The Effects of the Regulatory Capital Requirements of Basel III on the Cost of Capital of Banks

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Abstract As a response to the financial crises, the Basel Committee on Banking Supervisions (BCBS) endorsed the Basel III framework in 2010 to increase the overall loss absorbency of the banking sector. This paper contributes to the ongoing discussion on higher capital requirements as it analyzes the relation of higher capital requirements to the weighted average cost of capital (*WACC*). Based on a theoretical background from corporate finance a linear model is estimated using year-over-year differences for OLS and fixed-effects estimations. The sample is constructed using observations for about 680 banks from 22 jurisdictions covering the years 2003 to 2016. The results show a significant, positive relationship between the capital ratio and the *WACC*. However, the effect diminishes after the adoption of Basel III for emerging markets and raises for advanced economies.

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1 Introduction

The Basel Committee on Banking Supervision (BCBS) as the international standard setter for banking regulation endorsed in December 2010 a revised framework entitled "Basel III: A global regulatory framework for more resilient banks and banking systems" (BCBS, 2011). According to the BCBS the new standard should raise the loss absorbency capacity of the banking sector in order to avoid spillover effects to the real economy in future financial crises. The BCBS is reacting with its reform to the financial and economic crisis beginning in 2007 seeing one of its main reasons in the high leverage of the banking sector.

Support for this implicit argumentation can be found in the economic literature: Miles et al (2013) as well as Berger and Bouwman (2013) show that higher capital endowment in the banking sector can reduce the probability of a banking crisis (and therefore economic downturn). Yet, the results by Jordà et al (2017) show no empirical evidence on the reduction of the probability of a banking crisis. However, the authors emphasize that higher capital is still socially beneficial in terms of overall economic outcome as it reduces the recession resulting from a banking crisis.

However, representatives of the banking industry emphasize that higher capital endowment will cause higher cost of capital for the banking sector. As a result, this will cause higher cost for banking services, in particular, bank loans. Finally, higher capital ratios for the banking sector would reduce the overall economic development (American Bankers Association, 2010; Bundesverband Deutscher Banken, 2010). The Institute for International Finance (2011), an association of the banking industry, estimated that the changed capital requirements will reduce real economic growth in the USA by 0.1 percentage points, in the Euro area by 0.4 percentage points and in Japan by 0.3 percentage points. The Macroeconomic Assessment Group (2010), one of the expert groups of the BCBS, concludes that the higher capital requirements will reduce the annual economic growth by 0.03 percentage points in the period of adjustnt. In the steady state the annual economic growth would increase by 0.03 percentage points.

Several studies analyze the impact of higher capital requirements on the cost of capital using data from one jurisdiction only. Kashyap et al (2010) and

Junge and Kugler (2013) use fixed-effect regression to analyze the effect of capital ratios on equity β according to the Capital Asset Pricing Model by Sharpe (1964) for a sample of banks from the United States with time-specific effects, respectively, Switzerland with bank and time specific effects to indicate indirectly the effects on the overall cost of capital. Based on data for the United Kingdom, Miles et al (2013) use a period-over-period difference specification estimating the effects of capital ratios on CAPM equity β using OLS, fixed effects, and random effect estimations for the indirect analysis of the cost of capital. On a sample of banks from the European Union, Toader (2015) estimates the effect of capital ratios on CAPM equity β using OLS, fixed effects, and random effect estimations. Furthermore, Toader (2015) estimates the impact of raising capital ratios on the weighted average cost of capital *WACC* using simple OLS regression. Using an analytical approach, Firestone et al (2017) estimate the impact of higher capital ratios on the cost of capital for the banking sector of the United States using average values.

Mentioning that the post-crisis reforms made by the BCBS will be applied in all member countries (based on the commitment of the members), we are contributing to the literature using an international sample from 22 jurisdictions. As the overall cost of capital is our main variable of interest, we follow the approach by Toader (2015) using the weighted average cost of capital *WACC* as dependent variable but adjusting it for the given interest rate level. Furthermore to control for spurious regression, we follow Miles et al (2013) using difference specification (absolute year-over-year differences) and using OLS as well as fixed-effects estimations (including bank and time specific effects). In our research based on an international sample and including a wider range of observations after the endorsement of Basel III, we focus on the following two questions:

1. Which dependency exists in general between capital ratios of banks and the cost of capital?
2. Is there any change to the observed relationship due to the Basel III framework?

