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Has the Stabilizing Nature of Deposits Changed after the Crisis? Impact of Funding Structure on Bank's Risk

Keywords: bank's risk; funding structure; deposits

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Abstract

Theoretical background: The global financial crisis (GFC) has shown the importance of the funding model for the bank's stability. In this context, deposits were of particular importance as they proved to be a stable source of funding during market turmoil. As a result, many banks have changed the funding model, paying greater attention to financing obtained on the deposits market.

Purpose of the article: In this paper, we analyze the impact of funding models on the EU banks' risk after GFC, i.e. in 2011–2018. We put particular emphasis on the funding structure measured by the deposits to total assets ratio and changes that take place according to the type of institution (i.e. listing status, specialization, and funding model).

Research methods: In our research, we use panel data models together with a set of tests that allow us to deduce about properties of proposed models and allow us to analyze the significance of the impact of the bank-specific, macroeconomic, and dummy variables on the bank's risk. We apply "within", "fixed time effects" estimator from plm R package.

Main findings: We confirm the stabilizing function of deposits, but also the non-linear nature of the impact of the funding structure on the bank's stability, depending on the bank's specialization. This means that the stabilizing role of deposits for the bank's stability is just as important in the post-crisis period as it was during the outbreak of GFC in 2008, although the excessive growth of deposits in some types of banks may, however, lead to an increase in the risk level.

Introduction

The global financial crisis (GFC) as well as the crisis related to the debt problems of the euro area countries has contributed to renewed interest in how banks finance their operations, and thus to the funding models used by them. The turmoil in the financial markets in 2008–2009 proved to be a test for banks' funding structure in terms of risk generated and stability of functioning (Norden & Weber, 2010, pp. 69–93). As Martel et al. (2012) point out, in the years preceding the crisis, global banks and investment banks led to significant maturity as well as currency mismatch between assets and liabilities structure. The reaction of markets and regulators to the crisis prompted banks to reassess business strategies. As Roengpitya et al. (2014) indicate, the wholesale-funding model was quite popular in the pre-crisis period, but most banks departed from it in the first five years after the crisis, adopting the retail funding model.

The literature indicates that the scale of risk taken by banks in the pre-crisis period varied and depended to a large extent on the funding model adopted. Analysis of Vazquez and Federico (2015, pp. 1–14) proves that banks using the model based on retail funding sources were more resistant to the global financial crisis in 2007–2009, compared with banks based on wholesale funding. Similarly, the analysis of Huang and Ratnovski (2009) show that the use of the deposit-based funding model was a key factor in the relative resilience of Canadian banks during the financial crisis. The stabilizing nature of deposits in mitigating liquidity risk during tough conditions on financial markets is emphasized by Martel et al. (2012). They point out that financing of bank expansion with short term wholesale funds in the pre-crisis period, combined with the use of excessive leverage, were key factors in increasing imbalances and

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systemic risk, as well as the subsequent spread of the crisis mechanism. Hahm et al. (2013, pp. 3–36) found that the scale of using the funding model based on sources other than deposits and capital allows to predict crises in the financial market.

The GFC has forced the introduction of a new regulatory and supervisory framework and changed banks' funding models (Hart & Zingales, 2011, pp. 453–490; Buch & Dages, 2018). Banks returned to seeking financing in the retail and corporate deposits market, as well as a decline in the importance of funds obtained from financial institutions and an increase in the share of capital and reserves in the balance sheet structure.

The main aim of this article is to analyze the impact of funding models on the bank's risk in EU countries. Using the general-to-specific modeling approach we estimate the regression model including bank-specific, macroeconomic, and dummy variables for 1,132 EU banks. Therefore, we formulate the following research hypotheses:

H1: The banks' funding models have a significant impact on the bank's risk.

H2: After the GFC, deposit funding plays a stabilizing role for banks' risk in the EU.

H3: The strength and direction of the funding model's impact depends on bank status and specialization.

Our contribution to the literature is threefold. Firstly, we show that the bank's funding structure remains the vital determinant of the bank's risk and its stabilization role has not changed after the financial crisis. That is why we take into consideration only 2011–2018 years in order not to be affected by the disruptions in the first phase of the financial crisis.

Secondly, we extend Köhler's approach, which checked the impact of bank type on its stability. Our research allows answering the question of how a given type of institution affects the significance, as well as the strength and direction of macroeconomic and bank-specific factors on the bank's risk.

