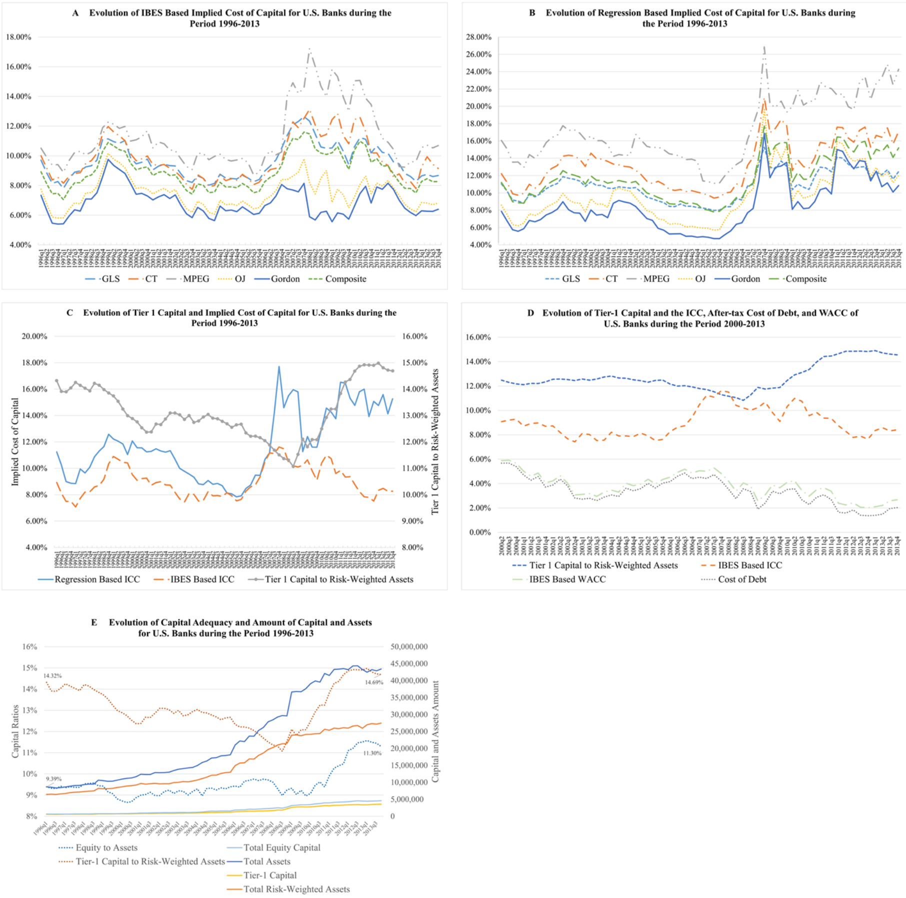

Fig. 1 Evolution of capital level and the ICC of US banks during the period from 1996–2013. These five figures show the evolution of banks' capital level and their ICC. The description of the measures of capital adequacy and the methods to compute ICCs are described in Table 1

the crisis might be due to the Federal Reserve's near-zero policy interest rate and abundant liquidity provision to the banking system, which may have reduced the cost of debt.

Figure 1E shows the evolution of banks' capital adequacy. The series T1CTORWA and ETOA behave differently before the financial crisis: T1CTORWA declines steadily from 1996 to the third quarter of 2007, while the level of the ETOA is similar in 1996 and 2007. Both capital ratios decline during the first part of the crisis (from third quarter of 2007 to the end of 2008), and they experience a significant increase after 2009. The increase in capitalization ratios after the crisis is concurrent with a rise in the average book values of assets and equity. The average value of total assets increased by 45.2% from $28.64 billion in the third quarter of 2007 to $41.6 billion (in 2007 constant dollars) by the end of 2013. During the same period, total equity capital increased by 84% from $2.4 billion to $4.49 billion. Thus, the increase in capital ratios after the financial crisis was due to higher numerators of capital ratios.

3 Analysis of the association between the level of capital, ICC, and the banks' cost of debt

Regulators have responded to crises that threatened the stability of the financial system by raising capital requirements. However, critics of these actions contend that they increase the cost of doing business for banks. To assess the effect of heightened levels of capital, we investigate the association between capital and banks' cost equity and cost of debt.

3.1 Univariate analysis of the association between the banks' level of capital and ICC

Table 3 presents the average of the five ICC measures described in Table 1 for banks grouped into deciles based on their T1CTORWA and ETOA ratios. This average falls across capital deciles, preliminary evidence of a negative association between capital and the cost of equity. Specifically, Panel A shows that the average IBES-based ICC is 90 bp lower for banks in the highest T1CTORWA decile than for those in the lowest decile. Panel C indicates that the composite IBES-based ICC declines by 70 bp when the ETOA more than doubles from the lowest to the highest decile. The negative association between banks' ICC and their capital is significantly stronger for regression-based ICCs (Panels B and D).

3.1.1 The impact of the financial crisis

Extant work suggests that the effect of capital can differ before and after the financial crisis. Bouwman et al. (2018) report that well-capitalized banks have higher risk-adjusted stock returns than less-capitalized banks, but only in bad times.[8] Table 4 presents the average ICCs for banks grouped into capital deciles before and after the onset of the 2007–2008 financial crisis. The association between the ICC and bank capital is stronger after the outbreak of the crisis. In particular, a comparison between Panels A and B indicates that the difference between the average IBES-based ICCs in the lowest and highest Tier-1 capital deciles is 80 bp before the crisis, but 190 bp after the crisis. This difference is larger in Panels C and D when we measure the capital level with the ETOA. These findings indicate that investors become more mindful of the risk associated with low levels of capital and that they impound that risk in stock prices.

3.2 Univariate analysis of the association between the level of capital and banks' cost of debt

As recognized by traditional theories of capital structure, firms find it increasingly costly to issue debt as the credit risk they impose on lenders increases. More equity capital reduces the probability of failure (Cole and Gunther 1995) and enhances banks' performance in times of financial distress (Beltratti and Stulz 2012). Thus, additional equity should reduce banks' cost of debt financing. However, substituting equity for debt means diminishing the

[8] Bouwman et al. (2018) contend that behavioral theories (e.g., Gennaioli et al. 2015) can explain these results. Behavioral biases lead investors to underestimate the probability of bad times that results in low price spreads between well- and less-capitalized banks during good times. Investors gradually revise their beliefs during bad times, resulting in a gradual increase in the price spread between well- and less-capitalized banks.

Table 3 Level of capital and banks' ICC. This table presents the average of the ICC measures described in Table 1 for banks grouped into deciles based on two measures of capital adequacy. Panels A and B group banks into deciles based on the Tier-1 capital-to-risk-weighted assets ratio (T1CTORWA). Panels C and D allocate banks into deciles based on the equity to total assets (ETOA). ICCs are computed using analysts' forecasts from I/B/E/S (Panels A and C) and are based on cross-sectional models (Panels B and D)

DECILE	1	2	3	4	5	6	7	8	9	10	(10)-(1)
Panel A. Average IBES-based ICCs by T1CTORWA deciles											
T1CTORWA	0.0831	0.0974	0.1051	0.1115	0.1177	0.1243	0.1319	0.1420	0.1584	0.2093	0.1262***
GLS	0.0934	0.0955	0.0959	0.0957	0.0959	0.0956	0.0947	0.0959	0.0947	0.0949	0.0014*
CT	0.1005	0.0978	0.0991	0.0999	0.0979	0.0964	0.0938	0.0958	0.0910	0.0901	-0.0104***
MPEG	0.1126	0.1117	0.1107	0.1122	0.1115	0.1102	0.1078	0.1103	0.1086	0.1069	-0.0057***
OJ	0.0791	0.0764	0.0765	0.0750	0.0748	0.0747	0.0746	0.0737	0.0707	0.0661	-0.0130***
GORDON	0.0727	0.0713	0.0708	0.0695	0.0704	0.0693	0.0694	0.0685	0.0656	0.0620	-0.0107***
Composite	0.0924	0.0912	0.0913	0.0906	0.0902	0.0893	0.0883	0.0884	0.0856	0.0834	-0.0090***
Panel B. Average Regression-based ICCs by T1CTORWA deciles											
GLS	0.1042	0.1075	0.1075	0.1050	0.1086	0.1069	0.1058	0.1085	0.1053	0.1003	-0.0039***
CT	0.1039	0.1346	0.1330	0.1277	0.1338	0.1322	0.1290	0.1353	0.1285	0.1154	-0.0155***
MPEG	0.1574	0.1611	0.1610	0.1607	0.1687	0.1651	0.1630	0.1751	0.1708	0.1580	0.0006***
OJ	0.0981	0.0963	0.0949	0.0911	0.0941	0.0932	0.0931	0.0957	0.0924	0.0775	-0.0207***
GORDON	0.0869	0.0856	0.0855	0.0811	0.0827	0.0818	0.0823	0.0851	0.0797	0.0683	-0.0186***
Composite	0.1161	0.1168	0.1157	0.1116	0.1165	0.1147	0.1129	0.1178	0.1133	0.1010	-0.0151***
Panel C. Average IBES-based ICCs by ETOA deciles											
ETOA	0.0581	0.0716	0.0784	0.0838	0.0891	0.0945	0.1002	0.1070	0.1170	0.1524	0.0943
GLS	0.0954	0.0961	0.0943	0.0937	0.0944	0.0954	0.0939	0.0960	0.0949	0.0982	0.0027***
CT	0.1008	0.1014	0.0983	0.0976	0.0981	0.0982	0.0936	0.0951	0.0913	0.0916	-0.0091***
MPEG	0.1126	0.1133	0.1099	0.1082	0.1124	0.1122	0.1093	0.1085	0.1075	0.1101	-0.0025***
OJ	0.0791	0.0782	0.0758	0.0752	0.0747	0.0756	0.0735	0.0736	0.0714	0.0678	-0.0113***
GORDON	0.0738	0.0735	0.0708	0.0705	0.0693	0.0695	0.0688	0.0680	0.0662	0.0617	-0.0122***
Composite	0.0931	0.0927	0.0899	0.0891	0.0900	0.0904	0.0880	0.0884	0.0858	0.0860	-0.0070***

Table 3 (continued)

DECILE	1	2	3	4	5	6	7	8	9	10	(10)-(1)
Panel D. Average Regression-based ICCs by ETOA deciles											
GLS	0.1143	0.1111	0.1079	0.1063	0.1050	0.1047	0.1037	0.1043	0.1024	0.1014	-0.0130***
CT	0.1533	0.1452	0.1374	0.1319	0.1310	0.1286	0.1243	0.1225	0.1181	0.1108	-0.0425***
MPEG	0.1935	0.1830	0.1725	0.1660	0.1624	0.1598	0.1561	0.1551	0.1504	0.1492	-0.0443***
OJ	0.1116	0.1052	0.0981	0.0950	0.0928	0.0908	0.0892	0.0875	0.0839	0.0753	-0.0363***
GORDON	0.0966	0.0940	0.0886	0.0848	0.0808	0.0797	0.0791	0.0770	0.0743	0.0664	-0.0302***
Composite	0.1321	0.1253	0.1187	0.1154	0.1139	0.1115	0.1094	0.1086	0.1049	0.0988	-0.0333***

Table 4 Level of capital and banks' ICC in the pre- and post-financial crisis periods. This table presents the average of IBES-based ICCs and regression-based ICCs for banks grouped into deciles based on Tier-1 capital to risk-weighted assets ratio (T1CTORWA) (Panels A and B), and ETOA (Panels C and D). Panels A and C cover the pre-financial crisis period, and Panels B and D the post-financial crisis period

