An Alternative Assessment of Banks' Risk in a Low Interest Rate Environment

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In this paper, we analyze the impact of a low interest rate environment on banks' risk-weighted assets (RWA)/total assets ratio, also known as RWA density. In theory, a low RWA density can imply a bank´s lower risk, lower capital requirements and, therefore, a higher return on average equity (ROAE), implying a bank's higher competitiveness. In the theoretical part, we identify the key factors affecting RWA variability, which is correlated with RWA density. In the empirical part, based on a sample of 352 banks from the Eurozone, Japan, Sweden, Switzerland and Denmark during the period 2011–2017, we apply the system of the Generalized Method of Moments. We did not find any evidence to support the main hypothesis that a low interest rate environment will influence banks' RWA density after 1 year. We rejected our hypothesis even for periods of 2 and 3 years. Our contribution to the literature is three-fold. Firstly, we discuss the theoretical and practical aspects

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of RWA variability and density. Secondly, unlike other researchers, we also focus on macro-level determinants (including a low interest rate environment), and identify ROAE and bank heterogeneity as significant determinants of RWA density. Finally, we examine a large data sample, which enables us to identify the key determinants of RWA density and to obtain robust results from across different regions and bank business models in the recent period. Our findings survive a battery of robustness checks and provide some solid support for regulators when they propose new bank capital requirements and reform the calculation of RWA.

Key words: bank; credit risk; density; low interest rates; panel data; risk-weighted assets.

JEL Classification: C33, E43, G21.

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1. Introduction

In the aftermath of the 2007–2009 global financial crisis (GFC), many central banks around the world cut interest rates to close to zero or even into negative territory [Borio et al., 2017]. Such policies have been implemented in countries such as Japan, Sweden, Switzerland, Denmark, and the Eurozone. However, the question remains: how have these actions affected banks' risk profiles?

The GFC has also highlighted several weaknesses of the global bank regulatory system known as the "Basel II" framework, which was set up by the Basel Committee on Banking Supervision (BCBS). Specifically, Gambacorta & Karmakar (2016) state that the GFC has revealed the limitations of risk-weighted bank capital adequacy (CAR) ratios, which are defined as regulatory capital divided by risk-weighted assets (RWA). The BCBS reacted to these limitations in the so-called "Basel III" reforms in 2010 [BCBS 2011; 2013; 2014; 2015]. The post-crisis reforms of the Basel capital accord first focused on the numerator of the CAR – the regulatory capital that banks must hold to increase their loss absorption capacity. Later, the emphasis was placed on the denominator of the CAR – the RWA – to harmonize banking rules and decrease risk weight heterogeneity in global banks [BCBS, 2016; Turk-Ariss, 2017]. The implementation of the RWA concept for bank risk management purposes has led to the creation of a new synthetic indicator, RWA density, defined as RWA divided by the total assets. Its main goal is to monitor better the risk profile of a balance sheet [Brie, Fréon, 2016].

Under Basel II, banks were allowed to use internal models to calculate RWAs and capital requirements [BCBS, 2006]. However, this resulted in RWA variability stemming from inadequate internal models and gaming behavior, which results in capital requirements that are inconsistent with the underlying risk of the assets [Bastos e Santos et al., 2020]. Put differently, some banks underestimated their real risk, which resulted in lower capital requirements.

Therefore, these banks artificially increased their return on average equity (ROAE) and, thus increased their apparent competitiveness.

Our motivation for this paper is to analyze the key determinants of RWA density with a special focus on the impact of a low interest rate environment. Specifically, we assume that banks applied search-for-yield strategies during low interest rates. As a result, we will test the following hypothesis: "A low interest rate environment will increase banks' RWA density ratio after 1 year." To a sample of 352 banks from the Eurozone, Japan, Sweden, Switzerland and Denmark during the period 2011–2017, which also covers the period of zero and negative rates, we apply the Generalized Method of Moments (GMM), a standard methodology for panel data analysis.