Thirdly, as we focus on the importance of funding structure for the bank's stability, we introduce additional clustering (retail-oriented and not retail-oriented banks).

This paper is organized as follows. The first section presents a review of the literature. Next, the data and research methodology are explained. The third section shows empirical results, followed by discussion and conclusions.

The article was prepared as part of a project financed by the National Science Centre entitled "The Structure of the Banking Sector's Funding Sources and the Domestic Banking Sector Stability in the Context of New Regulatory Initiatives" (contract number: UMO-2016/23/B/HS4/03220). Outcomes of our research were presented at the International Risk Management Conference, Global Virtual Conference, 9–10 October 2020. We appreciate the feedback from the participants of the Conference.

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Literature review

The bank's risk is measured similarly to earlier research (Köhler, 2015, pp. 195–212; Demirgüç-Kunt & Huizinga, 2010, pp. 626–650). We use a Z-score ratio as a measure of the bank's probability of default. The Z-score is calculated as a sum of ROA and equity to asset ratio divided by the standard deviation of ROA. The bank funding model is defined in terms of deposits to total assets ratio, as deposits constitute the largest part of banks' liabilities and due to their stabilizing role in limiting the bank's risk. Currently, the literature analyzing the relationship between the bank's risk of bankruptcy and the funding model focuses not only on the sources of financing banking activities but also on income diversification and other bank's characteristics. It is pointed out that the translation of the bank's funding model into the probability of its collapse is also dependent on the profitability resulting from the generated income. As Köhler (2015, pp. 195–212) emphasizes, investment banks and banks based on deposit funding differ not only in their funding model but also in their income structure. While in investment banks, the primary source of non-interest income is income from insurance, treasury management, or securitization, in banks financing on the deposits market, this type of income comes from fees and commissions for accounts, loans, consulting, and sale of insurance products. The author indicates that non-interest income of investment banks is characterized by higher volatility because they are more closely related to the variability of the market situation. Similar conclusions are emphasized by Maudos (2017, pp. 85–101), who indicates that the impact of income diversification on the bank's risks depends on the type of banking activity.

Similarly, Deyoung and Torna (2013, pp. 397–421) point to entirely different sources of risk for these two types of funding models. They note that it was not the non-interest income itself that increased the likelihood of bankruptcy, but rather the type of income. While a larger share of income from non-traditional activities, such as, e.g. securitization of assets, actually increased the likelihood of bank failures, risk diversification in the form of an increase in the share of non-interest income generated from fees and commissions from the sale of insurance reduced the likelihood of failure during the crisis.

Literature has no precise results regarding the impact of funding models on the bank's risk and profitability. While previous studies suggested a positive wholesale funding effect related to ensuring proper market discipline of banks (Calomiris & Kahn, 1991, pp. 497–513), the recent financial crisis has highlighted the negative effects of banks becoming dependent on non-deposit funding (Demirgüç-Kunt & Huizinga, 2010, pp. 626–650; Huang & Ratnovski, 2011, pp. 248–263; Acharya et al., 2011, pp. 1177–1209; Baselga-Pascual et al., 2015, pp. 138–166).

It is emphasized that the impact of funding models on banks' risk is highly non-linear. Altunbas et al. (2011) note that for banks with higher risk, stronger customer deposits base reduces the risk of bankruptcy compared to less risky banks.

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On the other hand, a higher percentage of wholesale funding reduces the stability of the riskiest banks, while it does not have adverse effects in less risky institutions. Ayadi et al. (2012, 2014) indicate that retail-oriented banks are, on the one hand, more secure and have a lower risk of bankruptcy. On the other hand, a diversified structure of funding sources will have a beneficial effect on profitability during the slowdown. Wholesale banks, on the other hand, are riskier due to the apparent lack of building appropriate liquidity buffers.