Deciles	1	2	3	4	5	6	7	8	9	10	(10)-(1)
Panel A. Average ICCs by T1CTORWA deciles during the period 1996/01 to 2007/06											
T1CTORWA	0.1036	0.1104	0.1120	0.1165	0.1182	0.1222	0.1271	0.1326	0.1481	0.1976	0.0940***
IBES based ICCs	0.0921	0.0886	0.0886	0.0887	0.0880	0.0882	0.0881	0.0867	0.0869	0.0842	-0.0080***
Regression based ICCs	0.1133	0.1060	0.1084	0.1102	0.1096	0.1090	0.1068	0.1100	0.1070	0.0981	-0.0152***
Panel B. Average ICCs by T1CTORWA deciles during the period 2007/07 to 2013/12											
T1CTORWA	0.0944	0.1177	0.1230	0.1229	0.1287	0.1286	0.1314	0.1364	0.1459	0.1826	0.0883***
IBES based ICCs	0.1077	0.0981	0.0956	0.0950	0.0979	0.0972	0.0928	0.0931	0.0909	0.0886	-0.0190***
Regression based ICCs	0.1724	0.1511	0.1452	0.1527	0.1517	0.1447	0.1366	0.1321	0.1353	0.1190	-0.0534***
Panel C. Average ICCs by ETOA deciles during the period 1996/01 to 2007/06											
ETOA	0.0587	0.0709	0.0774	0.0826	0.0878	0.0930	0.0984	0.1051	0.1150	0.1514	0.0927***
IBES based ICCs	0.0911	0.0908	0.0885	0.0885	0.0886	0.0890	0.0870	0.0874	0.0851	0.0851	-0.0060***
Regression based ICCs	0.1219	0.1156	0.1110	0.1087	0.1075	0.1065	0.1053	0.1050	0.1015	0.0962	-0.0257***
Panel D. Average ICCs by ETOA deciles during the period 2007/07 to 2013/12											
ETOA	0.0553	0.0749	0.0831	0.0895	0.0955	0.1017	0.1083	0.1164	0.1264	0.1569	0.1016***
IBES based ICCs	0.1105	0.1057	0.0987	0.0925	0.0969	0.0973	0.0924	0.0932	0.0886	0.0896	-0.0210***
Regression based ICCs	0.1992	0.1764	0.1578	0.1480	0.1461	0.1377	0.1295	0.1260	0.1210	0.1112	-0.0880***

benefits of debt, such as tax shields, and the disciplinary role of short-term debt. Specific to banks, substituting equity for deposits means losing the benefits provided by the Federal Deposit Insurance Corporation that allows banks to obtain cheap financing by issuing insured deposits. However, bankers complain that the insurance premium they pay more than offsets these benefits (Miller 1995). Thus, the effect of higher levels of capital on the cost of debt depends on the cost–benefit trade-off associated with equity and debt financing. To investigate this trade-off, we collect information about the after-tax cost of debt from Bloomberg. This information is only available after January 2000, restricting the analyses of the cost of debt to the period from 2000 to 2013.

Table 5 shows that the average after-tax cost of debt declines with the level of bank capital. Panel A shows that prior to the financial crisis, banks in the highest Tier-1 capital decile had a 10 bp lower cost of debt than banks in the lowest decile. This difference rose to 49 bp after the crisis. One possible reason that banks' cost of debt experienced a significant decline after the financial crisis was the Federal Reserve's low-interest rate policy: the average after-tax cost of debt for banks in the 5th ETOA decile declined from 3.53% before the financial crisis to 2.71% afterwards. These results are stronger in Panel B, when the ETOA is the measure of capital adequacy.

3.3 Regression analysis of the association between capital and the costs of equity and debt

The univariate analysis in the prior subsection indicates that the costs of equity and debt decline when capital increases. We now consider bank characteristics and market-wide factors that can affect the association between the level of capital and banks' cost of doing business.

We first estimate a parsimonious model that is similar to the model in Baker and Wurgler (2015). The estimation of Eq. (1) is useful for comparing our analysis that uses the ICC with the analysis by Baker and Wurgler (2015) that uses historical returns to estimate the cost of equity.

$$ICC_{i,t} = \upsilon_0 + \upsilon_1 Bank\ capital_{it} + \upsilon_2 Ln\ Book\ value_{it} + \upsilon_3 Beta_{it} + \upsilon_4 Market\ to\ Book_{it} + \pounds_{it} \tag{1}$$

We analyze IBES-based and regression-based ICCs, and two measures of *Bank capital* used in related studies (Kashyap et al. 2010; Baker and Wurgler 2015): T1CTORWA and ETOA.

Panel A of Table 6 shows the estimation of Eq. (1) using the cross-sectional regression approach of Fama and MacBeth (1973), which is commonly used by financial economists to address inference problems caused by correlation in the residuals that can be present in panel data sets (e.g., Petersen 2009). The results consistently demonstrate a negative association between capital and IBES-based ICCs. For instance, Model (1) shows that a 10 percentage point increase in Tier-1 capital is associated with a 116 bp reduction in the cost of equity. These results differ from the positive association between capital and the cost of equity estimated in Baker and Wurgler (2015). They find that higher capital ratios are associated with lower betas, but banks with lower betas have higher stock returns (the low-risk anomaly).

Panel B presents the bank fixed-effects regression analysis of Eq. (1) with the addition of *Financial crisis* that is an indicator variable that represents the start of the 2007–2008

Table 5 Level of capital and banks' after-tax cost of debt. This table presents the average after-tax cost of debt for banks allocated into deciles based on their level of capital. Panel A groups banks into deciles based on Tier-1 capital to risk-weighted assets ratio (T1CTORWA). Panel B allocates banks into deciles based on equity to total assets (ETOA). The analysis is reported for the overall sample period, for the pre-financial crisis period (January 2000 to June 2007), and for the post-financial crisis period (July 2007 to December 2013)

Panel A. Average cost of debt (%) by T1CTORWA deciles										
Decile	1	2	3	4	5	6	7	8	9	10	(10)-(1)
Period January 2000 to December 2013											
Cost of debt	0.0345	0.0339	0.0333	0.0333	0.0334	0.0332	0.0333	0.0343	0.0344	0.0326	-0.0019***
Period January 2000 to June 2007											
Cost of debt	0.0358	0.0356	0.0353	0.0353	0.0353	0.0352	0.0353	0.0364	0.0365	0.0348	-0.0010**
Period July 2007 to December 2013											
Cost of debt	0.0302	0.0285	0.0267	0.0267	0.0271	0.0266	0.0266	0.0271	0.0272	0.0253	-0.0049***
Panel B. Average after-tax cost of debt (%) by ETOA deciles											
Decile	1	2	3	4	5	6	7	8	9	10	(10)-(1)
Period January 2000 to December 2013											
Cost of debt	0.0367	0.0348	0.0341	0.0339	0.0334	0.0332	0.0329	0.0328	0.0314	0.0328	-0.0039***
Period January 2000 to June 2007											
Cost of debt	0.0382	0.0366	0.0361	0.0358	0.0354	0.0351	0.0351	0.0349	0.0332	0.0351	-0.0031***
Period July 2007 to December 2013											
Cost of debt	0.0317	0.0289	0.0277	0.0276	0.0271	0.0269	0.0255	0.0258	0.0254	0.0255	-0.0062***

Table 6 Fama–Macbeth and fixed-effects regression analyses of the association between equity capital and banks' ICC. Panel A presents the estimation of Eq. (1) using the Fama–MacBeth's (1973) regressions. Panel B presents the bank fixed-effects estimation of Eq. (1). The dependent variable in Models (1)–(4) is the composite IBES-based ICCs, and in Models (5)–(8) is the composite regression-based ICC. The table presents the analysis of two measures of *Banks Capital*: T1CTORWA and ETOA. These measures, ICC estimates, and the other independent variables are described in detail in Table 1

	IBES-based ICCs				Regression-based ICCs			
	T1CTORWA (1)	T1CTORWA (2)	ETOA (3)	ETOA (4)	T1CTORWA (5)	T1CTORWA (6)	ETOA (7)	ETOA (8)
Panel A. Fama–MacBeth regressions								
Bank capital	-0.1158***	-0.1321***	-0.0986***	-0.1275***	-0.1287***	-0.1881***	-0.3833***	-0.3810***
	(7.62)	(8.68)	(8.16)	(9.96)	(2.94)	(6.10)	(6.59)	(11.85)
Ln Book value		-0.0012***		-0.0004		-0.0098***		-0.0078***
		(4.04)		(1.38)		(6.83)		(5.61)
Beta		0.0027***		0.0021***		0.0030*		0.0009
		(4.80)		(3.64)		(1.81)		(0.53)
Market-to-book		-0.0079***		-0.0087***		-0.0259***		-0.0279***
		(11.05)		(10.44)		(11.99)		(12.34)
Constant	0.1034***	0.1301***	0.0992***	0.1177***	0.1327***	0.2963***	0.1555***	0.2892***
	(36.47)	(21.80)	(44.03)	(23.31)	(17.39)	(13.95)	(18.58)	(13.52)
Obs	16,227	15,076	16,227	15,076	24,012	21,872	24,012	21,872
R^2	0.0315	0.1387	0.0183	0.1283	0.0224	0.3170	0.0388	0.3376
Panel B. Fixed effects regressions								
Bank capital	-0.1281***	-0.1277***	-0.0879***	-0.1068***	-0.1606***	-0.1620***	-0.2918***	-0.3014***
	(7.24)	(7.32)	(3.36)	(3.59)	(4.27)	(3.92)	(4.60)	(3.90)
Ln Book value		-0.0011		-0.0004		-0.0124***		-0.0088**
		(1.05)		(0.33)		(3.49)		(2.48)
Beta		0.0038***		0.0029**		0.0114***		0.0109***
		(2.87)		(2.20)		(2.97)		(2.87)
Market-to-book		-0.0060***		-0.0062***		-0.0149***		-0.0157***
		(8.91)		(9.01)		(9.11)		(9.40)

Table 6 (continued)

	IBES-based ICCs				Regression-based ICCs			
	T1CTORWA (1)	T1CTORWA (2)	ETOA (3)	ETOA (4)	T1CTORWA (5)	T1CTORWA (6)	ETOA (7)	ETOA (8)
TED spread		0.0105***		0.0119***		0.0094***		0.0110***
		(11.52)		(12.40)		(3.16)		(3.67)
Financial crisis	0.0118***	0.0030**	0.0115***	0.0024	0.0483***	0.0339***	0.0494***	0.0327***
	(9.10)	(2.02)	(8.68)	(1.57)	(15.64)	(8.56)	(15.77)	(8.58)
Constant	0.1014***	0.1202***	0.0939***	0.1061***	0.1201***	0.2882***	0.1269***	0.2541***
	(48.53)	(9.07)	(39.68)	(7.83)	(25.84)	(6.62)	(22.50)	(5.97)
Obs	16,227	15,076	16,227	15,076	24,012	21,872	24,012	21,872
R^2	0.0543	0.1103	0.0406	0.1003	0.1305	0.1548	0.1332	0.1567

The *t*-statistics, in absolute values, are in parentheses. Significance levels are indicated as follows: * = 10%, ** = 5%, *** = 1%

financial crisis. Market-wide conditions affect banks' cost of financing. For the sake of simplicity, in this parsimonious model we include only the *TED spread* (the difference between the 3-month LIBOR and the 3-month T-bill rate) as an indicator of the perceived credit risk in the overall economy (e.g., Cornett et al. 2011). Model (1) shows that a 10 percentage point increase in Tier-1 capital is associated with about 128 bp decline in IBES-based ICC. Table 14 in Appendix A presents the analysis for the different ICC models in Table 1. The coefficients for *Bank capital* differ in magnitude but are consistent with the findings in Table 4 that supports the negative association between banks' level of capital and ICC not being dependent on the different measures of capital adequacy.