By answering the first question, our results show a significant positive relationship between capital ratios of banks and cost of capital indicating that higher capital endowment is in general connected with higher cost of capital. Regarding the second question, we could identify a lower sensitivity of the cost of capital on the

capital ratios after the endorsement of Basel III on the global level. This leads to the implication that the same rise in capital would lead to a lower increase in the cost of capital compared to the previous regulatory regime and therefore reduces the overall impact of higher capital requirements. When separating between advanced economies and emerging markets, advanced economies show higher sensitivity while emerging markets show lower (and not significant) sensitivity after the endorsement of Basel III. Our results regarding positive sensitivity are in line with the results by Firestone et al (2017), Junge and Kugler (2013), Kashyap et al (2010), and Miles et al (2013) showing a positive relation between higher capital ratios and cost of capital. But it differs from the results shown by Toader (2015) who estimates a negative relationship between *WACC* and capital ratios (see Section 5).

In Section 2, we give a brief overview of the theoretical background. This theoretical overview will be used in the empirical analysis to identify possible factors (tax shield, bankruptcy cost, information asymmetries, deposits as debt type, implicit state guarantee, dependency from the country of residence) influencing the relation of capital endowment and cost of capital. Section 3 defines the parameters used when measuring capital requirements and cost of capital as well as the econometric models used for OLS and fixed effect estimation. Section 4 will give an overview on the underlying sample. For the analysis, we use data by Thomson Reuters (now Refinitive) Datastream for the period from 2003 to 2016 for 22 member countries of the BCBS as well as data on corporate tax rates by KPMG (2017). The results are presented in Section 5 and show a significant, positive dependency between capital ratios and the cost of capital. To show the robustness of the relationship, we are using different specifications and estimation techniques (OLS, fixed effects). Moreover, the results show a reduction in the sensitivity of cost of capital to capital endowment after the endorsement of Basel III.

2 Theoretical Framework

When analyzing the relation of capital structure and cost of capital, different factors have to be considered. In the context of cost of capital and capital structure the Modigliani-Miller theorem (Modigliani and Miller, 1958) is often mentioned regarding the analysis of capital requirements (see e.g. Firestone et al, 2017; Junge and Kugler, 2013; Kashyap et al, 2010; Miles et al, 2013;

Toader, 2015). It assumes a company with indefinite lifespan and it is based on the assumption of a perfect market where no information asymmetry and no transaction cost exist. Also, no taxes are considered in its original form. The theorem concludes that the average cost of capital is independent of the capital structure and that it is equal to the expected yield of a pure equity financed company. Furthermore, the expected yield of equity rises with leverage.

In contrast to this theorem based on the perfect market assumption, factors of an incomplete market have to be considered in the dependency of capital endowment and cost of capital. Modigliani and Miller (1963) show that the incorporation of taxes lead to an adjustment of the original Modigliani-Miller theorem. As interest paid on debt is deducted from taxable income, a company can increase its economic value with higher indebtedness.

The so called trade-off theory by Kraus and Litzenberger (1973) implies a trade-off between the tax advantage and a disadvantage due to the expected bankruptcy cost in the case the company fails. As with further leverage, the debt service and therefore the probability of insolvency rises which will lead to an increase of the expected value of the bankruptcy cost.

The Modigliani Miller theorem is based on an ex ante view, i.e. without any adjustments to a higher capital ratio (Miller, 1995). Owing to information asymmetries, the company's management would prefer internal financing or funding on a risk free rate of interest to external financing and would prefer debt over equity finance (Myers, 1984).

In the model of DeAngelo and Stulz (2015), depositors accept a lower yield on deposits due to limited market access. For banks therefore, financing through deposits is more favorable than the use of hedging and risk management. This cost advantage over other types of funding results in a funding at optimal cost using only deposits.

To deviate further from a risk adequate interest rate on debt, implicit state guarantees can be mentioned. As a reaction to the financial crisis, the BCBS implemented further capital requirements for global systemically important banks (BCBS, 2013) as well as national relevant banks (BCBS, 2012). One of the reasons for this implementation is expected funding subsidies for large and complex banks. In such cases, market participants expect governmental support in terms of financial turmoil as perceived during the financial crises (BCBS, 2013, Para. 3). Furthermore, resolution regimes were introduced to resolve further this market distortion (BCBS, 2010). Tölö et al (2015) show that the implementation of such a resolution regime reduces the funding cost advantage. This can be seen as empirical evidence for the existence of an implicit state guarantee.