We contribute to the literature in three ways. Firstly, we discuss the theoretical and practical aspects of RWA variability and density. Secondly, whereas previous papers have generally looked for the micro-level determinants of RWA density, we focus on both micro- and macro-level determinants (including a low interest rate environment). Finally, we examine a large sample of 352 banks, which enables us to identify the key determinants of RWA density and obtain robust results across different regions and bank business models. In addition to that, our dataset covers the most recent period after the GFC and tries to explain the effects of the current environment characterized by low interest rates, modest GDP growth, and an increasing regulatory burden [BCBS, 2019].

The remainder of the paper is structured as follows. In Section 2 we provide the theoretical background to our research and present a review of the literature and key terms. Section 3 describes our research objective and the GMM system as a methodological approach. It also analyzes a data sample. Against this backdrop, in Section 5 we present the model, while Section 6 includes the results and related discussion. Finally, Section 7 concludes the paper and highlights its contribution.

2. Theoretical background

2.1. Literature review

In our paper, we analyze the key determinants of RWA density -an alternative indicator of bank risk- under low interest rates. We divided the literature review into three streams. Firstly, discuss recent studies on credit risk management and bank profitability in a low interest rate environment. Secondly, we focus on the stream of literature dealing with the determinants of RWA density. Thirdly, we deal with an analysis of relevant papers about credit risk management, with credit risk proxied by the non-performing loans (NPL)/total ratio (the NPL ratio and RWA density are positively correlated as our analysis indicates).

Firstly, we base our research on the recent literature about the effects of the recent period of low interest rates on credit risk management and banks' profitability. That literature is relatively rich. For example, Altunbas et al. (2012) explored how monetary policy can affect banks' risk-taking. Rejnuš (2015) analyzes the overall impact of low interest rates on several economic sectors (including banks). Borio et al. (2017) investigated how the short-term interest rate and the slope of the yield curve relate to bank profitability measured by the return on assets ratio. Bikker & Vervliet (2018) investigated risk-taking and bank profitability under low interest rates. More recently, Hanzlík & Teplý (2019) and Coleman & Stebunovs (2019) examined the key determinants of the net interest margin and the general profitability of European banks during a period of low interest rates. Most authors document that the low interest rate environment affects banks' profitability negatively and decreases their competitiveness [Carletti et al., 2020].

Secondly, the literature dealing with determinants of the RWA density is rather limited compared to the two previous literature streams. Most of the relevant works identify the micro-level (bank-level) determinants of RWA density rather than the macro-level determinants as we do. Furthermore, these studies cover primarily RWA variability, which is highly connected to RWA density. As expected, Bastos e Santos et al. (2020) find that a possible source of RWA variability could be due to banks gaming their internal models (i.e. that some banks may seek to game these models and lowball their risk weights). They list three reasons for RWA variability: i) the share of opaque assets held by banks (e.g. derivatives), ii) the degree to which a bank is capital-constrained, which is consistent with the gaming hypothesis, and iii) jurisdiction-specific factors. RWA density is also used when estimating the effects of bank capital regulation [Brie, Fréon, 2016; CGFS, 2018]. Šútorová and Teplý (2014) discovered the dynamics in the significant persistence of RWA density in the EU and estimated a significant positive effect of bank profitability on their dataset covering the period from 2006–2011. Brie & Fréon (2016) recognized RWA variety in the EU and concluded that their RWA density makes it possible to identify early those European banks where the activity is more adversely affected by the macroeconomic environment and/or by their investment strategies. They also demonstrated that the RWA density proves to be complementary to the CAR ratio. Turk-Ariss (2017) also documents substantial variations in bank risk weights across asset classes by country and counterparty exposure in the European banking sector. These findings could encourage discussions and policy suggestions for the ongoing international regulatory review and harmonization of risk weights.

Finally, the third stream focused on credit risk management. Chaibi & Ftiti (2015) discussed the determinants of NPLs in Germany and France. Radivojevic et al. (2017) performed an analysis and found a significant link between the NPL ratio and GDP in 25 emerging countries. Credit risk management in Central European countries was researched by, for instance, Stavárek & Vodová (2010), Vodová (2012), Jakubík & Moinescu (2015) or more recently by Černohorský (2017). Dimitrios et al. (2016) analyzed the possible effects of various bank-related and macroeconomic variables on NPL ratios. During our research, we were inspired by the abovementioned authors when selecting variables for our model.