The crisis has shown that the source of business risk depends on the bank's activities and its funding model. According to Chaffai and Dietsch (2015, pp. 173–182), banks that were more resistant to shocks are primarily retail banks that suffered fewer losses than banks with other funding models, even though retail-oriented banks have a relatively constant cost structure. The studies of Demirgüç-Kunt and Huizinga (2010, pp. 626–650) show that in the case of most banks, greater dependence on non-interest income and the funding model based more on non-deposits sources is associated with greater instability. Benefits from risk diversification can be achieved only by few banks characterized by a relatively low level of non-interest income and non-deposit funding. Köhler's (2015, pp. 195–212) analysis allows to indicate two relations between the funding model and the income structure. First of all, income diversification translates into improved results of retail banks, but, at the same time, increases the risk of destabilization of investment banks. Secondly, the increase in the share of non-deposit funding increases the stability of investment banks, while it decreases for retail banks.

Research methods

Research sample

In the first phase, 3,463 banks operating in the EU-28 were selected from the Orbis database provided by Bureau van Dijk Electronic Publishing. Then we limited the sample to 1,242 banks. The selection criteria were as follows. As we decided that the Deposits to total assets ratio would be the best proxy for the banks' funding structure, we require each institution to report at least seven out of eight years for both: total assets and deposits and short-term funding data in the period of 2011–2018. In the last step, selected variables were subject to the winsorizing procedure at the 1- and 99-percentile level. Finally, 1,132 banks were included in our database. Taking into consideration the number of variables (37), this resulted in 335,072 bank observations for the period from 2011 to 2018. The time range of the study does not cover the first phase of the financial crisis (2008–2010) in order to avoid disruptions in the financial statements of banks during this period.

Furthermore, based on the classification of the Orbis database, we divided the sample according to the listing status (listed banks – 116; not listed banks – 1,016;

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Model 2.1) and four categories of banks, namely: savings (372 banks – Model 2.2), cooperatives (417 banks – Model 2.3), commercials (262 banks– Model 2.4) and investments (81 banks – Model 2.5). Followed the Köhler (2015) approach, the last category included investment banks, investment & trust corporations, bank holding & holding companies, and securities firms. Next, we divided the sample differently: based on Deposits to total assets ratio (dastf2ta) and Net fees and commissions to operating income ratio (nfac2oi) we split it into two subsamples, comprising retail-oriented banks (288 banks – Model 3) and not retail-oriented banks (844 banks – Model 3).

Variables description

Our dependent variable is the Z-score, which is interpreted as a distance to default (the number of standard deviations that a bank's return on assets has to fall for the bank to become insolvent). So we treat it as a measure of insolvency risk in banks. In our research, Z-score is calculated as the sum of ROA and equity to asset ratio divided by the standard deviation of ROA (see: Berger et al., 2009, pp. 99–118; Kocisova et al., 2018, pp. 205–223). Using Köhler's (2015, pp. 195–212) approach, we use the standard deviation of the whole year sample (2011–2018) instead of the rolling window proposed by Mergaerts and Vennet (2016, pp. 57–75).

The bank's risk is dependent on different factors. We include four types of variables in the study: dependent variable, bank-specific variables, macroeconomic variables, and dummy variables.

According to Altunbas et al. (2011), the factors that increase the risk of insolvency in banks are credit expansion, low share of customer deposits in total assets, size of the bank, and low capital. The authors also determine dependence on wholesale financing and low diversification of income sources as factors determining the risk of banks' instability. Based on the literature, we examine 14 potential determinants of the bank's risk – 6 bank-level factors: funding model, bank's size, income diversification, operating efficiency, cost efficiency and credit activity, 2 macroeconomic drivers: GDP growth, price stability measured by the inflation rate, and 6 dummy variables relating to the bank's specialization. Variables' definitions, data sources and expected sign of impact on dependent variable are presented in Table 1.

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Table 1. Selected variables

Type of variable	Label		Definition	Source of data	Expected impact on Dependent variable
Dependent variable	bank risk	zscore	Z-score is calculated as a sum of ROA and equity to asset ratio divided by the standard deviation of ROA	Own based on Orbis	
Bank-specific variable	size	log(ta)	Logarithm of total assets	Own based on Orbis	+*/-**
	income diversification	nfac2oi	Net fees and commissions to operating income ratio	Own based on Orbis	-
	operating efficiency	nim	Net interest margin	Orbis	+
	cost efficiency	coi	Cost to income ratio	Orbis	+/-
	credit activity	nl2ta	Loans to total assets ratio	Orbis	-
	funding model	dastf2ta	Deposits and short term funding to total assets	Own based on Orbis	+
Macroeconomic variables	economic situation	gdp	GDP growth	World Economic Outlook, IMF	+
	price stability	inf	Inflation	World Economic Outlook, IMF	-
Dummy variable	listing status	d1	d1=1 for listed banks; 0 otherwise	Own based on Orbis	
	specialisation	d2	d2=1 for savings banks; 0 otherwise	Own based on Orbis	
		d3	d3=1 for cooperative banks; 0 otherwise	Own based on Orbis	
		d4	d4=1 for commercial banks; 0 otherwise	Own based on Orbis	
		d5	d5=1 for investment banks; 0 otherwise	Own based on Orbis	
	funding model	d6	d6=1 for retail-oriented banks; 0 otherwise	Own based on Orbis	