The coefficients are significantly larger in Models (5)–(8) when we use the regression-based ICCs. Hou et al. (2012) find that IBES-based estimations are more accurate, while Li and Mohanram (2014) argue that the Hou et al.'s (2012) model performs worse than a naïve random walk model as a predictor of earnings. In results not reported, we find that the absolute forecasting errors in earnings are significantly smaller for IBES than for the regression-based ICCs, especially after the financial crisis. The regression-based ICCs are unreliable following the onset of the crisis because post-crisis earnings are lower than predicted when using pre-crisis information. Thus, during the financial crisis, the implied discount rate needs to increase to equate the present value of those predicted high payoffs to the depressed stock prices. This explains why regression-based ICCs increased significantly more than IBES-based ICCs after the outbreak of the financial crisis. For these reasons, the IBES-based ICCs are the focus of our analysis in the rest of the manuscript.

The estimation of Eq. (1) offers preliminary evidence that the cost of equity measured by the ICC declines with the level of capital. We extend Eq. (1) with measures of the riskiness of banks' assets and liabilities, additional risk factors in the returns on stocks and bonds, and measures of the economic environment faced by investors:

$$\begin{aligned} Cost\ of\ Capital_{it} &= \pounds_0 + \pounds_1 Bank\ capital_{it} + \pounds_2 Ln\ Book\ value_{it} + \pounds_3 Beta_{it} + \pounds_4 Market\ to\ Book_{it} \\ &+ \pounds_5 ROE_{it} + \pounds_6 Efficiency\ ratio_{it} + \pounds_7 Liquid\ assets_{it} + \pounds_8 Ln\ Z_{it} + \pounds_9 Deposits\ to\ assets_{it} \\ &+ \pounds_{10} Int.\ income\ to\ revenues_{it} + \pounds_{11} Loan\ concentration_{it} + \pounds_{12} Real\ estate\ loans_{it} \\ &+ \pounds_{13} Non-performing\ loans_{it} + \pounds_{14} TED\ spread_t + \pounds_{15} High\ VIX_t + \pounds_{16} Bond\ liquidity_t \\ &+ \pounds_{17} Yield\ curve_t + \pounds_{18} T-10\ ret_t + \pounds_{19} Corporate\ bonds\ ret_t + \pounds_{20} Financial\ Crisis_t + \Omega_{it} \end{aligned} \tag{2}$$

Equation (2) includes measures to evaluate the banks' performance and the riskiness of their assets. Return on equity *(ROE*) and *Efficiency ratio* are important determinants in our analysis because investors require lower returns from better performing and more efficient banks. We include *Loan concentration,* computed as the Herfindahl–Hirschman index of the size of different loan categories, because loan portfolios are riskier when they are more highly concentrated (e.g., Berger and Bouwman 2013). *Real estate loans* gauges banks' exposure to real estate, which had a negative impact on banks' performance during the financial crisis. *Nonperforming loans* is an additional measure to evaluate the quality of banks' assets. Beltratti and Stulz (2012) argue that banks with more liquid assets can reduce their balance sheet when facing financing problems. A high ratio of liquid assets to assets (*Liquid assets*) should thus diminish investors' perceptions of the risk of banks' operations. We include the distance to default (*Ln Z*), which was introduced by Laeven and Levine (2009), as a measure that is inversely related to the probability of insolvency.

Equation (2) also contains measures correlated with the perceived risk of banks' liabilities. We include the *Deposits to assets,* which is the ratio of deposits to banks' assets, because Ivashina and Scharfstein (2010) find evidence that during the 2007–2008 financial crisis, banks that had better access to deposit financing cut their lending by less than other banks. This finding suggests that the amount of deposits decreases the perceived risk of banks. The variable *Interest income to revenues* is included to account for the effect of different businesses models (e.g., Gropp et al. 2018). We also add several measures of liquidity and market risk. *High VIX*, which is one of the proxies for bad times in Bouwman et al. (2018), identifies the months when the Chicago Board Options Exchange volatility index is above its 80th percentile. The VIX Index is also used as an indicator of risk aversion (e.g., Bekaert et al. 2013). *Bond liquidity,* which is proposed by Fontaine and Garcia (2012), is a liquidity risk factor constructed using bond liquidity premiums. *Yield curve* is computed as the change in the 10-year minus the 1-year Treasury constant maturity yield. These measures of frictions in the credit markets should impact risk premiums and thus banks' cost of capital. We analyze the effect of two bond-risk factors proposed by Gandhi and Lustig (2015). *T-10 ret* is the excess return on an index of 10-year government bonds, and *Corporate bonds ret* is the excess returns on an index of investment-grade bonds.

Table 7 reports the estimation of Eq. (2). The dependent variable is the ICC in Models (1) and (2), and the cost of debt in Models (3) and (4). All the variables are winsorized at the 1st and 99th percentiles to mitigate the impact of possible outliers. All the models include bank fixed effects to account for unobserved time-invariant bank characteristics.

The results demonstrate that both the cost of equity and the cost of debt decline with bank capital. A 10 percentage point increase in T1CTORWA is associated with 74 bp lower IBES-based ICCs and with 20 bp lower after-tax cost of debt. This analysis also shows that an increase in banks' market-to-book ratio is associated with lower costs of equity and debt. The rest of the coefficients suggest that the determinants of the costs of equity and debt are different. Banks' book value of equity, profitability, and distance to default are not significantly associated with the ICC, but they are negatively associated with the cost of debt. Banks with more deposits and fewer nonperforming loans have a lower cost of debt, but the coefficients for these variables are statistically insignificant in the analysis of the ICC. Banks' cost of equity increases with loan concentration and declines with the amount of real estate loans, but these attributes lack statistical significance in the analysis of the cost of debt. Control variables related to market-wide conditions are more relevant than banks' specific characteristics in explaining their cost of equity. Measures to gauge frictions in credit markets are important to explain the cross-sectional variation in the cost of debt.

3.3.1 Regression analysis of the association between capital and the costs of equity and debt before and after the onset of the 2007–2008 financial crisis

The univariate analysis in Table 4 shows that the association between the level of capital and its cost changed during the financial crisis. To examine this finding in a multivariate setting, Table 8 presents the estimation of Eq. (2) in the pre- and post-financial crisis periods. For the sake of conciseness, we only report the main variables of interest; the complete estimation can be found in Table OA5 of the Online Appendix.

Models (1)–(4) show that the association between the ICCs and bank capital is stronger after the outbreak of the financial crisis. A 10 percentage point increase in T1CTORWA is associated with a 50 bp decline in the ICC before the financial crisis but with a 114 bp decline after the financial crisis. The adjusted R^2 indicates that the model does a better job

Table 7 The impact of bank specific characteristics and market conditions on the association between the level of capital and the costs of equity and debt. This table presents the bank fixed-effects estimation of Eq. (2). Models (1)–(2) give the analysis when the dependent variable is the composite IBES-based ICC. Models (3)–(4) give the analysis when the dependent variable is the after-tax cost of debt.. The table presents the analysis of two measures of *Banks Capital*: T1CTORWA and ETOA. The measures of the capital level, ICC estimates, after-tax cost of debt, and the other independent variables are described in Table 1

	Period 1996/01 – 2013/12		Period 2000/01 – 2013/12	
	IBES-based ICC		After-tax cost of debt	
	T1CTORWA	ETOA	T1CTORWA	ETOA
	(1)	(2)	(3)	(4)
Bank capital	-0.0715***	-0.0830***	-0.0202**	-0.0371***
	(3.83)	(2.87)	(2.01)	(3.19)
Ln Book value	0.0031*	0.0040**	-0.0019***	-0.0016**
	(1.94)	(2.42)	(2.80)	(2.48)
Beta	0.0002	0.0002	0.0003	0.0003
	(0.10)	(0.13)	(0.61)	(0.60)
Market-to-book	-0.0055***	-0.0058***	-0.0007***	-0.0009***
	(6.96)	(7.13)	(2.62)	(3.14)
ROE	-0.0070	-0.0065	-0.0133***	-0.0129***
	(1.10)	(1.00)	(7.52)	(7.28)
Efficiency ratio	-0.0136**	-0.0128**	-0.0077***	-0.0074***
	(2.23)	(2.13)	(4.09)	(3.82)
Liquid assets	-0.0042	-0.0110*	0.0014	-0.0012
	(0.69)	(1.83)	(0.53)	(0.53)
Ln Z	-0.0006	-0.0003	-0.0012***	-0.0010***
	(1.23)	(0.69)	(6.92)	(6.14)
Deposit to assets	0.0084	0.0090	-0.0125***	-0.0127***
	(0.88)	(0.95)	(3.50)	(3.60)
Int. income to revenues	0.0001	0.0000	0.0000	0.0000
	(0.19)	(0.10)	(0.04)	(0.11)
Loan concentration	0.0267***	0.0261***	-0.0075	-0.0080
	(3.13)	(3.20)	(1.02)	(1.09)
Real estate loans	-0.0279***	-0.0286***	0.0070	0.0073
	(2.99)	(3.28)	(0.78)	(0.84)
Non-performing loans	-0.0663	-0.0875	0.1596***	0.1569***
	(0.64)	(0.85)	(3.07)	(3.07)
TED spread	0.0036**	0.0035**	0.0043***	0.0043***
	(2.26)	(2.22)	(12.29)	(12.34)
High VIX	0.0014***	0.0014***	-0.0016***	-0.0016***
	(3.35)	(3.37)	(10.49)	(10.64)
Bond liquidity	-0.0027***	-0.0028***	-0.0047***	-0.0047***
	(5.78)	(5.89)	(30.35)	(30.87)
Yield curve	0.0000	-0.0001	-0.0010***	-0.0010***
	(0.08)	(0.11)	(5.07)	(5.02)
T-10 ret	-0.0579***	-0.0566***	0.1675***	0.1685***
	(2.92)	(2.84)	(34.31)	(34.81)

Table 7 (continued)

	Period 1996/01 – 2013/12		Period 2000/01 – 2013/12	
	IBES-based ICC		After-tax cost of debt	
	T1CTORWA	ETOA	T1CTORWA	ETOA
	(1)	(2)	(3)	(4)
Corporate bond ret	0.0596**	0.0633**	-0.0334***	-0.0318***
	(2.10)	(2.22)	(5.86)	(5.60)
Financial crisis	0.0015	0.0017	-0.0049***	-0.0050***
	(0.55)	(0.63)	(14.63)	(14.74)
Year/quarter dummies	Yes	Yes	Yes	Yes
Constant	0.0619**	0.0492*	0.0759***	0.0731***
	(2.32)	(1.83)	(6.39)	(6.52)
Obs	13,492	13,492	16,042	16,042
R^2	0.2533	0.2525	0.6664	0.6671

The *t*-statistics, in absolute values, are in parentheses. Significance levels are indicated as follows: * = 10%, ** = 5%, *** = 1%

in explaining the variance of the ICC before the financial crisis.[9] The estimation in Models (5)–(8) indicates that after controlling for bank-specific characteristics and market-wide conditions, the association between capital and the cost of debt is stronger before than after the financial crisis. A 10 percentage point increase in T1CTORWA is associated with about a 36 bp decline in the after-tax cost of debt before the financial crisis, but with a 13 bp decline after the financial crisis.