3 Methodology

The capital requirements of the Basel III framework (BCBS, 2011) consists in general of two different calculation methods:

1. The risk sensitive capital requirement and
2. the leverage Ratio.

Owing to data availability, we use the approach of risk sensitive capital requirement which is based on the relation of regulatory equity to risk weighted assets (RWA):

$$Capital\ Ratio = \frac{Regulatory\ Equity}{RWA} \geq minimum\ ratio. \tag{1}$$

The ratio of regulatory equity and RWA (capital ratio) should be at all times above the minimum ratio. With introduction of the first Basel framework (BCBS, 1998, Para. 28), this is 8 % for the overall capital ratio. Since Basel II, the regulatory equity can be broken down into Tier 1 and Tier 2. The separation is based on the different cases when the capital instrument is used for loss absorbency. Tier 1 is used in a going-concern case (business activities will continue) while Tier 2 is used in the gone-concern case (losses are higher than Tier 1 and business activities will discontinue; BCBS, 2006, Para. 49 seq.; BCBS, 2011, Para. 49seq.). With the implementation of Basel III, the minimum Tier 1 ratio of 4 % will be steadily increased to 6 % starting in 2013 (BCBS, 2011, Para. 94 (a) and 94 (b)).

Regarding the cost of capital, we define the weighted average cost of capital *WACC* as follows (see e.g. Brealey et al, 2016):

$$WACC = \frac{S}{V}\rho + \frac{D}{V}r\,(1-\tau). \tag{2}$$

The weighted average cost of capital *WACC* is the result of the cost of equity ρ and the cost of debt r weighted by the market value of equity S respectively the market value of debt D in relation to the company value V. The company value V is defined as the sum of S and D. As the market value for the varieties of debt is not available, we use the book value of debt as an approximation. Furthermore, the cost of debt is adjusted by the corporate tax rate τ to include the tax advantage of interest before dividends.

For the calculation of the cost of equity, we use the CAPM:

$$\rho_{i,t} = r^{long}_{free,\,c,t} + \beta_i \, MRP_c. \tag{3}$$

The bank (i) and time specific (t) cost of equity $\rho_{i,t}$ is calculated using the country (c) and time specific risk free rate of interest $r^{long}_{free,c,t}$ and the country specific market risk premium MRP_c as well as the bank specific beta coefficient β_i. As measure for the risk free rate of interest, we follow the recommendation of the German Association of Public Accountants (IdW, 2008) to use the yield of a 10 year sovereign bond for each country. *Note*: 10 year sovereign yields for Saudia Arabia could not be obtained. In this case, the fixed leg of an interest swap with a term of 10 years is used. For the calculation of the market risk premium the average difference between the historical total returns of stock index (assuming the reinvestment of dividends) $\rho_{M,t,c}$ and the yield of the sovereign bond $r^{long}_{free,\,t,c}$ is used. The calculation uses data of a period from 1990 to 2016. Due to data availability, years for a specific jurisdiction are considered only if $\rho_{M,t,c}$ as well as $r_{free,\,t,c}$ are available.

$$MRP_c = \frac{1}{T} \sum_{t}^{T} \left(\rho_{M,t,c} - r^{long}_{free,\,t,c} \right). \tag{4}$$

For the calculation of β_i, the log total returns of the specific bank (ρ_i) and the log returns of a country specific stock index ($\rho_{M,c}$) are used on a calendar year basis:

$$\beta_i = cor(\rho_i, \rho_{M,c}) \cdot \frac{\sigma_{(\rho_i)}}{\sigma_{(\rho_{M,c})}}. \tag{5}$$

As interest rates on all individual type of debts are not available, we follow the simple approach contributed by Vélez-Pareja (2009):

$$r_{i,t} = \frac{R_{i,t}}{D_{i,t}}. \tag{6}$$

The bank and time specific cost of debt $r_{i,t}$ is the relation of the interest expenses of the period $R_{i,t}$ and the book value of debt of the period $D_{i,t}$. One could argue that the interest expenses are the result of contracts made in previous periods. However, a forward-looking approach such as a calculation using CDS spreads

is not used as we would like to analyze the *WACC* including any potential effect of the use of deposits which is assumed to be more independent of any type of rating than a CDS spread.