Note:
*(+) – positive impact on Dependent variable
**(-) – negative impact on Dependent variable

Source: Authors' own study.

We treat the relation of deposits to total assets as the primary bank-specific explanatory variable because it indicates the funding model (see Table 1). Based on the existing literature, it can be expected that the increase in the stable deposits base will positively translate into improved bank stability.

The literature emphasizes the need to analyze the impact of the funding model on the bank's risk, while taking into account the income differentiation, and thus an indication of its source – interests or commissions and fees. That is why we choose Net fees and commissions to operating income ratio, which indicates the bank's income diversification (Demirgüç-Kunt & Huizinga, 2010, pp. 626–650).

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We also choose the size of the bank, measured by the logarithm of total assets. According to Boyd and Runkle (1993, pp. 47–67) and Ali and Puah (2018, pp. 1166–1186), larger banks are riskier because they may be tempted to abuse the status "too big to fail", which also includes maintaining lower capital ratios (see also: Galletta & Mazzù, 2019, pp. 1–18). This is also in line with the results of Kozak's (2020, pp. 31–40) research, which shows that large banks are more efficient.

The next variable used to describe the factors influencing a bank's risk is the Loans to total assets ratio. The indicator shows the extent to which the bank is involved in traditional operations which indirectly indicates the nature of the bank's activities (Mergaerts & Vennet, 2016, pp. 57–75). Beltratti and Stulz (2012, pp. 1–17) point out that banks with higher loans level are those with a smaller portfolio of securities, and therefore with a potentially higher share of deposits.

As a control variable, we also choose Net interest margin, which measures the operating activity. This indicator allows monitoring whether banks with a low level of interest margin do not take excessive risk to improve profitability (Köhler, 2015, pp. 195–212). The second measure of efficiency is Cost to income ratio, which indicates the efficiency and productivity of banks. A high level of the ratio generally means lower efficiency. However, Balcerzak et al. (2017, pp. 51–70) indicates the diversification of the efficiency level among banking sectors with the so-called EU-15 and the member states that joined the EU after 2004.

The model includes also macroeconomic variables – GDP growth and inflation. The literature shows that banks from countries with a higher level of economic development are more profitable and have a higher level of capital. The influence of inflation is not apparent. A higher inflation rate may reduce the bank's stability (Köhler, 2015, pp. 195–212), but it may also translate into greater depositors' willingness for opening deposits, which are considered as stable funding sources.

We select the dummy variable, referring to the type of institution. We use three criteria. Firstly, we divide banks into listed and unlisted ones. The second criterion is connected with the specialization of the institution. In this context we distinguish savings banks, cooperative banks, commercial banks and investment banks. Descriptive statistics for each type of banks are presented in Table 2.

Lower stability ratios characterize listed banks (see Table 2). The median of Z-score in listed banks is 37.0 while in not listed banks – 60.3. In terms of funding structure, not listed banks rely on deposits to a greater extent. The median of deposits to total assets ratio for not listed banks equals 84.8%, while for listed banks – 77.8%.