This analysis allows us to contrast the stability of the structural models in the pre- and post-financial crisis periods without imposing restrictions on the distribution of the error terms. The disadvantage of performing separate analyses for both periods is a loss of information. As an alternative analysis, Panel A in Table 15 in Appendix B gives an estimation of Eq. (2) that uses interaction terms. The coefficient for *Bank capital post-crisis* is twice as large as the coefficient for *Bank capital pre-crisis.* This analysis confirms that the negative association between the level of capital and banks' ICCs is stronger after the onset of the crisis. However, we cannot reject that the association between capital and the cost of debt is similar before and after the financial crisis.

[9] In the analysis of the ICC, several bank characteristics are statistically significant only before the crisis: the ICC increases with *Ln Book value* and *Loan concentration* and is negatively associated with banks' *ROE* and *Real estate loans*. After the crisis there is a negative association between the ICC, *Deposit to assets* and *Nonperforming loans*. The coefficient for *High VIX* is negative before the crisis, but positive afterwards. These findings can be explained because market participants assign a low value to risk during expansions and become more risk averse during contractions. In the analysis of the cost of debt, nonperforming loans are positively associated with banks' cost of debt, but only after the crisis.

Table 8 Analysis of the association of capital with the cost of equity, and with the cost of debt in the pre- and post-financial crisis periods. This table presents the bank fixed-effects estimation of Eq. (2). Models (1)–(4) give the analysis when the dependent variable is the composite IBES-based ICC. Models (5)–(8) give the analysis when the dependent variable is the after-tax cost of debt. The analysis is performed for the pre-financial-crisis period (2000/01—2007/06), and for the post-financial crisis period (2007/07–2013/12). The table presents the analysis of two measures of *Bank Capital*: T1CTORWA and ETOA. The measures of the capital level, ICC estimates, after-tax cost of debt, and the other independent variables are described in Table 1. All models include the characteristics in Eq. (2). But for the sake of brevity, we only report the estimate results of banks' capital, size, beta, market-to-book, and ROE in this table

	Period 1996/01 – 2007/06		Period 2007/07 – 2013/12		Period 2000/01 – 2007/06		Period 2007/07 – 2013/12	
	Composite IBES-based ICC				After-tax cost of debt			
	T1CTORWA	ETOA	T1CTORWA	ETOA	T1CTORWA	ETOA	T1CTORWA	ETOA
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Bank capital	-0.0494***	-0.0636**	-0.1150***	-0.1239**	-0.0357***	-0.0487***	-0.0142	-0.0178
	(2.84)	(2.33)	(2.96)	(2.06)	(2.87)	(4.15)	(1.53)	(1.43)
Ln Book value	0.0048***	0.0056***	-0.0040	-0.0027	-0.0024**	-0.0015	-0.0059***	-0.0065***
	(3.11)	(3.60)	(0.83)	(0.55)	(2.19)	(1.57)	(5.00)	(5.46)
Beta	0.0003	0.0004	-0.0091**	-0.0095***	0.0002	0.0003	-0.0015**	-0.0018**
	(0.17)	(0.23)	(2.59)	(2.71)	(0.19)	(0.29)	(2.25)	(2.58)
Market-to-book	-0.0032***	-0.0035***	-0.0028	-0.0037	-0.0001	-0.0003	-0.0009**	-0.0007*
	(5.29)	(5.59)	(1.14)	(1.46)	(0.23)	(0.95)	(2.07)	(1.65)
ROE	-0.0411***	-0.0415***	-0.0075	-0.0076	-0.0127***	-0.0132***	-0.0089***	-0.0085***
	(10.69)	(10.85)	(0.81)	(0.81)	(6.41)	(6.66)	(5.40)	(5.45)
Market-wide characteristics	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year/quarter dummies	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Constant	0.0377	0.0274	0.2629***	0.2502***	0.0997***	0.0863***	0.1298***	0.1365***
	(1.60)	(1.19)	(3.72)	(3.55)	(5.73)	(5.94)	(7.61)	(8.03)
Obs	8953	8953	4539	4539	9339	9339	6703	6703
R^2	0.3727	0.3724	0.1364	0.1346	0.6784	0.6786	0.6632	0.6501

The *t*-statistics, in absolute values, are in parentheses. Significance levels are indicated as follows: * = 10%, ** = 5%, *** = 1%

Table 9 Level of capital and banks' WACC. This table presents the average weighted average cost of capital (WACC) for banks grouped by their level of capital. WACC is computed using composite (average) IBES-based ICCs. Panel A groups banks into deciles based on equity-to-total assets (ETOA). Panel B allocates banks into deciles based on Tier-1 capital to risk-weighted assets ratio (T1CTORWA). The analysis is reported for the overall sample period, for the pre-financial crisis period (January 2000 to June 2007), and for the post-financial crisis period (July 2007 to December 2013)

Panel A. Average IBES-based WACC (%) by T1CTORWA deciles										
1	2	3	4	5	6	7	8	9	10	(10)-(1)
Period January 2000 to December 2013										
0.0394	0.0391	0.0392	0.0387	0.0388	0.0381	0.0384	0.0389	0.0383	0.0382	-0.0012**
Period January 2000 to July 2007										
0.0403	0.0401	0.0401	0.0401	0.0400	0.0394	0.0397	0.0402	0.0399	0.0402	-0.0001
Period July 2007 to December 2013										
0.0346	0.0347	0.0351	0.0337	0.0345	0.0339	0.0339	0.0347	0.0337	0.0326	-0.0020*
Panel B. Average IBES-based WACC (%) by ETOA deciles										
1	2	3	4	5	6	7	8	9	10	(10)-(1)
Period January 2000 to December 2013										
0.0404	0.0393	0.0391	0.0386	0.0379	0.0380	0.0380	0.0387	0.0373	0.0402	-0.0002
Period January 2000 to July 2007										
0.0412	0.0403	0.0404	0.0401	0.0391	0.0391	0.0395	0.0400	0.0386	0.0419	0.0007
Period July 2007 to December 2013										
0.0357	0.0346	0.0336	0.0332	0.0338	0.0342	0.0332	0.0340	0.0334	0.0356	-0.0001

4 Banks' capital and their WACC

The analysis so far has demonstrated a negative association between banks' costs of equity and debt and banks' capital. These results, however, do not necessarily entail a negative association between the level of capital and banks' WACC because, as theorized by M-M, additional equity reduces its cost, and this reduction offsets the increased weight of equity in the capital structure.[10] In this section, we explore the potential impact of the level of capital on banks' WACC.

Table 9 shows the WACC of banks grouped into capital level deciles. The WACC is estimated as the weighted average of the cost of equity (measured by the ICC) and the after-tax cost of debt in which the weights are the ETOA ratio and the (1-ETOA), respectively. There are small differences in the WACC when comparing the best- and the worst-capitalized banks. Panel A shows that the average IBES-based WACC is only 12 bp higher for banks in the lowest Tier-1 capital decile than for those in the highest decile. This difference is 2 bp when capital level is measured by the ETOA in Panel B. The overall cost of capital for a bank in the 5th ETOA decile declined by 53 bp (from 3.91% before the crisis to 3.38% after the crisis). This decline in the WACC may be explained by the near-zero

[10] For instance, in our sample, the average ETOA for banks in the 5th decile is 8.91%, the average cost of equity is 9%, and the average cost of debt is 2.71%. For banks in the 10th decile, the average ETOA is 15.24%, the average cost of equity is 8.6%, and the average cost of debt is 2.55%. Thus, on average, banks with more equity have lower costs of equity and debt. However, we do not find this association between equity and the WACC. The WACC for banks in the 5th decile is 3.27% (2.71% × 91.09% + 9% × 8.91%), and the WACC for the best-capitalized banks is 3.472% (2.55% × 84.76% + 8.6% × 15.24%). Consistent with the M&M theory, substituting equity for cheaper debt does not have a significant effect on the banks' overall cost of capital in our sample.

interest rate monetary policy and by the intensification in the provision of liquidity to the banking system in response to the crisis.

Table 10 reports the estimation of Eq. (2) when the WACC is the dependent variable. The coefficient for *Bank capital* lacks statistical significance before and after the financial crisis. Models (5) and (6) of Panel A in Table 15 in Appendix B indicate that we cannot reject that the association between the level of capital and the WACC is similar before and after the financial crisis.

In robustness checks (unreported), we obtain qualitatively identical conclusions when we use the alternative measures of capital adequacy in Table 2 and the regression-based ICC. To analyze whether the results are driven by banks with low and high levels of capital for circumstances not accounted for by our control variables, we replicate the analysis excluding banks in the 10^{th} and 90^{th} equity capital deciles and we obtain similar results to those reported here.

5 The potential effects of the endogeneity between banks' level of capital and its cost

The analyses in the prior sections have demonstrated that the cost of equity and the cost of debt decline, while the overall cost of capital remains unaltered when the level of capital increases. However, two potential sources of endogeneity exist in our study that cast doubts on these findings. First, banks may hold capital as a buffer against negative shocks that may reduce their capital below minimum requirements, which might force them to either raise additional capital or to cut dividends. If banks with riskier operations adopt higher levels of capital as a cushion, then the level of capital and its cost are endogenous. Second, there might be unobserved banks' characteristics that affect their access to capital. Thus, *Bank capital* may be correlated with the error terms in Eq. (2) that will result in inconsistent estimators of the coefficients reported earlier. Absent a natural experiment, without a shock to capital unrelated to the cost of capital, we are left with econometric alternatives to infer the effect of endogeneity. In this section we use an instrumental variable estimation approach and a dynamic GMM panel estimator to account for this endogeneity.

5.1 An instrumental variable estimation approach

We estimate Eq. (2) using two instrumental variables (IV) for the level of capital to address the potential effects of endogeneity. Our first IV is the average level of capital in the prior 12 quarters (similar findings are obtained if we use the prior 4 or 8 quarters). The rationale for including this IV is the potential effect of observable and unobservable bank characteristics that are correlated with the capital in prior quarters but not necessarily with the error terms. The second IV captures the risk of banks dropping below the minimum required level of capital. To assess this risk, we add the variable *Stdvt of bank capital* that is the standard deviation of the capital ratio during the prior 12 quarters. Ceteris paribus, banks that can sustain a stable level of capital should hold less capital for precautionary reasons.[11]

[11] We also consider using banks' weighted average effective state income tax rate, an IV proposed by Ashcraft (2008) and by Berger and Bouwman (2009, 2013). Schandlbauer (2017) finds that the state corporate income tax rate has a first order effect on banks' capital structure. However, we cannot reject at conventional significance levels the null hypothesis that the coefficient of this measure equals zero in the reduced-form equation. The finding that the effective state tax rate is not correlated with the level of capital after considering the effect of other exogenous variables indicates that it is not a good IV candidate for bank capital in our sample.