Controlling for different levels of interest rates, we use the difference (named $WACC_{i,t}^{Spread}$) between *WACC* and the short-term money market (expressed as risk free short term interest rate $r_{free,t,c}^{short}$):

$$WACC_{i,t}^{Spread} = WACC_{i,t} - r_{free,t,c}^{short}. \tag{7}$$

To control for a spurious regression, we follow the approach by Miles et al (2013) using first differences (absolute difference to the previous period) to estimate the relation of $WACC^{Spread}$ to the Tier 1 capital ratio *CR* with the following linear model:

$$\Delta WACC_{i,t}^{Spread} = \alpha_0 + \alpha_1 \Delta\, CR_{i,t} + \sum_{k=1}^{K} \alpha_{k+1} \Delta Control_{k,i,t} + \epsilon_{i,t}. \tag{8}$$

$Control_{k,i,t}$ is an institute and time specific set of 1 to K control variables which is chosen based on the theoretical concepts shown in Section 3. This includes the ratio of deposit to total liabilities as an indicator for the use of deposits (*Deposit ratio*). Following Toader (2015), we use the logarithm of total assets (*Size*) as a parameter for including any potential impact of the "too big to fail effect". As Modigliani and Miller (1958) assume equivalent earnings for equivalent companies, we use the return on assets (*RoA*) as ratio of earnings before interest and taxes to total assets as indicator for the profitability. Moreover, we use the corporate tax rate (*tax*) to control for any change in the national tax code. All control variables are also considered as absolute difference to the previous period. As the corporate tax rate is used in the calculation of the *WACC*, we test for endogeneity using the Durbin-Wu-Hausman test based on a dummy as a combination of country and time. The test does not reject the null hypothesis under which both specifications using the difference of the tax rate as well using the dummy variable result in consistent estimators. For the purpose to check for robustness, we follow Miles et al (2013) and Toader (2015) using the ordinary least squares estimation (OLS) (see Equation 8) and a fixed effect estimation (FE) as given in Equation 9. Contrary to Miles et al (2013) and Toader (2015) we do not apply a random effects estimation as the used observations are by

definition not randomly chosen from the population. Additionally, the subject specific error terms are endogenous as a Hausman-Test shows. Therefore, a random effects model is not suitable. For the fixed effect estimation the model is adjusted as follows:

$$\Delta WACC_{i,t}^{Spread} = u_i + \alpha_1 \Delta\, CR_{i,t} + \sum_{k=1}^{K} \alpha_{k+1} \Delta Control_{k,i,t} + \gamma_t + \epsilon_{i,t}. \tag{9}$$

Table 1: Description of the variables used in the regression models.

Variables	**Description**
$\Delta WACC^{Spread}$	Weighted Average cost of capital as spread above the country specific money market rate as difference to previous period (in percentage points)
Δ *CR*	Tier 1 capital ratio (i.e. Tier 1 capital /RWA) as difference to previous period (in percentage points)
B2	Dummy variable equals 1 for the years 2004 to 2010, otherwise 0
B3	Dummy variable equals 1 for the years 2011 to 2016, otherwise 0
Δ *Size*	Log total assets as difference to previous period
Δ *Deposit ratio*	Deposit to total liabilities as difference to previous period (in percentage points)
Δ *RoA*	Earnings before interest and taxes (EBIT) to total assets as difference to previous period (in percentage points)
Δ *Tax rate*	Country specific tax rate published by KPMG (2017) as difference to previous period (in percentage points)

The variable u_i is a bank specific effect while γ_t denotes a time effect. To analyze our second question, we expand our model using dummy variables to mark Basel II or Basel III regime. $B2$ is 1 before the endorsement of the Basel III framework (years 2004 to 2010) and 0 thereafter (years 2011 to 2016) while $B3$ is 0 for 2004 to 2010 and 1 for 2011 to 2016:

$$\begin{aligned} \Delta WACC_{i,t}^{Spread} = \quad & \alpha_1 \Delta\, CR_{i,t} \cdot B2 + \alpha_2 \Delta\, CR_{i,t} \cdot B3 \\ & + \sum_{k=1}^{K} \alpha_{k+2}\, Control_{k,i,t} + \epsilon_{i,t}. \end{aligned} \tag{10}$$

Note that the specification for the fixed effect estimation changes to:

$$\begin{aligned} \Delta WACC_{i,t}^{Spread} = \quad & u_i + \alpha_1 \Delta\, CR_{i,t} \cdot B2 + \alpha_2 \Delta\, CR_{i,t} \cdot B3 \\ & + \sum_{k=1}^{K} \alpha_{k+2} Control_{k,i,t} + \gamma_t + \epsilon_{i,t}\,. \end{aligned} \tag{11}$$

Table 1 gives an overview over the variables used in the various regression models.