Descriptive statistics indicate differences between banks also in terms of their specialization. Relatively, the most stable are cooperative banks (median of Z-score 70.9) and savings banks (median of Z-score 70.3). The lowest stability ratio is for investment banks – median 29.3. Savings banks can be characterized by the highest share of deposits in the funding structure (median of 87.5%). For comparison, in cooperative banks, the deposits to total assets ratio is 79.5%, and in commercial banks 81.3%. Investment banks use deposits as a funding source to the smallest

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Table 2. Descriptive statistics

		All banks	Listed banks	Unlisted banks	Savings banks	Cooperative banks	Commercial banks	Investment banks
ta (thousands of euro)	Mean	36827961.35	163057773.50	21966066.12	2622048.47	10053862.27	81396481.56	180661901.20
	Median	617000.50	15070007.11	483615.00	174456.00	520647.78	3886655.00	16130523.64
	St. dev.	155670834.00	328082630.50	111035467.60	13186928.50	76764458.55	217863182.60	336818415.50
nfac2oi (%)	Mean	25.70	32.26	24.93	25.42	23.21	27.22	34.62
	Median	24.15	28.14	23.87	25.27	22.38	24.77	27.57
	St. dev.	13.56	17.75	12.76	7.49	8.51	17.57	28.48
nim (%)	Mean	1.92	2.12	1.90	1.88	2.05	2.11	0.87
	Median	1.87	1.77	1.87	1.81	2.01	1.96	0.78
	St. dev.	0.83	1.21	0.77	0.58	0.56	1.15	0.93
coi (%)	Mean	69.47	63.74	70.14	74.78	66.47	65.39	73.64
	Median	69.43	62.34	70.11	74.14	66.38	64.82	72.63
	St. dev.	16.08	14.16	16.16	12.43	11.97	20.41	23.51
nl2ta (%)	Mean	57.74	54.66	58.11	60.16	60.16	55.68	38.34
	Median	59.96	59.39	60.00	60.76	61.39	58.96	39.40
	St. dev.	17.68	20.60	17.26	13.81	13.86	20.80	27.68
dastf2ta (%)	Mean	78.41	72.63	79.09	86.42	76.51	75.82	60.10
	Median	84.03	77.81	84.80	87.50	79.45	81.32	62.82
	St. dev.	14.66	14.22	14.56	6.16	12.80	15.75	22.29
z-score (%)	Mean	103.37	48.96	109.80	153.63	107.25	45.67	42.54
	Median	57.25	36.95	60.33	70.27	70.90	35.23	29.30
	St. dev.	191.92	42.79	201.45	272.67	164.70	44.02	51.74

Source: Authors' own study.

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extent. On the other hand, investment banks are distinguished by the highest share of Net fees and commissions to operating income (median – 27.6) with the lowest share of Deposits and short-term funding to total assets (62.8).

Thirdly, according to funding and income structure we distinguish retail-oriented banks (Dummy variable d6=1 for retail-oriented banks and 0 for not retail-oriented banks).

Model

Taking into account the first research hypothesis regarding the impact of banks' funding models on bank risk, we propose the following regression model:

$$y_{it}=\beta' X_{it}+\gamma' D_{it}+\lambda_t+\alpha_i+\epsilon_{it} \quad (1)$$

where: y_{it} – the Z-score or one of the risk-adjusted (RA) components of Z-score, i.e. return on assets to standard deviation of ROA (Roa2SdRoa) or total equity to total assets ratio divided by the standard deviation of ROA (Car2SdRoa); X_{it} – a set of independent variables, that means a factor the impact of which we are investigating; D_{it} – a matrix of additional bank or country-specific variables; λ_t, α_i – time and bank-specific dummies, and ϵ_{it} – an error term.

The double index (*it*) indicates variation over time (*t*) and concerning for individual objects, i.e. the banks (*i*) subjected to analysis.

As one of the goals of this article is to point out the factors which determine the risk in different types of banks, dummy (binary) bank-specific variables, as well as products of dummy variables and factors of interests, are included in the matrix D_{it}. While pure binary variables are convenient in inference about shifts in mean(s), the dummy and factors products allow for deducing in slope(s) shifts which is an important part of our research. In particular, we mark out five bank types: (1) listed, (2) savings, (3) cooperative, (4) commercial, (5) investment (see Table 4), (6) retail-oriented (see Table 7).

The model is constructed according to the general-to-specific modeling approach (see Croissant & Millo, 2008; Baltagi, 2013). The plm package: Linear Models for Panel Data operating in the R environment is used for modeling and testing purposes. The ready-made tests and estimators available in this package are used.

The testing procedure is as follows:

– eliminating the extreme values via the winsorizing procedure, all banks variables are winsorized at the 1- and 99-percentile level,

– testing the poolability of the data,

– testing the significance of individual and time effects,

– testing the type of effects: fixed versus random,

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– the estimation of the model(s) using the within-groups estimator and general-to-specific modeling procedure,

– making inferences from the model, in particular inferences about the significance of model parameters and due to use products of dummy and variables also inference about changes in effects of variables of interests imposing on y_{it}.