Table 10 Analysis of the association between equity capital and banks' WACC. This table presents bank fixed-effects estimation of Eq. (2). The table presents the analysis of two measures of *Bank Capital*: T1CTORWA and ETOA. The dependent variable is the WACC that is computed using composite IBES-based ICCs. The measures of the capital level, ICC estimates, and the other independent variables are described in Table 1. Models (1)–(2) shows the analysis for the complete sample period; Models (3)–(4) for the pre-financial crisis period; and Models (5)–(6) for the post-financial crisis period

	Period 2000–2013		January 2000 to June 2007		July 2007 to December 2013	
	T1CTORWA (1)	ETOA (2)	T1CTORWA (3)	ETOA (4)	T1CTORWA (5)	ETOA (6)
Bank Capital	0.0011	0.0037	-0.0112	-0.0007	0.0013	0.0215
	(0.11)	(0.29)	(1.06)	(0.06)	(0.12)	(1.60)
Ln Book value	-0.0011*	-0.0011*	-0.0006	-0.0004	-0.0055***	-0.0060***
	(1.65)	(1.70)	(0.62)	(0.43)	(4.09)	(4.40)
Beta	-0.0003	-0.0003	-0.0006	-0.0006	-0.0024***	-0.0025***
	(0.52)	(0.52)	(0.63)	(0.62)	(2.89)	(3.35)
Market-to-book	-0.0012***	-0.0012***	-0.0008***	-0.0008**	-0.0016***	-0.0012**
	(4.05)	(3.64)	(2.66)	(2.56)	(3.00)	(2.22)
ROE	-0.0170***	-0.0170***	-0.0172***	-0.0170***	-0.0121***	-0.0170***
	(5.12)	(5.18)	(9.48)	(9.14)	(4.66)	(6.86)
Efficiency ratio	-0.0092***	-0.0093***	0.0008	0.0011	-0.0132***	-0.0134***
	(4.11)	(4.14)	(0.17)	(0.23)	(5.06)	(5.40)
Liquid assets	-0.0014	-0.0012	0.0015	0.0011	0.0059*	0.0061*
	(0.58)	(0.50)	(0.59)	(0.40)	(1.90)	(1.85)
Ln Z	-0.0008***	-0.0008***	-0.0002	-0.0003	-0.0009***	-0.0010***
	(4.62)	(4.74)	(1.08)	(1.15)	(4.06)	(4.38)
Deposits to assets	-0.0078**	-0.0077**	-0.0025	-0.0019	-0.0071	-0.0075
	(2.21)	(2.15)	(0.66)	(0.54)	(1.34)	(1.45)
Int. income to revenues	0.0001	0.0001	0.0034	0.0033	0.0000	0.0000
	(0.26)	(0.26)	(0.85)	(0.83)	(0.17)	(0.33)
Loan concentration	-0.0066	-0.0066	-0.0205***	-0.0205***	-0.0006	-0.0005
	(0.81)	(0.80)	(2.65)	(2.64)	(0.07)	(0.06)
Real estate loans	0.0080	0.0080	0.0178**	0.0175**	0.0071	0.0069
	(0.83)	(0.82)	(2.09)	(2.07)	(0.72)	(0.71)
Non-performing loans	0.1687***	0.1682***	-0.0868	-0.0930	0.2195***	0.1911***
	(2.81)	(2.78)	(0.54)	(0.57)	(4.43)	(3.91)
TED spread	0.0046***	0.0046***	0.0062***	0.0062***	0.0062***	0.0064***
	(11.16)	(11.22)	(8.28)	(8.26)	(15.26)	(16.25)
High VIX	-0.0014***	-0.0014***	-0.0046***	-0.0046***	0.0005**	0.0006***
	(7.68)	(7.76)	(28.26)	(27.95)	(2.55)	(2.71)
Bond liquidity	-0.0045***	-0.0045***	-0.0001	-0.0001	-0.0086***	-0.0087***
	(26.66)	(27.21)	(0.45)	(0.38)	(35.28)	(37.86)
Yield curve	-0.0008***	-0.0008***	-0.0044***	-0.0044***	-0.0028***	-0.0030***
	(3.76)	(3.74)	(20.63)	(20.22)	(8.25)	(8.86)
T-10 ret	0.1403***	0.1400***	0.4188***	0.4188***	0.1991***	0.1990***
	(22.87)	(22.89)	(35.48)	(35.46)	(26.21)	(26.42)
Corporate bond ret	-0.0115*	-0.0115*	-0.3935***	-0.3932***	-0.0048	-0.0057
	(1.66)	(1.70)	(24.16)	(24.18)	(0.62)	(0.73)

Table 10 (continued)

	Period 2000–2013		January 2000 to June 2007		July 2007 to December 2013	
	T1CTORWA (1)	ETOA (2)	T1CTORWA (3)	ETOA (4)	T1CTORWA (5)	ETOA (6)
Financial crisis	-0.0044***	-0.0044***				
	(10.46)	(10.52)				
Year/quarter dummies	Yes	Yes	Yes	Yes	Yes	Yes
Constant	0.0617***	0.0617***	0.0672***	0.0634***	0.1385***	0.1427***
	(5.20)	(5.31)	(4.71)	(4.90)	(7.16)	(7.13)
Obs	10,688	10,688	6161	6161	4527	4527
R^2	0.6933	0.6934	0.7558	0.7556	0.6828	0.6841

The *t*-statistics, in absolute values, are in parentheses. Significance levels are indicated as follows: * = 10%, ** = 5%, *** = 1%

Table 11 presents the IV estimation of Eq. (2). The results are broadly consistent with those in the other sections. In the analysis of the ICC, the coefficients for *Bank capital* have a negative sign and are larger in both magnitude and statistical significance than those in the fixed-effects regression estimation. The negative association between the level of capital and the cost of equity is stronger after the financial crisis (Model 7) than before it (Model 4). The results further demonstrate a negative association between the level of capital and banks' after-tax cost of debt. There is no discernible relation between the level of capital and the WACC.

5.2 A dynamic general method of moments (GMM) panel estimation

The fixed-effects estimation ameliorates the bias that arises from unobservable heterogeneity. However, it assumes independency between the current observations of the explanatory variables and the past values of the dependent variable (the cost of capital in our analysis), or some other firm characteristics. If this assumption is not satisfied, then the fixed-effects regression is not consistent. It can be argued that this assumption is not fulfilled in our analysis because the current level of capital depends on prior levels of the cost of capital. To address this potential source of endogeneity, we replicate the analysis using the dynamic GMM panel estimator developed by Holtz-Eakin et al. (1988) and Arellano and Bond (1991).[12] This estimator comprises the lags of the cost of capital, bank characteristics, and market conditions as instruments. Specifically, we use lags of 2 to 8 (t-2 to t-8) in the untransformed variables as instruments. Our choice of the number of lags is driven by a trade-off: increasing the number of valid lags ensures exogeneity at the cost of using weak instruments that are measured with Hansen over-identification tests.

Table 12 presents the estimation of Eq. (2) after adding lag variables for the cost of capital and the level of capital. In the analysis of the cost of equity, we expand Eq. (2) with one lag for every measure of the cost of equity and capital ratios; we obtain similar findings when

[12] We use xtabond2 in Stata IC/15 to estimate the dynamic GMM regression. See subsection 3.3 and Appendix 1 in Wintoki et al. (2012) for a description of the implementation of xtabond2. We use the "collapse option" to reduce the proliferation of instruments.

Table 11 Instrumental variable analysis of the association between equity capital and banks' cost of capital. This table presents the second stage of the IV estimation of Eq. (2). The lagged levels of capital and *Stdvt of bank capital*, which is the standard deviation of the capital adequacy ratio during the prior 12 quarters, are used as instruments. Models (1)–(3) show the analysis of the complete sample; Models (4)–(6) the analysis of the pre-financial crisis period; and Models (7)–(9) the analysis of post-financial crisis period. Bank capital is measured by the ETOA ratio. The table presents the analysis of IBES-based ICCs, the after-tax cost of debt, and the WACC (computed using IBES-based ICCs). The control variables, whose coefficients are not reported are: *ROE, Deposits to assets, Liquid assets, Ln Z, Deposits to assets, Int. income to revenues, Loan concentration, Real estate loans, Non-performing loans, High VIX$_t$ Bond Liquidity, Yield curve, T-10 ret,* and *Corporate bond ret.* The measures of the capital level, ICC estimates, and the other independent variables are described in Table 1. The table presents the coefficients of the IV estimation in the first-stage and provides tests for the validity and relevance (or informative) criteria of the IVs. The weak-identification test denotes the Kleibergen-Paap rk Wald F statistic; the under-identification test displays the Kleibergen-Paap rk LM statistic

	Period 2000–2013			January 2000 to June 2007			July 2007 to December 2013		
	IBES-based ICCs (1)	Cost of debt (2)	IBES-based WACC (3)	IBES-based ICCs (4)	Cost of debt (5)	IBES-based WACC (6)	IBES-based ICCs (7)	Cost of debt (8)	IBES-based WACC (9)
Bank capital	-0.1527***	-0.0347***	0.0001	-0.1196***	-0.0859***	-0.0155	-0.1314**	-0.0354***	0.0119
	(6.22)	(4.39)	(0.01)	(4.57)	(4.81)	(1.39)	(2.22)	(2.73)	(0.95)
Ln Book value	0.0062***	0.0006*	0.0010***	0.0091***	-0.0015***	-0.0006	-0.0017	0.0013**	0.0018***
	(5.53)	(1.81)	(2.76)	(5.77)	(2.67)	(1.05)	(0.58)	(2.17)	(2.62)
Beta	0.0007	0.0006**	0.0004	-0.0020	0.0002	-0.0009*	-0.0084***	0.0004	0.0000
	(0.56)	(2.26)	(1.46)	(1.22)	(0.32)	(1.70)	(3.62)	(1.01)	(0.00)
Market-to-book	-0.0046***	-0.0008***	-0.0011***	-0.0034***	-0.0009***	-0.0012***	-0.0038**	-0.0004	-0.0007*
	(8.00)	(4.65)	(5.80)	(7.16)	(4.00)	(5.29)	(2.11)	(1.41)	(1.93)
TED spread	0.0027	0.0005	0.0007	0.0077**	0.0054***	0.0050***	-0.0083***	-0.0076***	-0.0063***
	(1.28)	(0.99)	(1.37)	(2.06)	(5.18)	(5.05)	(2.63)	(11.86)	(8.66)
Post-financial crisis	0.0003	-0.0027***	-0.0022***						
	(0.11)	(5.68)	(4.18)						
Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year/quarter dummies	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
First-stage IV variables									
Lag Bank capital	0.7739***			0.7493***			0.6656***		
	(61.85)			(40.63)			(31.58)		

Table 11 (continued)

	Period 2000–2013			January 2000 to June 2007			July 2007 to December 2013		
	IBES-based ICCs (1)	Cost of debt (2)	IBES-based WACC (3)	IBES-based ICCs (4)	Cost of debt (5)	IBES-based WACC (6)	IBES-based ICCs (7)	Cost of debt (8)	IBES-based WACC (9)
Stdv. of bank capital	0.1237***			0.0965			0.2325***		
	(13.09)			(1.42)			(4.12)		
Obs	9977	14,825	9977	5771	8610	5771	4206	6215	4206
R^2	0.2188	0.6851	0.7142	0.3297	0.6788	0.7563	0.1346	0.7143	0.7335
Weak-	479.57			143.66			109.28		
identification test	($p < 0.01$)			($p < 0.01$)			($p < 0.01$)		
Under-	740.23			275.22			187.76		
identification test	($p < 0.01$)			($p < 0.01$)			($p < 0.01$)		

The *t*-statistics, in absolute values, are in parentheses. Significance levels are indicated as follows: * = 10%, ** = 5%, *** = 1%

we use two, three, or four lags. In the analysis of the cost of debt and the WACC, we add two lags of the after-tax cost of debt and the WACC, respectively, because we cannot reject the null hypothesis of the second-order serial correlation when only one lag is included.

This analysis further demonstrates that the costs of equity and debt decline with the level of capital. The coefficients for *Bank capital (t)* are negative in the analyses of the costs of equity and debt, and they are larger in magnitude than in the fixed-effects and IV estimation. The coefficients for *Bank capital (t)* lack statistical significance in the analysis of the overall cost of capital. Thus, this analysis also fails to demonstrate a significant association between the two measures of capital adequacy and the overall cost of capital for banks. Table 12 gives the *p*-values for the Arellano–Bond tests of first- and second-order autocorrelations, and the *p*-value of the Hansen *J* test of over-identification. In each model, we can reject the null hypothesis of the first-order autocorrelation in the first differenced residuals. The fact that all the tests of the *AR* (2) and Hansen J have *p*-values of more than 10% indicates that we cannot reject the hypothesis that the second-order serial correlation is zero and the hypothesis that the instruments are valid.