4 Data

For the empirical analysis, only banks from member countries of the BCBS (as well as Malaysia holding an observer status) are included to safeguard that the national regulations are based on the Basel framework. Furthermore, as the CAPM is used for the calculation of the cost of equity, only listed firms are included. For the measurement of the corporate tax rate, a country and time specific rate published by KPMG (2017) is applied. To consider the level of the risk free rate of interest, the data include money market reference rates for unsecured 3 months interbank loans for each jurisdiction. The data are obtained from Thomson Reuters (now Refinitive) Datastream and covers the years 2003 to 2016. Beside the parameters mentioned to calculate the *WACC*, a sufficient amount of data for the regulatory equity (RWA, Tier 1) and for values of the financial statements (total assets, equity, interest expense, etc.) has to be obtained to include an observation point. To protect from any quality issues in the data, we excluded observations with a Tier 1 capital ratio of above 50 % as well as observations with negative equity. These restrictions as well as general data availability result in an unbalanced sample regarding jurisdictions and calendar years. Tables 2 and 3 show the number of observations as well as the average values on Tier 1 capital ratios and the different components for the calculation of $WACC^{Spread}$.

We used R version 3.4.3 (R Core Team, 2017) to carry out the statistical analysis employing the packages AER version 1.2.5 (Kleiber and Zeileis, 2008), car version 2.1.2 (Fox and Weisberg, 2011), data.table version 1.10.0 (Dowle and Srinivasan, 2017), lmtest version 0.9.34 (Zeileis and Hothorn, 2002), plm

version 1.6-5 (Croissant and Millo, 2008; Millo, 2017), readxl version 0.1.1 (Wickham, 2016), sandwich version 5.33 (Zeileis, 2004, 2006), and stargazer version 5.2 (Hlavac, 2015).

Table 2: Data sample: Averages by jurisdictions (2003 to 2016).

Country	N	CR	Cost of capital				r_{free}		MRP	τ
			$WACC^{Spread}$	$WACC$	ρ	r	short	long		
		[%]	[%]	[%]	[%]	[%]	[%]	[%]	[%]	[%]
Australia*	54	8.9	−1.0	3.4	10.5	3.6	4.4	4.5	5.9	30.0
Belgium*	21	13.4	2.5	4.0	7.7	5.7	1.5	2.5	5	34.0
Canada*	108	11.0	−0.4	1.6	6.1	1.8	2.0	3.4	3.7	31.2
China†	137	9.9	−1.3	2.4	10.5	2.1	3.7	2.9	12.6	25.9
France*	64	10.4	−0.2	1.4	7.7	1.8	1.6	2.5	4.5	33.5
Germany*	33	10.5	−0.3	1.5	8.9	2.0	1.8	2.7	5.8	33.1
Great Britain*	63	11.1	−1.1	1.4	9.0	1.3	2.6	3.7	3.9	26.5
India†	133	9.7	−1.8	5.3	19.7	5.8	7.2	7.9	10.2	33.8
Indonesia†	211	14.9	−1.0	7.0	19.9	5.5	8.0	9.1	19.6	27.1
Italy*	202	9.7	−0.3	1.3	4.1	1.7	1.7	2.6	1.7	33.7
Japan*	793	9.1	0.1	0.5	8.1	0.2	0.3	1.2	9.4	40.1
Luxembourg*	7	8.8	0.9	2.6	3.3	3.6	1.7	2.7	4.6	29.0
Malaysia†	89	11.4	−1.0	2.2	6.1	2.1	3.2	4.0	2.1	25.7
Russia†	20	10.8	−3.8	5.4	14.7	5.4	9.2	8.9	13.8	20.4
Saudi Arabia†	90	15.5	1.4	3.5	10.8	1.3	2.2	4.1	13.6	20.8
Singapore*	29	13.0	0.4	1.8	7.4	1.3	1.4	2.7	4.5	19.0
South Africa†	54	15.4	−2.2	4.8	13.9	4.4	7.0	8.2	6.5	32.6
South Korea*	11	10.7	−0.6	1.8	8.0	2.0	2.4	2.5	6.2	23.8
Spain*	73	9.8	0.8	2.2	12.1	2.0	1.4	2.3	8.6	30.8
Sweden*	50	12.7	0.4	2.2	15.6	1.8	1.8	2.7	11.6	26.0
Switzerland†	100	16.6	1.0	1.5	6.9	1.2	0.5	1.6	6.6	19.9
United States*	4.834	13.9	0.03	1.8	7.0	1.6	1.8	3.2	6.6	39.3
Total	7.176	12.9	−0.1	1.9	8.0	1.7	2.0	3.2	7.3	37.1
†: AE	6,442	13.0	0.04	1.6	7.2	1.5	1.6	2.9	6.7	38.2
*: EM	734	12.6	−1.1	4.6	14.7	3.9	5.7	6.4	12.6	27.4

Jurisdictional classification based on IMF (2017)

AE: advanced economies, EM: emerging markets

Table 2 shows that banks of the United States are dominating the sample given that 4.834 of 7.176 banks are from the US. For 13 jurisdictions the *WACC* is on average below the money market rate. Additionally, we see that in some cases like the US, Japan, France, and Germany the *WACC* is very close to the money market rate. Belgium shows an unusual high value of $WACC^{Spread}$. This value is caused by the Belgian bank Dexia which received state aid during the financial crises (see European Commission, 2010) and is, therefore, plausible.