We identified a list of several benefits from the proposed methodology (models of panel data): (1) controlling for heterogeneity of individual banks; (2) more informative data, more variability, less collinearity among the variables; (3) more degrees of freedom and hence more efficiency in estimation. As a major limitation in our approach we find: (1) data collection problems; (2) the elimination of the extreme values done via the winsorizing procedure produces in fact a censored database which does not cover entire individual banks of interest.

Results

The study is divided into three stages. In the first, we estimate the impact of bank-specific and macroeconomic factors on the banks' stability measured by Z-score ratio (Model 1.1). Moreover, in line with Köhler (2015, pp. 195–212), we estimate the impact of those variables on components of the Z-score (Model 1.2–1.3). Then we analyze determinants of the bank's risk, taking into account listing status and bank specialization (Model 2.1–2.5). In the last stage, we examine the change in the impact of factors in retail-oriented and other banks (Model 3). In the discussion, wherever the concept of the significance of a variable is used, a 10% level of significance is assumed for brevity.

Determinants of bank's stability – empirical result for Models 1.1–1.3

In Model 1.1, which is treated as a baseline model, explanatory variables show joint statistical significance (Wald test). Explanatory variables (except one dummy: d5) are also individually significant (Student's *t*-test). Additionally, the relevant tests indicate the insignificance of time effects (while individual, i.e. banks type-specific effects, are captured by dummy d1–d5 variables). The Hausman test result indicates the need to estimate the model with fixed effects. As a result, we use "within", "fixed time effects" estimator from plm R package. The above model can be considered a "good model", and in the light of the results obtained, it may be treated as a tool for making inferences about the relation to be verified. The results of these estimations are presented in Table 3.

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Table 3. Empirical results – determinants of bank's stability – Models 1.1–1.3

		Model 1.1.	Model 1.2.	Model 1.3.
Dependent variable		Z-score (zscore)	ROA/standard deviation of ROA (roaa2sdroaa)	equity to asset/standard deviation of ROA (car2sdroaa)
Size	log(ta)	23.8189	0.3821	23.4403
		(20.4606)***	(16.7723)***	(20.4296)***
Income diversification	nfac2oi	-0.5492	0.0174	-0.5642
		(-3.2846)**	(5.3035)***	(-3.4276)***
Operating efficiency	nim	19.3533	0.4180	18.9622
		(6.4099)***	(7.0644)***	(6.3754)***
Cost efficiency	coi	1.4121	-0.0423	1.4520
		(10.4172)***	(-16.0175)***	(10.882)***
Credit activity	nl2ta	-0.5323	0.0015	-0.5358
		(-4.2654)***	(0.6293)	(-4.3608)***
Funding	dastf2ta	1.6935	0.0401	1.6548
		(9.3703)***	(11.3692)***	(9.2952)***
Economic situation	gdp	5.6049	0.4802	5.1237
		(2.6415)**	(11.542)***	(2.4495)*
Price stability	inf	-23.9832	-0.0356	-23.9605
		(-5.5776)***	(-0.4223)	(-5.6518)***
Listing status	d1 – listed	-56.8370	-0.7312	-56.1140
		(-7.6398)***	(-5.0079)***	(-7.6496)***
Specialization	d2 – savings	146.6140	2.4792	144.1713
		(22.5566)***	(19.4708)***	(22.5025)***
	d3 – cooperative	102.1839	1.7408	100.4664
		(17.1057)***	(14.8804)***	(17.0602)***
	d5 – investment	2.8528	0.3650	2.3649
		(0.296)	(1.9313).	(0.2493)

Regressions are estimated with annual data from 2011 to 2018 using one way "time effects" "within" estimator from R package plm, *t* statistics are in parentheses with *p* values marked as follows: $*p < 0.1$, $**p < 0.05$, $***p > 0.001$.

Source: Authors' own study.

Taking into account the main aim of the article, we focus on the impact of the bank's funding structure on the bank's Z-score. First of all, our estimates indicate that this variable is statistically significant for a bank's stability, which confirms our first and second hypothesis. What is more, there is a positive correlation between Z-score and Deposits and short-term funding to total assets ratio (dastf2ta). The positive impact of the increase in deposits on the bank's risk should be explained by the fact that they are considered as a stable source of funding, resistant to financial market turmoil, as opposed to non-deposit funding.