6 The effect of bank size

Governments are more predisposed to provide support to larger rather than to smaller banks. For instance, during the 2007–2008 financial crisis, the 10 largest financial institutions received 83% of the emergency credit extended by the Federal Reserve (Gandhi and Lustig 2015). Ueda and di Mauro (2013) find that government subsidies to systemically important financial institutions translated into better credit ratings and advantages in funding costs. Gandhi and Lustig (2015) find that large commercial banks have lower risk-adjusted returns than small- and medium-sized banks, especially during the financial crisis. In a cross-country analysis, Gandhi et al. (2020) find that large financial firms earn lower returns than nonfinancial firms of similar size and risk exposure, and this difference is related to country characteristics that affect the likelihood of bailouts. Based on this evidence, they argue that equity is cheap for large financial institutions because implicit government guarantees absorb part of the risk borne by shareholders.

Motivated by this work, we analyze the impact of bank size on our analysis. We identify systemically important banks as those that participated in the SCAP or CCAR program after the financial crisis. To extend this analysis to before the financial crisis, we also identify banks with at least $50 billion in assets (in 2007 constant dollars) before the crisis. We choose $50 billion as the cutoff point because this was the threshold established in November 2011 by the Federal Reserve Board for banks to participate in the CCAR. Consistent with the findings in Gandhi and Lustig (2015), who use risk-adjusted returns as the measure of the cost of equity, Table 16 in Appendix C shows that, ceteris paribus, large banks have a lower ICC than other banks. This spread is wider after the onset of the financial crisis: large banks had 25 bp lower ICC than for other banks before the crisis, and 163 bp lower ICC after the onset of the crisis.

To analyze the impact of bank size on the association between the level of capital and its cost, we double sort banks by capital level deciles as well as asset quintiles. The results in Table 17 in Appendix D (Panels A1 and A2) show that the ICC declines when banks' level of capital and their size increase. One exception to this result is the best-capitalized banks: the cost of equity is greater for large than for small banks in the 10^{th} capital decile. The cost of debt also declines with banks' level of capital and size in the majority of the capital

Table 12 Dynamic panel GMM analysis of the association between banks' capital and their cost of capital. This table presents the dynamic GMM estimation of Eq. (2) that is expanded by lag variables of the cost of capital and the level of capital. The dependent variable is the cost of equity in Models (1)–(2), the cost of debt in Models (3)–(4), and the WACC in Models (5)–(6). *Bank Capital* represents two measures of bank capital (T1CTORWA and ETOA). *Controls* is a vector of the bank characteristics and market conditions in Eq. (2) that are described in Table 1. AR (1) and AR (2) are tests for first- and second-order autocorrelations in the first differenced residuals

	Cost of Equity		Cost of Debt		WACC	
	T1CTORWA (1)	ETOA (2)	T1CTORWA (3)	ETOA (4)	T1CTORWA (5)	ETOA (6)
Cost of equity (t-1)	0.6752***	0.6372***				
	(12.40)	(12.59)				
Cost of debt (t-1)			0.6132***	0.6531***		
			(8.53)	(9.92)		
Cost of debt (t-2)			0.0962**	0.0671		
			(1.99)	(1.47)		
WACC (t-1)					0.4276***	0.4508***
					(4.31)	(4.74)
WACC (t-2)					0.0855*	0.0928*
					(1.68)	(1.82)
Bank Capital (t)	-0.1545**	-0.2723**	-0.0836**	-0.0729**	0.0171	-0.0488
	(2.09)	(2.18)	(2.46)	(2.37)	(0.50)	(0.94)
Bank Capital (t-1)	0.1020	0.1669	0.0809***	0.0635**	-0.0132	0.0505
	(1.39)	(1.34)	(2.59)	(2.49)	(0.46)	(0.99)
Controls	Yes	Yes	Yes	Yes	Yes	Yes
Year/quarter dummies	Yes	Yes	Yes	Yes	Yes	Yes
Financial crisis	0.0014	0.0071***	-0.0032***	-0.0074***	-0.0013	-0.0015
	(0.55)	(2.81)	(4.56)	(11.53)	(1.20)	(1.43)
Constant	-0.0104	-0.0010	0.0130	0.0082	0.0215*	0.0163
	(0.33)	(0.03)	(1.33)	(0.87)	(1.81)	(1.18)
Controls	Yes	Yes	Yes	Yes	Yes	Yes
Year/quarter dummies	Yes	Yes	Yes	Yes	Yes	Yes
Obs	9820	9820	15,091	15,091	8216	8216
AR(1) test (p-value)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
AR(2) test (p-value)	(0.57)	(0.47)	(0.52)	(0.79)	(0.50)	(0.57)
Hansen test of over-identification (p-value)	(0.93)	(0.96)	(0.07)	(0.12)	(0.14)	(0.21)

The *t*-statistics that are based on robust standard errors, in absolute values, are in parentheses. Hansen is a test of over-identification of the instruments. Significance levels are indicated as follows: * = 10%, ** = 5%, *** = 1%

deciles (Panels B1 and B2). The differences between the WACC of banks in the first and the fifth size quintiles are largely negative and statistically significant that indicate, on average, larger banks have a lower WACC than smaller banks in the majority of capital deciles. However, there is not a clear association between the level of capital and the WACC when we move across size quintiles.

To further analyze the impact of bank size on the cost of capital, Table 13 reports the estimation of Eq. (2) for the samples of large and medium-to-small banks. For the sake of simplicity, we only report the estimation of the parsimonious model in Table 6 using ETOA, the ratio used in the computation of the WACC. This analysis demonstrates that there is not a discernible relation between the level of capital and the ICC for systemically important banks, while the cost of equity declines with the level of capital for smaller banks. As a consequence, the WACC for large banks increases in the cross-section when capital increases, but there is not a significant association between capital and the WACC for non-systemically important banks before or after the onset of the financial crisis. A possible explanation is that the additional capital is marginally less valuable for banks that are more likely to benefit from governmental bailouts. The effect of capital as a buffer against negative shocks is diluted by the implicit government subsidies that absorb some of the insolvency risk otherwise borne by investors.[13]

Panel B of Table 15 in Appendix B presents the estimation for the complete sample with interaction terms to contrast the association between the level of capital and the cost of capital for systemically important banks and other banks. This analysis yields similar conclusions to the analysis reported in Table 13. In results not reported, we find qualitatively identical results from the IV analysis on the effect of bank size compared to those discussed in the prior section.

7 Robustness analysis using alternate measures for the costs of equity, debt, and capital

The analysis in the prior sections is based on the ICC as a measure of the cost of equity and the after-tax cost of debt provided by Bloomberg. In this section, we replicate our analysis using alternative measures for the costs of equity and debt.

7.1 Banks' cost of equity measured by the financial capital asset pricing model (FCAPM)

We compute the cost of capital by using the expected returns estimated from the FCAPM. This model was proposed by Adrian et al. (2015) and augments the standard Fama and French (1993) three-factor model with a financial sector ROE factor and the spread between the financial sector return and the market return. The reason we chose this model is that Adrian et al. (2015) show that the FCAPM explains the cross-sectional variation in

[13] A caveat with this bailout argument proposed in the literature is that it requires that the market participants must presume that the government protects their investments, and banks will not repay the government for its support. However, investors lost the value of their investments in failed banks. We also know that government securities purchases and lending programs to support the financial system generated billions of dollars for taxpayers that indicate the majority of banks repaid the government for their support. Thus, investors overestimated the probability of bailouts in some well-known bank failures. However, we cannot exclude the bailout explanation because the government indeed intervened to protect the large financial institutions and the real economy. It is possible that investors in large financial institutions could have experienced larger losses without this government support.

Table 13 The association between equity capital and banks' cost of capital for large banks (the impact of bank size). This table presents the bank-fixed estimation of Eq. (2) for the sample of large banks and other banks in the pre- and post-financial crisis periods. The table presents the analysis of the cost of equity, as measured by composite IBES-based ICCs; the after-tax cost of debt; and the WACC (computed using IBES-based ICCs). The level of capital is measured by banks' Tier-1 capital ratio. We identify large banks as those that participated in the Supervisory Capital Assessment Program (SCAP) in 2009 or the Comprehensive Capital Analysis and Review (CCAR) from 2011 to 2013. Banks that participated in CCAR are also identified as large banks in the year 2010, although neither the SCAP nor the CCAR existed in the year 2010. Before the crisis, we identify all banks that have assets more than 50 billion in at least one of the quarters of a specific year (assets measured in 2007 constant dollars). The measures of ICC estimates, measures of the capital level, and the other independent variables are described in Table 1

	Pre-crisis—January 2000 to June 2007						Post-crisis—July 2007 to December 2013					
	Large banks			Medium-small size banks			Large banks			Medium-small size banks		
	IBES-based ICCs (1)	Cost of debt (2)	IBES-based WACC (3)	IBES-based ICCs (4)	Cost of debt (5)	IBES-based WACC (6)	IBES-based ICCs (7)	Cost of debt (8)	IBES-based WACC (9)	IBES-based ICCs (10)	Cost of debt (11)	IBES-based WACC (12)
Bank capital	-0.0593	0.1156**	0.1804***	-0.0573**	-0.0555***	-0.0062	-0.0142	0.0186	0.1018***	-0.1445**	-0.0294**	0.0195
	(0.49)	(2.48)	(3.81)	(2.11)	(4.59)	(0.52)	(0.10)	(0.51)	(2.92)	(2.33)	(2.29)	(1.32)
Ln Book value	0.0068	-0.0011	0.0010	0.0062***	-0.0020*	-0.0005	0.0197	-0.0037	0.0047	-0.0050	-0.0058***	-0.0059***
	(1.25)	(0.45)	(0.46)	(3.73)	(1.88)	(0.47)	(0.94)	(1.17)	(1.33)	(1.09)	(4.65)	(4.37)
Beta	-0.0036	0.0020	-0.0010	0.0014	0.0005	-0.0006	-0.0163	-0.0004	-0.0015	-0.0107***	-0.0023***	-0.0027***
	(0.86)	(0.86)	(0.39)	(0.85)	(0.42)	(0.64)	(1.48)	(0.23)	(0.89)	(3.01)	(3.33)	(3.32)
Market-to-book	-0.0013	-0.0016**	-0.0015	-0.0028***	-0.0003	-0.0007*	0.0091	0.0022	0.0010	-0.0049*	-0.0012**	-0.0013**
	(0.84)	(2.16)	(1.65)	(3.95)	(0.77)	(1.87)	(1.49)	(1.41)	(0.67)	(1.82)	(2.45)	(2.27)
TED spread	0.0265***	0.0029	0.0053***	0.0080***	0.0060***	0.0065***	-0.0076	0.0041***	0.0673***	0.0011	0.0076***	0.0066***
	(4.66)	(1.55)	(3.16)	(4.78)	(7.41)	(8.16)	(1.42)	(3.60)	(5.28)	(0.57)	(24.56)	(16.73)
Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year/quarter dummies	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Constant	-0.0015	0.0550	-0.0047	0.0097	0.0948***	0.0651***	-0.0814	0.0732	-0.1355*	0.2479***	0.1273***	0.1368***
	(0.01)	(1.13)	(0.10)	(0.39)	(5.39)	(3.96)	(0.24)	(1.28)	(2.00)	(3.56)	(6.69)	(6.73)
Obs	602	463	370	8351	8876	5791	376	433	376	4163	6270	4151
R^2	0.5082	0.8841	0.8736	0.3765	0.6711	0.7516	0.4683	0.7715	0.8433	0.1213	0.6569	0.6809

The *t*-statistics, in absolute values, are in parentheses. Significance levels are indicated as follows: * = 10%, ** = 5%, *** = 1%

returns and absorbs much of the time-series variation in the returns of the financial sector. We find that the average annualized return from the FCAPM is 8.52% that is similar in magnitude to the average IBES-based ICC at 8.92%.