2.2. Risk-weighted assets (RWA) density

The RWA concept first appeared in the Basel I bank accords prepared by the BCBS (1988). Over time, the reinforcement of banks' balance sheets has become a priority for the BCSB ever since the establishment of its first prudential measures [Brie, Fréon, 2016]. Basel I's original purpose was to break down banks' assets and weigh them according to their riskiness:

$$RWA_t = \sum_{i=1}^{n} w^i \cdot Asset_t^i, \quad (1)$$

where w^i is the corresponding weight for $Asset^i$. Under the current Basel Capital Accords, the banks themselves perform an independent assessment of the riskiness of credit instruments through internal models. This is, however, a reason why RWA has become a target of criticism. Many researchers, such as Dewatripont et al. (2010), Cannata et al. (2012), Le Leslé & Avramova (2012), more recently Brie & Fréon (2016) and Bastos e Santos et al. (2020) mention numerous reasons why the concept of RWA is to be revisited. Firstly, from the regulator's point of view, banks can be incentivized to underestimate their risk to avoid larger capital requirements. Conservative banks can then lose their competitive advantage as they face relatively stricter regulation and leave less conservative banks to gain market share. Secondly, RWAs rely on external ratings that correspond to the current economic cycle – in times of growth, ratings can be too optimistic, and they can react to a crisis when it is already too late. Therefore, the RWA may fail to warn in advance of the potential crisis. Thirdly, the internal calculation of RWA by individual banks can worsen the comparability between banks and undermine the overall credibility of the measure as a credit risk measure. Finally, the calculation can be very complex; for a large cross-border bank, this can lead to the overall RWA figure being composed of RWA from its subsidiaries in different countries.

Despite its shortcomings, RWA remains a key concept in bank regulation [BCBS, 2011]. However, the recent Basel III regulatory framework introduced a leverage ratio, which is simpler and non-risk-weighted [BCBS, 2014; Brie, Fréon, 2016; Gambacorta, Karmakar, 2016]. To test our hypothesis, we adopt as a measure of riskiness the ratio of risk-weighted assets to a bank's total assets (RWA density):

$$RWADensity_t = \frac{RWA_t}{TotalAssets_t}. \quad (2)$$

At time t, we calculate it as RWA over the total assets of a bank. This allows us to compare conveniently banks of different sizes with each other and to analyze the changes in their riskiness over time. Nevertheless, the denomination by assets does not address all the comparability concerns discussed above. Equation 2 also implies that RWA variability is correlated with RWA density.

3. Research objective, methodology and data

3.1. Research objective

Our research objective is to establish how the negative interest rates set by some global central banks have affected banks' risk profiles. Based on a literature review we test the following main hypothesis: "A low interest rate environment will increase banks' RWA density ratio after 1 year." To make our results more robust, we also test the hypothesis for periods of 2 and 3 years. Moreover, we will identify the key determinants of a bank´s RWA density.

3.2. Methodology

To a sample of 352 banks from the Eurozone, Japan, Sweden, Switzerland and Denmark during the period 2011–2017, which will be analyzed below, we apply the GMM system as our methodological approach. GMM is a standard methodology for panel data analysis and was first used by Arellano & Bond (1991) and later developed by Arellano & Bover (1995) and Blundell & Bond (1998). We estimate the models with a collapsed matrix of instruments, which reduces the number of instruments. Our model is then as follows:

$$y_{i,t} = \alpha + \beta x_{i,t} + \mu_i + v_{i,t}, \qquad (3)$$

where $i = (1,\ldots,N)$ are individual groups, $t = (1,\ldots,T)$ represents the year, $y_{i,t}$ is the explained variable, $x_{i,t}$ is a matrix of regressors, μ_i is a group-specific constant term, and $\nu i, t \sim$ i.i.d. $N\left(0,\sigma_{\varepsilon}^{2}\right)$ is a variable capturing exogenous shocks to the model. This model is static but can be modified into a dynamic model:

$$y_{i,t} = \alpha + \phi y_{i,t-1} + \beta x_{i,t} + \mu_i + v_{i,t}. \qquad (4)$$

Since μ_i is uncorrelated with the lagged $y_{i,t-1}$ term, and this variable is now endogenous to the model, we cannot use the aforementioned methods, as they are unusable for the estimation of Equation 4. This caveat can be solved through the already discussed GMM system. GMM as an estimation method is also used in studies relevant to our research, including Borio et al. (2017) and Chaibi & Ftiti (2015). In our empirical analysis, we use an implementation of the GMM system that was further developed by Roodman (2009, 2018). We estimate the models with a collapsed matrix of instruments, which reduces the number of instruments.