Table 3: Data sample: Averages by jurisdictions (2003 to 2016).

Year	N	*CR*	Cost of capital				r_{free}		*MRP*	τ
			$WACC^{Spread}$	*WACC*	ρ	r	short	long		
		[%]	[%]	[%]	[%]	[%]	[%]	[%]	[%]	[%]
2003	345	11.4	0.5	2.0	6.8	1.8	1.5	4.1	7.2	35.2
2004	466	12.1	−0.2	2.1	7.9	1.5	2.3	4.0	7.1	34.8
2005	514	12.1	−1.7	2.3	8.6	1.9	3.9	4.2	7.1	38.6
2006	554	12.3	−1.9	2.8	8.7	2.6	4.7	4.3	7.3	38.3
2007	573	12.3	−1.9	2.7	8.5	2.9	4.6	4.0	7.2	38.5
2008	597	12.1	−0.2	2.1	6.8	2.5	2.2	2.7	7.3	37.9
2009	576	12.5	1.2	1.9	9.1	1.9	0.7	3.6	7.3	37.7
2010	599	13.3	0.8	1.7	8.0	1.5	0.9	3.3	7.4	37.5
2011	607	13.9	0.3	1.5	7.4	1.3	1.2	2.3	7.4	37.3
2012	587	14.0	0.5	1.4	7.3	1.1	0.9	2.0	7.5	36.8
2013	511	13.7	0.5	1.6	8.3	1.1	1.0	3.0	7.5	36.8
2014	437	14.0	0.5	1.7	7.7	1.1	1.2	2.7	7.4	36.3
2015	406	13.4	0.3	1.7	7.8	1.2	1.4	2.7	7.5	35.8
2016	404	13.5	0.5	1.9	9.1	1.0	1.5	2.7	7.4	35.7
Total	7,176	12.9	−0.1	1.9	8.0	1.7	2.0	3.2	7.3	37.1
Basel II	3,879	12.4	−0.5	2.2	8.2	2.1	2.7	3.7	7.3	37.7
Basel III	2,952	13.8	0.4	1.6	7.9	1.1	1.2	2.5	7.4	36.5

Basel II: 2004 to 2010; Basel III: 2011 to 2016

Regarding the calculated market risk premiums, Italy and Malaysia show unusual low values resulting from low performance of the included stock market indexes compared to the yield on sovereign bonds in the observed period of 1990 to 2016. For the other countries included, we observe a range from 3 % to 9 %

which is in general consistent with the literature (Fernandez, 2017). Moreover, we distinguish between advanced economies (AE) and emerging markets (EM) based on International Monetary Fund (IMF) (2017). The capital ratio for both groups is on a similar level while the cost of capital differs showing negative $WACC^{Spread}$ for emerging markets and a average value of around 0 for advanced economies. It is notable that the sample for emerging markets is much smaller (734 observations) compared to the sample for advanced economies (6.442 observations). Therefore, part of our analysis is focused on a pooled sample.

Table 3 shows the time perspective: The *WACC* and its main component, the cost of debt r, follow the development of the money market rate. It raises until 2007 with strong reduction afterwards caused by lower interest rate levels during 2008 to 2012. The relaxation after 2012 results in minor raises, only. On the other site, the cost of equity ρ is more volatile and does not follow any specific trend. When aggregating the years for Basel II (2004 to 2010) and Basel III (2011 to 2016), we see that on average the capital ratios were increased from 12.4 % to 13.8 % indicating the development of higher capital endowment. The descriptive statistics for the variables used in the regression analysis are shown in Table 4.

Table 4: Descriptive statistics on variables used in Table 5.

Statistic	N	Mean	Median	St. Dev.	Min.	Max.
$\Delta\, WACC^{Spread}$	6,499	0.053	−0.046	1.264	−15.771	16.880
$\Delta\, CR$	6,499	0.033	0.063	2.442	−25.555	38.746
$\Delta\, CR \cdot B2$	6,499	0.017	0	1.850	−25.555	38.746
$\Delta\, CR \cdot B3$	6,499	0.092	0	1.842	18	39
Δ *Size*	6,499	0.074	0.056	0.139	−0.569	1.694
Δ *Deposit ratio*	6,499	0.326	0.239	4.060	−26.806	25.941
Δ *RoA*	6,499	−0.058	−0.012	1.031	−18.815	15.365
Δ *Tax rate*	6,499	0.144	0	1.596	10	6

Table 5: Dependency between the year-over-year difference of WACC as spread above the money market rate and the Tier 1 capital ratio.