The results in Online Appendix Table OA3 indicate that there is not a significant association between the capital level and the cost of equity from the FCAPM. There is no discernible relation between the level of capital and the WACC before the crisis. However, the WACC increases with the level of ETOA, a result that differs from the analysis using the ICC. The finding that the ICC and the cost of equity from the FCAPM yield different results in our analysis is consistent with prior studies that demonstrate that the empirical association between risk and return differs when we measure the cost of equity by the ICC or by asset pricing models (e.g., Pastor et al. 2008; Chava and Purnanandam 2010).

7.2 Banks' cost of debt measured by loan spread

In prior sections, we have used the after-tax cost of debt provided by Bloomberg, which is a widely used source of information by investors and increasingly by academicians. However, while we are confident about its reliability, we lack information about the detailed construction of this measure of the cost of debt. To check the robustness of our findings, in this subsection, we replicate the analysis by using loan spreads from the Thomson Reuters Loan Pricing Corporation's (LPC) DealScan database. The measure of the cost of debt from DealScan is *All-In-Drawn,* which is calculated as the amount that the borrower pays in basis points over a benchmark rate, the six-month London Interbank Offering Rate (LIBOR) plus annual fees paid to lenders. The sample construction and analysis are described in more detail in the Online Appendix. The estimation in Online Appendix Table OA4 further demonstrates that firms with higher levels of capital have a lower cost of debt financing after controlling for bank characteristics and market-wide conditions. The coefficients are larger when we use this measure of the cost of debt than when we use Bloomberg's after-tax cost of debt. A 10 percentage point increase in Tier-1 capital is associated with about an 80 bp decline in loan spreads.

7.3 Analysis of the cost and the level of capital as measured by the market value of equity

We replicate the analysis using the ratio of the market value of equity to bank assets. The motivation to conduct this analysis is that regulatory capital is measured by the ratios of book values, and thus they do not reflect market fluctuations. Furthermore, market-generated requirements may differ from regulatory requirements (e.g., Berger et al. 1995). The averages of the market value *quasi-ETOA*, and the market value of equity to risk-weighted assets are 14.75% and 20.72%, respectively, and are significantly larger than the same ratios based on book values.

The estimation (untabulated) of Eq. (2) using the *quasi-ETOA* yields similar results to the analysis using book values. The coefficient for *Bank capital* remains negative in the analyses of the costs of equity and debt before and after the financial crisis. This analysis further demonstrates that there is no significant association between *Bank capital* and the overall cost of capital. When we contrast large and medium-to-small banks, we find that there is no noticeable association between the level of capital and the costs of equity and debt for large banks, and there is a positive association between the level of capital and the WACC for large banks.

8 Conclusions

The goal of raising the level of required capital is to improve the stability of the financial system. The financial industry has lobbied against this regulation by contending that higher levels of capital may impose costs on the economy. Both regulators and the financial industry can find support for their ideas in a rich body of academic research. We contribute to this debate by providing new evidence on the association between banks' level of capital and their cost of capital.

Our analysis demonstrates a negative cross-sectional association between banks' costs of equity and debt and their level of capital. The negative association between this level and banks' ICC is stronger after the onset of the 2007–2008 financial crisis. Thus, our analysis provides additional evidence that investors assign a low value to equity risk during expansions and become more risk-averse during contractions (e.g., Thakor 2016). The negative association between the level of capital and banks' costs of equity and debt compensates for the difference in the costs of these sources of financing. As a consequence, consistent with the M-M irrelevance proposition, the overall cost of capital remains unaltered when its level increases.

These results do not support the critics' claim that regulation to increase banks' capital has a negative impact on the provision of credit because additional capital increases the cost of doing business. However, banks with different characteristics may choose different capital structures to minimize their cost of doing business. Therefore, heightened capital requirements could lead to a suboptimal capital structure. Absent a natural experiment of a shock to capital unrelated to its cost, we are left with two alternatives to infer causation. One is to control for bank characteristics and market conditions that affect the levels of capital. A second alternative is to use econometric techniques that account for endogeneity between the cost of capital and banks' capital structure. Both alternative analyses consistently show that the cost of equity and the cost of debt decline and the WACC remains unchanged when the level of capital increases.

The analysis of the sample of large banks yields different results. There is no discernible cross-sectional correlation between the level of capital and the costs of equity and debt for large banks. We also find that large banks have a lower ICC than other banks. A possible explanation is that the implicit government subsidies absorb some of the insolvency risk in large banks, which diminishes the value of capital as a buffer against negative shocks. Because the costs of equity and debt remain unaltered when the level of capital increases, the WACC of the largest banks in our sample increases with the level of capital.

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Data Availability The datasets in this current study are not publicly available but are available from the corresponding author on reasonable request.

Declarations

Conflicts of interests/Competing interests The authors have no relevant financial or non-financial interests to disclose.

9 Appendix

9.1 Appendix A

Table 14 Analysis of the association between Tier-1 capital and five different measures of banks' ICC. Panel A presents the bank fixed-effects estimation of Eq. (1) when the dependent variables are the five ICC measures from the models in Table 1 that are computed using analysts' forecast from I/B/E/S. Panel B shows the bank fixed-effects estimation of Eq. (1) when the five ICCs are estimated based on cross-sectional models. Capital adequacy measures, ICC estimates, and the other independent variables are described in detail in Table 1. The *t*-statistics, in absolute values, are in parentheses

	GLS	CT	MPEG	OJ	Gordon
	(1)	(2)	(3)	(4)	(5)
Panel A: IBES-based ICCs					
Bank capital	-0.0937***	-0.1600***	-0.1612***	-0.1473***	-0.0661***
	(6.06)	(5.18)	(2.87)	(4.60)	(3.82)
Ln Book value	0.0009	-0.0070***	0.0018	0.0030**	-0.0002
	(0.89)	(4.32)	(0.80)	(2.15)	(0.17)
Beta	0.0047***	0.0018	-0.0012	0.0038**	0.0080***
	(3.98)	(0.69)	(0.43)	(2.20)	(5.26)
Market-to-book	-0.0072***	-0.0056***	-0.0101***	-0.0052***	-0.0028***
	(11.94)	(4.70)	(8.82)	(5.37)	(3.48)
TED Spread	0.0117***	0.0111***	0.0237***	0.0131***	0.0029**
	(12.50)	(6.33)	(12.14)	(5.83)	(2.48)
Financial crisis	0.0008	0.0079**	0.0137***	-0.0050***	-0.0067***
	(0.62)	(2.40)	(4.17)	(3.04)	(4.10)
Constant	0.0988***	0.2032***	0.1064***	0.0533***	0.0813***
	(7.72)	(9.36)	(4.13)	(3.16)	(5.02)
Obs	14,470	14,408	13,659	14,045	14,519
R^2	0.1550	0.0401	0.1144	0.0435	0.0235
Panel B: Regression-based ICCs					
Bank capital	-0.0781***	-0.2559***	-0.5096***	-0.4848***	-0.1914***
	(2.71)	(4.92)	(4.49)	(4.86)	(4.33)
Ln Book value	-0.0049**	-0.0132***	-0.0148***	-0.0019	-0.0073*
	(2.15)	(3.38)	(3.02)	(0.47)	(1.78)
Beta	0.0075***	0.0112**	0.0092*	0.0106***	0.0133***
	(2.92)	(2.57)	(1.71)	(2.58)	(3.13)
Market-to-book	-0.0132***	-0.0188***	-0.0230***	-0.0151***	-0.0117***
	(11.52)	(10.02)	(9.85)	(8.05)	(6.68)
TED Spread	0.0123***	0.0161***	0.0223***	0.0161***	0.0117***
	(6.16)	(4.74)	(5.33)	(4.61)	(3.63)
Financial crisis	0.0169***	0.0314***	0.0546***	0.0355***	0.0393***
	(6.43)	(7.14)	(8.94)	(8.13)	(8.18)
Constant	0.1823***	0.3303***	0.4010***	0.1637***	0.1908***
	(6.55)	(6.89)	(6.84)	(3.37)	(3.72)
Obs	21,866	21,654	18,651	20,347	20,151
R^2	0.1581	0.1591	0.2085	0.1246	0.1418

Significance levels are indicated as follows: * = 10%, ** = 5%, *** = 1%

9.2 Appendix B

Table 15 Analysis to contrast the association between equity capital and banks' cost of capital before and after the financial crisis, and for large and medium-to-small banks. This table presents the estimation of Eq. (2) to analyze the association between the level of capital and the composite IBES-based ICC (Models 1–2), with the cost of debt (Models 3–4), and with the WACC (Models 5–6). The table uses two measures of *Bank Capital*: T1CTORWA and ETOA. *Panel A* contrasts the association between the level of capital and its cost before and after the financial crisis. *Bank Capital pre-crisis* equals *Bank Capital* for the pre-financial crisis period, and zero otherwise. *Bank Capital post-crisis* equals *Bank Capital* for the post-financial crisis period and zero otherwise. *Panel B* contrasts the association between the level of capital and its cost for large and non-large banks. We identify large banks as those that participated in the Supervisory Capital Assessment Program (SCAP) in 2009 or the Comprehensive Capital Analysis and Review (CCAR) from 2011 to 2013. Before the crisis, we identify all banks that have assets of more than 50 billion in at least one of the quarters of a specific year (assets measured in 2007 constant dollars). The estimation includes the control variables in Eq. (2) that are described in Table 1. The *t*-statistics, in absolute values, are in parentheses

	Cost of equity		**Cost of debt**		**WACC**	
	T1CTORWA	ETOA	T1CTORWA	ETOA	T1CTORWA	ETOA
	(1)	(2)	(3)	(4)	(5)	(6)
Panel A. Contrasts the association between the level of capital and the cost of capital in the pre- and post-financial crisis periods						
Bank Capital pre-crisis	-0.0501**	-0.0542*	-0.0136	-0.0265**	0.0112	0.0005
	(2.28)	(1.69)	(0.94)	(2.08)	(0.95)	(0.03)
Bank Capital post-crisis	-0.1105***	-0.1290***	-0.0170	-0.0315**	-0.0077	0.0066
	(3.14)	(2.80)	(1.55)	(2.25)	(0.59)	(0.43)
Financial crisis	0.0074	0.0084	-0.0019	-0.0019	-0.0023	-0.0050***
	(1.41)	(1.50)	(1.06)	(1.59)	(1.53)	(3.48)
Control variables	Yes	Yes	Yes	Yes	Yes	Yes
Year/quarter dummies	Yes	Yes	Yes	Yes	Yes	Yes
Obs	12,863	12,863	15,536	15,536	10,301	10,301
R^2	0.2519	0.2511	0.6683	0.6802	0.6913	0.6910
F-value (*p-value*) for the test of equality between Bank Capital pre-crisis = Bank Capital post-crisis	13.59***	13.84***	0.16	0.63	1.89	0.30
	($p<0.01$)	($p<0.01$)	($p=0.70$)	($p=0.43$)	($p=0.17$)	($p=0.59$)

Table 15 (continued)