3.3. Data analysis

In this section, we undertake an empirical analysis of our data sample. We base our research on a unique panel data set from the Orbis Bank Focus database including 352 banks from Denmark, the Eurozone, Japan, Sweden, and Switzerland in the period 2011–2017, which makes our research unique compared to that of other researchers. Our original data set covered all Eurozone countries. However, after statistical analysis, we excluded Cyprus, Greece, Italy, and Portugal as outliers. Table 1 indicates that the analyzed banks came primarily from Germany, Denmark, Austria, and Japan. The largest country in the sample available for testing the current hypotheses is Germany, with 144 observations for individual banks in 2015, accounting for 40,9% of the dataset. The second largest is Denmark with 33 observations, and the third most frequent is Austria, having 31 banks and covering 8,8% of the dataset, followed by Japan (25 banks). The mean value of the RWA density of the whole sample reached 48,62%, while the median value differed only slightly (49,89%).

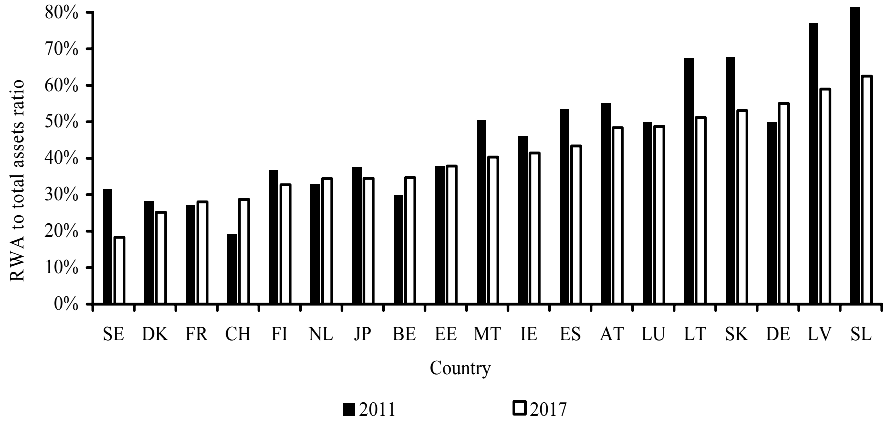
Fig. 1 shows the RWA density in different countries in the period 2011–2017, which also covers the period of zero and negative rates. It implies an overall decrease in RWA density across the observed countries. We see relatively low levels of this indicator in developed countries such as Japan (JP), Switzerland (CH), and France (FR), which can be attributed to the high use of internal bank models and a high bank-government nexus in these countries. For instance, under Basel II, the risk weight of claims on sovereigns with AAA to AA- ratings (including domestic government bonds) was zero, which implied a zero capital buffer [Le Leslé, Avramova, 2012]. On the other hand, we can see relatively high levels also in the Central and Eastern European countries (Estonia (EE), Latvia (LA), Lithuania (LT), Slovakia (SK), and Slovenia (SL)). We offer the following explanation: The relationship between RWA density and log-transformed total assets is downward sloping, and most banks in the countries included in the dataset are relatively smaller than the banks in larger countries (the weighting by assets also makes this more apparent, combined with the small number of observable banks in these countries). Thus, the smaller countries on average have a higher level of RWA density compared to the larger countries, assuming that the average size of the banks is greater in the latter group.

Table 1.