	$\Delta WACC^{Spread}$									
	OLS		*FE*		*OLS*		*FE*		*FE*	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Δ *CR*	0.030***	0.028***	0.035***	0.027***						
	(0.008)	(0.008)	(0.008)	(0.008)						
Δ *CR* · *B*2					0.034***	0.031***	0.039***	0.031***	0.016***	0.082*
					(0.013)	(0.012)	(0.013)	(0.012)	(0.005)	(0.044)
Δ *CR* · *B*3					0.025***	0.025***	0.030**	0.022*	0.023***	0.048
					(0.009)	(0.009)	(0.012)	(0.013)	(0.005)	(0.039)
Δ *Size*		−0.134		−0.428***		−0.137		−0.433***		
		(0.145)		(0.153)		(0.146)		(0.152)		
Δ *Deposit ratio*		0.009		0.001		0.009		0.001		
		(0.006)		(0.007)		(0.006)		(0.007)		
Δ *RoA*		−0.157***		0.026		−0.157***		0.026		
		(0.021)		(0.017)		(0.021)		(0.018)		
Δ *Tax rate*		−0.268***		−0.156***		−0.268***		−0.156***		
		(0.009)		(0.018)		(0.009)		(0.018)		
Constant	0.052***	0.089***			0.052***	0.089***				
	(0.016)	(0.018)			(0.016)	(0.018)				
AE included	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No
EM included	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No	Yes
Observations	6,499	6,499	6,499	6,499	6,499	6,499	6,499	6,499	5,845	654
R^2	0.003	0.138	0.440	0.461	0.003	0.138	0.440	0.461	0.6844	0.3192
Adjusted R^2	0.003	0.138	0.374	0.397	0.003	0.137	0.374	0.397	0.6476	0.2062
F Statistic	22.056***	208.364***	43.332***	54.081***	11.304***	173.647***	21.977***	45.180***	13.163***	2.930*

Notes: OLS: Ordinary Least Squares Regression, FE: Fixed Effects Panel Regression, AE: Advanced Economies, EM: Emerging Markets
*p < 0.1; **p < 0.05; ***p < 0.01
Heteroscedasticity- and autocorrelation-consistent standard errors in parenthesis (Arellano, 1987), constant term for fixed effects models is omitted due to introduction of bank and time specific effects.

5 Results

Table 5 shows the results of the specifications given in Equation 7 in model (1) (without control variables) and (2) (with control variables). Furthermore, the fixed-effect estimations are model (3) (without control variables) and model (4) (with control variables). Please note that no constant term is reported as it is replaced by bank and time specific effects (see Equation 8). The extended models as specified in Equation 10 and 11 including framework related dummy variables are shown without and with control variables in models (5) and (6), respectively (7) and (8). The models (1) to (8) as specified in Table 5 show a significant, positive coefficient for the parameter $\Delta\ CR$ in a range of 0.028 to 0.035. This means that in general an increase in the change of the Tier 1 ratio of 100 basis points (BP) would be associated to a change in the increase of $WACC^{Spread}$ of 2.8 BP to 3.5 BP. All models are significant based on the F-statistics to a significance level of 1 %. Using the difference of the Tier 1 ratio $\Delta\ CR$ only as it is done in models (1) and (5), we still estimate significant coefficients, however, the resulted R^2 is close to zero showing that the sole change in capital endowment cannot explain a high amount of variability in the changes of the cost of capital. Using the method of variance inflation factors, we cannot identify any noticeable impact of multicollinearity.

Using the Breusch-Godfrey test, we test positive to serial correlation. As we test also positive on heteroscedasticity using the Breusch-Pagan test, we use standard errors corrected for heteroscedasticity and serial correlation using Arellano (1987) estimators. Using the Lagrange Multiplier Tests, the fixed effects used in the models (3), (4), (7), and (8) are significant when applied jointly using the specification according to Honda (1985).