	Cost of equity		**Cost of debt**		**WACC**	
	T1CTORWA	ETOA	T1CTORWA	ETOA	T1CTORWA	ETOA
	(1)	(2)	(3)	(4)	(5)	(6)
Panel B. Contrasts the association between the level of capital and the cost of capital for large and non-large banks						
Bank Capital large	-0.0291	0.1101	0.0184	0.0280	0.0410	0.0933***
	(0.38)	(1.18)	(0.71)	(1.05)	(1.32)	(3.72)
Bank Capital non-large	-0.0742***	-0.1015***	-0.0111	-0.0314***	-0.0026	0.0061
	(3.81)	(3.46)	(1.03)	(2.64)	(0.23)	(0.47)
Large size	-0.0048	-0.0206**	-0.0025	-0.0054*	-0.0029	-0.0085***
	(0.61)	(2.54)	(1.02)	(1.95)	(0.95)	(3.30)
Financial crisis	-0.0671***	-0.0671***	-0.0588***	-0.0585***	-0.0024***	-0.0547***
	(6.73)	(6.72)	(23.06)	(23.48)	(3.44)	(19.24)
Control variables	Yes	Yes	Yes	Yes	Yes	Yes
Year/quarter dummies	Yes	Yes	Yes	Yes	Yes	Yes
Obs	12,863	12,863	15,536	15,536	10,301	10,301
R^2	0.2814	0.2823	0.7433	0.7442	0.5683	0.7771
F-value (*p-value*) for the test of equality between Bank Capital large = Bank Capital non-large	1.43	5.48**	1.30	4.98**	1.95	11.47***
	($p = 0.23$)	($p = 0.02$)	($p = 0.26$)	($p = 0.03$)	($p = 0.16$)	($p < 0.01$)

Significance levels are indicated as follows: * = 10%, ** = 5%, *** = 1%

9.3 Appendix C

Table 16 The effect of banks size on the association between bank capital and the ICC. This table presents the OLS estimation of Eq. (2) that is extended by the variable *Large banks* that equals one if a bank participated in the Supervisory Capital Assessment Program (SCAP) in 2009 or the Comprehensive Capital Analysis and Review (CCAR) from 2011 to 2013. We also consider CCAR banks as systemically important in the year 2010, although neither the SCAP nor the CCAR existed in the year 2010. Before the crisis, we identify all banks that have assets of more than 50 billion in at least one of the quarters in a specific year (assets measured in 2007 constant dollars). The dependent variable is the composite IBES-based ICC. All models include the right-hand side characteristics in Eq. (2) as well as bank and year-quarter dummies, but for the sake of brevity, we do not report their coefficients. The independent variables are described in Table 1. *Q1 assets* equals one if a bank is in the 1st asset-quartile in a specific quarter, and zero otherwise. *Q2 assets* and *Q4 assets* are defined in the same way but large banks are excluded from *Q4 assets*. The *t*-statistics, in absolute values, are in parentheses

	Period 1996/01 – 2013/12		Period 1996/01 – 2007/06		Period 2007/07 – 2013/12	
	(1)	(2)	(3)	(4)	(5)	(6)
ETOA	-0.0949***	-0.0938***	-0.0674***	-0.0699***	-0.0927***	-0.0886**
	(6.49)	(6.29)	(4.86)	(5.03)	(2.61)	(2.51)
Large banks	-0.0019	-0.0054**	-0.0025**	-0.0050***	-0.0163***	-0.0206***
	(1.01)	(2.50)	(1.97)	(3.32)	(2.97)	(3.34)
Q1 assets		0.0054***		0.0039***		0.0036
		(3.15)		(3.06)		(0.57)
Q2 assets		0.0026***		0.0034***		-0.0010
		(2.69)		(4.31)		(0.27)
Q4 assets		-0.0032***		-0.0018**		-0.0047*
		(4.02)		(2.53)		(1.92)
Firm-characteristics	Yes	Yes	Yes	Yes	Yes	Yes
Market wide-characteristics	Yes	Yes	Yes	Yes	Yes	Yes
Bank dummies	Yes	Yes	Yes	Yes	Yes	Yes
Year/quarter dummies	Yes	Yes	Yes	Yes	Yes	Yes
Constant	-0.0610**	-0.0574**	-0.2039***	-0.2303***	-0.1584**	-0.1681**
	(2.41)	(2.27)	(6.60)	(7.54)	(2.22)	(2.39)
Obs	12,863	12,863	8527	8527	4336	4336
R^2	0.5201	0.5150	0.6131	0.6144	0.5834	0.5838

Significance levels are indicated as follows: * = 10%, ** = 5%, *** = 1%

9.4 Appendix D

Table 17 Capital level, firm size, and banks' cost of capital. This table presents the average cost of equity, cost of debt, and the average weighted average cost of capital (WACC) during the period from 2000–2013 for a sample of banks grouped into total asset quintiles and capital level deciles. Capital level is measured by the Tier-1 capital-to-risk-weighted assets ratio (T1CTOA) and by the equity-to-assets ratio (ETOA). Panels A1 and A2 present the average ICC computed using analysts' forecasts from I/B/E/S. Panels B1 and B2 present the average after-tax cost of debt. Panels C1 and C2 show the average WACC computed using IBES-based ICC. The last column contrasts the mean ICC of the portfolios of banks with the lowest and the highest capitalization level

Size Quintiles	1	2	3	4	5	6	7	8	9	10	(10)-(1)
Panel A1. Average Composite IBES-based-ICCs by T1CTORWA deciles and Size quintiles											
1	0.1019	0.1001	0.0968	0.0967	0.0964	0.0908	0.0925	0.0906	0.0886	0.0786	-0.0234***
2	0.1038	0.0971	0.0979	0.0961	0.0939	0.0926	0.0895	0.0870	0.0867	0.0817	-0.0221***
3	0.0993	0.0889	0.0911	0.0871	0.0851	0.0879	0.0871	0.0865	0.0833	0.0830	-0.0163***
4	0.0904	0.0889	0.0827	0.0831	0.0833	0.0834	0.0821	0.0830	0.0816	0.0835	-0.0069***
5	0.0949	0.0913	0.0909	0.0909	0.0901	0.0851	0.0888	0.0875	0.0862	0.0859	-0.0090***
(5)-(1)	-0.0070***	-0.0088***	-0.0059***	-0.0058***	-0.0063***	-0.0057***	-0.0037*	-0.0031	-0.0024	0.0073***	
Panel A2. Average IBES-based-ICCs by ETOA 1 deciles and Size quintiles											
1	0.0979	0.0977	0.0997	0.0940	0.0919	0.0913	0.0928	0.0928	0.0891	0.0859	-0.0121***
2	0.1014	0.0957	0.0927	0.0895	0.0928	0.0914	0.0893	0.0919	0.0933	0.0886	-0.0128***
3	0.0954	0.0897	0.0891	0.0886	0.0893	0.0884	0.0870	0.0895	0.0818	0.0805	-0.0149***
4	0.0903	0.0867	0.0832	0.0829	0.0836	0.0823	0.0860	0.0835	0.0834	0.0802	-0.0101***
5	0.0894	0.0905	0.0859	0.0881	0.0897	0.0896	0.0880	0.0873	0.0890	0.0939	0.0045**
(5)-(1)	-0.0085***	-0.0072***	-0.0138***	-0.0059***	-0.0022	-0.0017	-0.0048**	-0.0055***	-0.0001	0.0080***	
Panel B1. Average after-tax cost of debt by T1CTORWA deciles and Size quintiles											
1	0.0398	0.0365	0.0355	0.0356	0.0334	0.0333	0.0351	0.0355	0.0322	0.0339	-0.0060***
2	0.0369	0.0386	0.0378	0.0346	0.0339	0.0330	0.0328	0.0322	0.0290	0.0285	-0.0083***
3	0.0382	0.0360	0.0376	0.0361	0.0350	0.0348	0.0324	0.0315	0.0292	0.0285	-0.0097***
4	0.0387	0.0381	0.0376	0.0366	0.0355	0.0338	0.0302	0.0290	0.0282	0.0280	-0.0107***
5	0.0382	0.0371	0.0363	0.0359	0.0331	0.0303	0.0286	0.0262	0.0244	0.0276	-0.0106***
(5)-(1)	-0.0016*	0.0006	0.0008	0.0003	-0.0003	-0.0030***	-0.0065***	-0.0093***	-0.0078***	-0.0063***	

Table 17 (continued)

Size Quintiles	1	2	3	4	5	6	7	8	9	10	(10)-(1)
Panel B2. Average after-tax cost of debt by ETOA deciles and Size quintiles											
1	0.0399	0.0367	0.0352	0.0353	0.0364	0.0356	0.0327	0.0335	0.0330	0.0326	-0.0074***
2	0.0372	0.0381	0.0373	0.0362	0.0345	0.0339	0.0317	0.0301	0.0297	0.0286	-0.0086***
3	0.0399	0.0369	0.0364	0.0361	0.0330	0.0325	0.0327	0.0317	0.0294	0.0308	-0.0091***
4	0.0407	0.0378	0.0361	0.0348	0.0341	0.0337	0.0325	0.0296	0.0277	0.0285	-0.0122***
5	0.0361	0.0356	0.0342	0.0326	0.0324	0.0315	0.0321	0.0293	0.0257	0.0284	-0.0077***
(5)-(1)	-0.0038***	-0.0011	-0.0010	-0.0027***	-0.0040***	-0.0041***	-0.0006	-0.0042***	-0.0073***	-0.0042***	
Panel C1. Average IBES-based WACC by T1CTORWA deciles and Size quintiles											
1	0.0381	0.0405	0.0411	0.0408	0.0374	0.0391	0.0394	0.0398	0.0412	0.0382	0.0001
2	0.0396	0.0378	0.0398	0.0400	0.0406	0.0395	0.0389	0.0394	0.0369	0.0393	-0.0003
3	0.0386	0.0395	0.0392	0.0388	0.0408	0.0374	0.0402	0.0395	0.0370	0.0368	-0.0018
4	0.0363	0.0385	0.0384	0.0383	0.0391	0.0377	0.0377	0.0382	0.0386	0.0396	0.0033
5	0.0405	0.0393	0.0380	0.0355	0.0342	0.0355	0.0343	0.0358	0.0371	0.0357	-0.0048***
(5)-(1)	0.0025	-0.0012	-0.0031***	-0.0053***	-0.0032**	-0.0036***	-0.0051***	-0.0041***	-0.0041***	-0.0025*	
Panel C2. Average IBES-based WACC by ETOA deciles and Size quintiles											
Size Quintiles	1	2	3	4	5	6	7	8	9	10	(10)-(1)
1	0.0401	0.0390	0.0398	0.0406	0.0390	0.0396	0.0395	0.0397	0.0380	0.0405	0.0004
2	0.0402	0.0397	0.0383	0.0387	0.0390	0.0378	0.0392	0.0398	0.0389	0.0409	0.0007
3	0.0437	0.0397	0.0388	0.0385	0.0370	0.0385	0.0386	0.0381	0.0374	0.0395	-0.0042***
4	0.0404	0.0411	0.0405	0.0367	0.0382	0.0383	0.0366	0.0381	0.0361	0.0390	-0.0014
5	0.0372	0.0364	0.0384	0.0384	0.0364	0.0363	0.0370	0.0378	0.0365	0.0415	0.0043***
(5)-(1)	-0.0029**	-0.0027**	-0.0014	-0.0023**	-0.0026	-0.0033***	-0.0025**	-0.0019**	-0.0015*	0.0010	

The ***, **, and * indicate statistical significance of the difference in means test at the 1%, 5%, and 10% levels, respectively

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