Risk-weighted assets density, observations in 2015, summarized by country

	N	Of total N, %	Mean, %	Median, %
Austria (AT)	31	8,8	52,27	52,39
Belgium (BE)	11	3,1	39,61	37,72
Switzerland (CH)	15	4,3	40,97	35,93
Germany (DE)	144	40,9	52,53	56,15
Denmark (DK)	33	9,4	63,54	73,60
Estonia (EE)	2	0,6	39,06	39,06
Spain (ES)	9	2,6	43,46	42,55
Finland (FI)	5	1,4	25,24	33,42
France (FR)	16	4,5	33,83	30,25
Ireland (IE)	4	1,1	47,11	45,47
Japan (JP)	25	7,1	40,47	39,85
Lithuania (LT)	3	0,9	58,21	60,86
Luxembourg (LU)	8	2,3	41,33	37,86
Latvia (LA)	1	0,3	62,20	62,20
Malta (MT)	3	0,9	45,31	45,68
Netherlands (NT)	18	5,1	45,39	39,39
Sweden (SE)	15	4,3	27,26	18,76
Slovenia (SL)	6	1,7	56,45	57,51
Slovakia (SK)	3	0,9	59,44	60,43
All	352	100	48,62	49,89

Source: Authors based on the Orbis Bank Scope database.

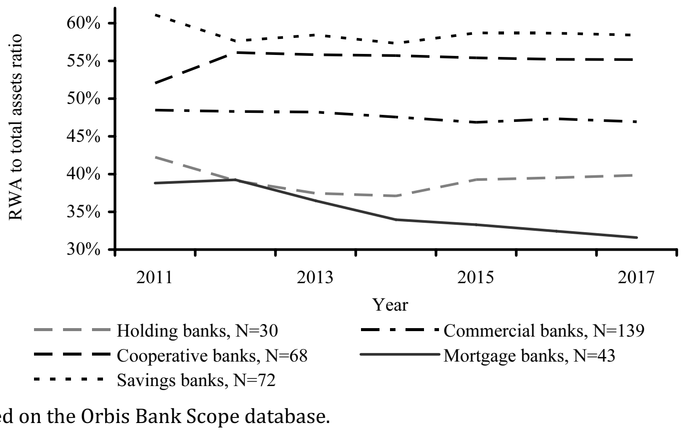


Note: for explanation of abbreviations see Tab.1.

Fig. 1. Risk-weighted assets to total assets, average by country, weighted by assets, 2011 and 2017

Source: Authors based on the Orbis Bank Scope database.

Fig. 2 displays the development of RWA density in the period 2011–2017 in the observed countries in terms of bank business models, since we are also interested in bank heterogeneity. The largest banking category in the sample, commercial banks (139 in the sample), declined modestly over time, while mortgage banks (43) reported the most significant decrease in RWA density in the observed period (we will focus on mortgage banks in more detail in Section 6). After the GFC, regulators motivated the banks to decrease their RWA levels. For instance, in the European banking industry, RWA density reduced by approximately 20% between the years 2007–2017 [Schildbach, Schneider, 2017]. In our period and dataset, this trend is only marginal. For cooperative banks (68), holding banks (30) and savings bank (72), the evolution over time does not, however, exhibit any clear trend.



Source: Authors based on the Orbis Bank Scope database.

Fig. 2. Risk weighted assets to total assets, unweighted average by year and bank category, 2011–2017

4. Model specification

In this section, we describe our model and key variables. Our hypothesis states that "A low interest rate environment will influence banks' RWA density after 1 year", in order to reflect a low interest environment, which makes our research unique. To obtain our results, we undertake a robustness check also for 2 and 3 years. When testing it, we will estimate the following model and its modifications based on Equation 4:

$$RWAtoAssets_{i,t} = \alpha + \phi RWAtoAssets_{i,t-1} + \theta MonIR.L\lambda_{i,t} + \\ + \rho_1 InterestRate3M_{i,t} + \rho_2 InterestRate3M_{i,t-1} + \beta x_{i,t} + \mu_i + \nu_{i,t}, \quad (5)$$

where the $RWAtoAssets_{i,t}$ is the explained variable, then we include constant α, and the first lag of RWA density as $RWAtoAssets_{i,t-1}$ and $MonIR.L\lambda_{i,t}$ represent a dummy variable indicating whether the given observation attained the zero lower bound, lagged by λ periods (where we estimate variants for λ = (0,1,2,3)). The variables $InterestRate3M_{i,t}$ and $InterestRate3M_{i,t-1}$ allow us to observe the effect of the interbank interest rate and its lag, and $x_{i,t}$ is a matrix of other variables (see also Table 2 and Table 3 below). ϕ, θ, β, ρ_1, ρ_2 are coefficients of variables, and, as the case may be, μ_i is an error term of fixed components and $\nu_{i,t}$ is an error term of exogenous shocks.