The relationship could be shown to be robust by using different model specifications as well as estimation methods. Therefore, it answers our question showing that there is a positive relationship between the capital ratio and the cost of capital. The estimated positive coefficient is in line with the results achieved by the mentioned country specific works estimating the relationship between cost of capital and capital ratios indirectly using regressions on CAPM equity β (Junge and Kugler, 2013; Kashyap et al, 2010), using different specifications (Miles et al, 2013) as well as using an analytical approach (Firestone et al, 2017). Nevertheless, our results are contradictory to the results of Toader (2015) showing negative coefficients in estimating the relationship between the logarithmic

values of the *WACC* and Tier 1 capital ratios using a simple OLS. However, the definition of the *WACC* used by Toader (2015) differs in mapping external ratings of banks to CDS spread when estimating the cost of debt. Due to data availability as well as to include potential effects of funding advantages using deposits, we use an accounting based approach for our calculation.

Using the expanded specifications (5) to (8) the regression coefficient for $CR \cdot B2$ (Tier 1 ratio for observations from 2004 to 2010 referring to the "Pre-Basel III-Period") is significant to a level of 1 % while for $CR \cdot B3$ (Tier 1 ratio for observations from 2011 to 2016 referring to the "Basel III-Period") the significance level is lower. The values of the coefficients for the "Basel III-Period" are lower than for the "Pre-Basel III-Period" for every specification showing a reduced sensitivity after the endorsement of Basel III. This implies that the same rise in the capital endowment (measured in a rise of Tier 1 ratio) would result in a lower rise in the cost of capital compared to the old regulatory regime. One could argue that there might be reverse causality between capital ratios and cost of capital given that bank managers might adjust their capital ratios due to minimizing cost of capital (following the trade-off theory by Kraus and Litzenberger, 1973). Though, this argumentation is only partially correct as changes in the cost of capital will be considered when setting the target management capital ratio above the minimum requirement. We see the adjustment to the capital ratio as mainly exogenous given the high impact of capital regulation.

Compared to Basel II, the Basel III framework increases the minimum required Tier 1 ratio from 4 % to 8.5 %. This includes the capital conservation buffer of 2.5 %. For simplification reasons we do not consider other capital buffer requirements. If we assume a constant distance to the minimum ratio and linearity, we would calculate the following change in $WACC^{Spread}$ using a sensitivity of about 3 BP deviated from specification (2) and (4):

$$3\ BP \cdot (8.5 - 4.0) = 13.5\ BP \tag{12}$$

Therefore, we calculate an impact of 13.5 BP in raising $WACC^{Spread}$ due to the rise of Tier 1 for our sample. Considering that the average *WACC* in our sample is 1.6 %, the calculated impact can be viewed as quite low. As Basel III also includes a revision of the definition of overall RWA as well as of the Tier 1 capital components (which can be assessed as stricter), the overall impact might be underestimated. If we split our sample in banks from advanced economies as seen in specification (9), respectively emerging markets as seen in

specification (10), we still estimate positive coefficients. Using the subsample for advanced economies, the coefficient is significant for $CR \cdot B2$ as well as $CR \cdot B3$. However, the coefficient $CR \cdot B3$ is larger implying a higher sensitivity after the endorsement of Basel III. In the smaller subsample for emerging markets, the coefficient for $CR \cdot B2$ is higher compared to the one for $CR \cdot B3$ (the latter not significant any more). The results show that the higher coefficients for $CR \cdot B2$ in the specification (5) to (8) are mainly driven by the emerging markets given the higher sensitivity in the pre Basel III period.

6 Conclusions

The BCBS identified high leverage in the banking sector as one of the main sources for the financial crisis beginning in 2007. As a response, the regulatory capital requirements were raised by the endorsement of the new regulatory framework "Basel III". In the economic literature, several studies analyze the impact of the raised capital requirements. We contributed to this discussion by using an international sample representing the majority of the BCBS member countries.

Regarding the question of which dependency exists in general between capital ratios of banks and the cost of capital, we identified a positive relationship between capital ratios and the cost of capital. The relationship is robust as different model specification and estimation methods show.

Regarding the question, whether there is any change to the observed relationship due to the Basel III framework, we could show that globally the sensitivity of the cost of capital on the capital ratios was reduced after the endorsement of Basel III. This implies that the same rise in capital would result in a lower rise in the cost of capital than in the previous regulatory regime reducing the overall effect of higher capital requirements. Nevertheless, the effect is mostly connected to emerging markets. Only when incorporating advanced economies, we estimate a raise in the sensitivity of the cost of capital to capital ratios.

To continue to analyze this implication, future research could focus on the finalization of the Basel III framework (BCBS, 2017a) which might not have a significant impact on the banking sector as a whole but nonetheless on some individual banks as stated in BCBS (2017b).

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