Firstly, we selected variables based on the above-mentioned literature review on bank profitability [Borio et al., 2017; Claessens et al., 2018, Hanzlík, Teplý, 2019] and credit risk management [Chaibi, Ftiti 2015, Dimitrios et al., 2016; Radivojevic et al., 2017]. Secondly, in our final presented model, we use variables that are believed to have an impact on the explained variable. The impacts of the variables included in the model are summarized in Table 2 for bank-specific parameters and Table 3 for macroeconomic variables (including possible negative interest rates).

Table 2.

Expected effect of the bank-specific and bank dummy variables explaining risk-weighted assets density

Variable (sign)	Description
RWADensity	The ratio of risk-weighted assets to the banks' total assets
ROAE (+)	Higher returns can be associated with riskier positions in assets. Particularly in an environment of low interest rates, ownership of assets with a higher proportion of conservative investment positions may result in the lower profitability of the banks. This variable is treated as endogenous in estimations
LoansToDeposits (+/–)	We use this variable as a proxy for riskiness – how willing the banks' are to lend [Dimitrios et al., 2016]. However, RWA is also associated with other balance sheet and off-balance sheets assets, so the effect can be two-fold; treated as endogenous
log(Assets) (–)	We expect RWA density to decrease with the size of the banks as discussed in the descriptive part. This variable is treated as exogenous to the model

Continues

Variable (sign)	Description
CooperativeBank (–)	Cooperative banks can be considered stable institutions [Kuc, Teplý, 2018]; we expect this group to have lower RWA density compared to other bank types
MortgageBank (–)	A higher share of collateralized housing loans should result in a smaller level of RWA density. We assume the *MortgageBank* variable to be significant

Source: Authors.

Table 3.

Expected effect of the macroeconomic variables explaining RWA density

Variable (sign)	Description
InterestRate3M (+/–)	The immediate effect of the interbank interest rate can be negative or positive
GDPGrowth (–)	A negative effect on RWA is expected – a declining economy might imply the worsening of asset quality in the economy. Additionally, including GDP in the model allows us to control for the economic cycle
MonIR.Lλ (+)	We hypothesize that the effect is positive – during a low interest rate environment, banks might try to pursue riskier positions

Source: Authors.

Because the literature estimating directly the determinants of RWA density is limited, we assume that similar variables will affect RWA density. From the available variations of different models, we chose those variables that were not highly correlated and those that helped us to explain the RWA density ratio.

We also addressed concerns about and criticism of RWA raised by Cannata et al. (2012) or Le Leslé & Avramova (2012) based on the claim that every country can have a different methodology for computing RWA (and this possibly applies even at the bank level). In the model, we included dummy variables for Austria, Germany, Denmark, France, the Netherlands (the most frequent countries in the sample) and for Japan (mainly because the European Central Bank does not supervise the Japanese banks, and the difference can, therefore, be significant). On the other hand, to avoid overspecification, we did not include dummy variables for Sweden and Switzerland, as their coefficients were not significant.

5. Results and discussion

5.1. Baseline results

To take into account spatial interconnectedness of regional housing markets we In this part, we discuss the key findings of our research and compare them with those of other researchers. The results of the estimation of Equation 4 using the two-step GMM system are presented in Table 4. We decided not to include the variable InterestRate3M in the main models (see also the robustness checks in Section 5.2). The effect of the lagged dependent variable *RWADensity* is significant, suggesting that the previous realizations of the variable have an important role in explaining the current level of RWA density. This outcome was anticipated, because RWA is a combination of assets, including all items from short-term to long-term positions. Nevertheless, the value of the coefficient close to 1 suggests that the lagged variable itself successfully explains a large portion of the current state.

The coefficient for the bank-specific variable capturing profitability – *ROAE* – does not refute our expectations described in Table 2; the coefficient is significant in all specifications of the model as well as in the non-robust and robust version of the estimations. Moreover, the effect of *LoansToDeposits* is insignificant. Therefore, we do not have enough evidence to accept our assumptions about the variable as a proxy for riskiness.

We have found significant effects of the dummy variables capturing bank heterogeneity, most evidently in the model in column (5), although it is not significant in the robust version. We expected these coefficients to be important in the explanation of RWA density, as we argued in the previous Subsection. The most significant coefficient is the *MortgageBank* estimate in the model in column 5 in Table 4, confirming the expected negative impact on RWA. Importantly, the coefficient for *log(Assets)* has the correct predicted sign, and it is statistically significant in the non-robust version of estimations.

Table 4.

Risk-weighted assets density estimation results, two-step system GMM

	(1) RWA D.	(2) RWA D.	(3) RWA D.	(4) RWA D.	(5) RWA D.
L.RWADensity	0,859***	0,863***	0,880***	0,853***	0,829***
ROAE	0,0592***	0,0616***	0,0530***	0,0573***	0,0595***
LoansToDeposits	0,0000264	0,0000128	–0,00000521	0,0000133	0,0000536
HoldingBank	–2,090*	–1,973*	–2,037*	–2,197*	–2,309*
CommercialBank	–0,855	–0,847	–0,738	–0,958*	–1,006*
CooperativeBank	–0,275	–0,272	–0,180	–0,193	–0,182
MortgageBank	–3,093**	–3,175***	–2,972**	–3,426***	–3,700***
log(Assets)	–0,642*	–0,637*	–0,547*	–0,678**	–0,821**
GDPGrowth	–0,111***	–0,0771***	–0,0686***	–0,0598***	–0,0676***
CountryAT	1,623***	1,757***	1,470**	1,417**	1,719***

Continues

	(1) RWA D.	(2) RWA D.	(3) RWA D.	(4) RWA D.	(5) RWA D.
CountryDE	1,455***	1,628***	1,512***	1,491***	1,596***
CountryDK	1,252	1,269	1,043	1,292	1,580
CountryFR	0,924	1,091*	0,941	0,937	1,086*
CountryJP	2,017***	2,000***	1,793***	1,905***	2,188***
CountryNL	0,661	0,908	0,591	0,442	0,439
MonIR.L0	0,469				
MonIR.L1		0,0544			
MonIR.L2			–0,00546		
MonIR.L3				–0,218	
Constant	16,48*	16,32*	14,13	17,83*	21,28**
Observation	1691	1691	1691	1691	1691
Instruments	34	34	34	34	33
Number of groups	360	360	360	360	360
Observations per group	6	6	6	6	6
Wald st. p-value	0,0000	0,0000	0,0000	0,0000	0,0000
A-B AR(1) p-value	0,0020	0,0015	0,0016	0,0015	0,0017
A-B AR(2) p-value	0,9849	0,9819	0,9958	0,9802	0,9477
Hansen J p-value	0,4441	0,2818	0,2476	0,2080	0,4502

Note: * $p < 0,05$, ** $p < 0,01$, *** $p < 0,001$.

Source: Own research.

Furthermore, the results of macroeconomic variables show the significance of the *GDPGrowth* coefficient and confirm the expected negative effect on the RWA density ratio; that is, the non-robust coefficient is significant. Nevertheless, we did not confirm any significance of the coefficients capturing the interest rates: The coefficients in columns 1–4 for *MonIR.Lλ* are statistically insignificant. Therefore, we argue that the specification in column 5 in Table 4 is likely to be superior to other models. Additionally, we identified a significant effect of the dummy variables controlling for the effects of individual countries. The results show that for the model in column 5, the coefficients controlling for individual effects in Denmark, Germany, and Japan are statistically significant. Thus, the level of *RWAdensity* might be country-dependent.

5.2. Robustness checks

We did several robustness checks. Firstly, we checked the corresponding results of the same estimation in Table 4 with errors robust to autocorrelation and heteroscedasticity (the results are not reported in this paper because of their limited scope). However, the results did not change significantly. Secondly, we did the Arelando-Bond test for the autocorrelation of order 1, which is statistically significant at the 1% level. Nevertheless, we tried to control for the order 1 autocorrelation with the lagged variable *RWADensity*, and we rejected the autocorrelation of order two. We do not reject the null hypothesis of the Hansen J test (the null hypothesis states that the instruments are exogenous), which suggests that we did not specify the instruments in the model incorrectly. Finally, we did include the estimation of the alternative models with the variable *InterestRate3M* and its lag included (the results are not reported in this paper). However, the explanatory power of these models is inferior to the models´ results presented in Table 4.

5.3. Summary of results and comparison with other researches

We did not find any evidence to support the hypothesis that the low interest rate environment will influence banks' RWA density after 1 year. In fact, after carrying out the robustness checks, we rejected our hypothesis even for 2 and 3 years. Hence, we reject our hypothesis. We identified potential determinants of RWA density, notably ROAE, and identified heterogeneity in our sample of bank categories. The results of our estimation are aligned with the outcomes of Šútorová & Teplý (2014), who also discovered the dynamics in the significant persistence of RWA density and estimated a significant positive effect of bank profitability on their dataset covering the EU banks in the period 2006–2011. Other researchers such as Borio et al. (2017), Hanzlík & Teplý (2019) and Coleman & Stebunovs (2019) explored the effect of low interest rates on banks' risk and competitiveness (measured using profitability ratios) through standard econometric tools suitable for a panel data analysis. However, they did not examine RWA density as an explanatory variable. On the other hand, some authors, including Brie & Fréon (2016) and Turk-Ariss (2017), examined RWA density and variability in the European banking sector, but they did not use panel data in their research.

5.4. Further research opportunities

We see three opportunities for further research. Firstly, further analysis of the impact of the low interest rate environment on bank risk profiles (including, in addition to RWA density, other credit risk indicators such as the NPL ratio, cost of risk, or the CAR ratio) and competetiveness (market power, profit and cost efficiency, etc.) can be conducted. Secondly, an assessment of other micro- and macro-economic variables influencing RWA density would be useful (e.g., market concentration, regulatory capital, the composition of RWAs in terms of credit, market, and operation risks). Finally, a larger data sample (more analyzed banks and a longer observed period) might reveal interesting facts about the analyzed RWA density/low interest rates nexus.

6. Conclusion

In our paper, we focused on the determinants of RWA density of banks in countries, which experienced negative interest rates. In theory, a low RWA density can imply a bank´s lower risk, lower capital requirements, and therefore higher ROAE, implying its higher competitiveness. Most authors document that low interest rates affect banks' profitability negatively and decrease their competitiveness [Carletti et al., 2020].

In the theoretical part, we identify the key factors of RWA variability (asymmetric information, differences in risk assessments, the jurisdiction-specific effect, gaming), which is correlated with RWA density. Based on a sample of 352 banks from the Eurozone, Japan, Sweden, Switzerland, and Denmark during the period 2011–2017, we did not find any evidence to support the hypothesis that the low interest rate environment will increase the banks' RWA density after 1 year. We rejected our hypothesis even for 2 and 3 years and did not identify banks´ search-for-yield strategies during low interest rates. We also dealt with the relatively strong effects of regulation in individual countries. Nevertheless, we identified the potential determinants of e RWA density, notably ROAE, and identified heterogeneity in our sample of the bank's categories. The results of our estimation are aligned with the outcomes of Šútorová & Teplý (2014), who also discovered the dynamics in the significant persistence of RWA density.

Our contribution to the literature is therefore three-fold. Firstly, we discussed the theoretical and practical aspects of RWA variability and density. Secondly, we also focused on macro-level determinants (including a low interest rate environment) and identified ROAE, and bank heterogeneity as significant determinants of RWA density. Finally, we examined a large sample of 352 banks, which enabled us to identify the key determinants of RWA density and achieve robust results across different regions and bank business models. On top of that, our dataset covers the most recent period after the GFC and tries to explain the effects of the current economic environment. Our findings survive a battery of robustness checks and provide some solid support for regulators when they propose new bank capital requirements and reform the calculation of RWA.

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