Moreover, our estimates indicate that the bank's Z-score is dependent on its size, income diversification, operating efficiency, cost efficiency, and activity on the credit market. Among macroeconomic variables, both: GDP growth and inflation are statistically important.

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In particular, dependent variable of Z-score is negatively correlated with Net fees and commissions to operating income (nfac2oi), Net loans to total assets (nl-2ta), Inflation. On the other hand, the dependent variable is positively correlated with the Net interest margin (nim) (Köhler, 2015, pp. 195–212), bank size (Laeven & Majnoni, 2003, pp. 178–197; Foos et al., 2010, pp. 2929–2940; Oordt & Zhou, 2019, pp. 365–384), cost to income ratio (Sysoyeva, 2020, pp. 491–508) and GDP.

Determinants of banks' stability in different types of banks – empirical result for models 2.1–2.5

Empirical results indicate also that dummy variables describing the type of bank is a statistically significant determinant of the bank's financial stability measured by the Z-score ratio. That is why we decide to estimate the impact of selected variables on the bank's risk in the following models using criteria of listing status and specialization:

– Models 2.1. in which we analyze the changes in the impact of selected variables in listed banks in comparison with not listed banks (dummy variable d1=1 for listed banks and 0 – otherwise),

– Model 2.2. in which we analyze the changes in the impact of selected variables in savings banks in comparison with not saving banks (dummy variable d2=1 for saving banks and 0 – otherwise),

– Model 2.3. in which we analyze the changes in the impact of selected variables in cooperative banks in comparison with not cooperative banks (dummy variable d3=1 for cooperative banks and 0 – otherwise),

– Model 2.4. for commercial banks in which we analyze the changes in the impact of selected variables in commercial banks in comparison with not commercial banks (dummy variable d4=1 for commercial banks and 0 – otherwise),

– Model 2.5. in which we analyze the changes in the impact of selected variables in investment banks in comparison with not investment banks (dummy variable d5=1 for investment banks and 0 – otherwise).

The methodology of estimation Models 2.1–2.5 is consistent with Model 1.1 presented above.

The proposed approach allows primarily to estimate whether the impact of variables in the selected subgroups has changed. Moreover, it allows us to conclude about the possible change in the direction in the impact of a given variable on the bank's risk in the analyzed sub-groups. The summary of the empirical results for Models 2.1–2.5 are presented in Table 4.

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Table 4. Determinants of bank stability in different types of banks – summary of empirical result for Models 2.1–2.5

Subsample / Variable/ model	Not listed banks (Model 2.1.)	Not savings bank (Model 2.2.)	Not cooperative banks (Model 2.3.)	Not commercial banks (Model 2.4.)	Not investment banks (Model 2.5.)
	Significance				
log(ta)	***	*	***	***	***
nfac2oi	***	insignificant	***	***	***
nim	*	insignificant	insignificant	***	insignificant
coi	***	insignificant	***	***	***
nl2ta	insignificant	insignificant	*	*	insignificant
dastf2ta	***	***	***	***	***
gdp	insignificant	insignificant	*	***	insignificant
inf	***	*	**	***	**
d1	-	***	insignificant	***	insignificant
Change in direction of influence[a]					
	In listed vs. not listed banks	In savings vs. not savings banks	In cooperative vs. not cooperative banks	In commercial vs. not commercial banks	In investment vs. not investment banks
log(ta)	-	N	N	N	-
nfac2oi	Y	-	Y	Y	Y
nim	-	-	-	-	-
coi	N	-	Y	N	N
nl2ta	-	-	Y	Y	-
dastf2ta	-	Y	-	-	N
gdp	-	N	-	N	-
inf	-	N	Y	N	Y
d1	-	N	-	Y	-
Change in strength of influence[b]					
	In listed vs. not listed banks	In savings vs. not savings banks	In cooperative vs. not cooperative banks	In commercial vs. not commercial banks	In investment vs. not investment banks
log(ta)	-	SP	SP	WP	-
nfac2oi	-	-	-	-	-
nim	-	-	-	-	-
coi	WP	-	-	WP	WP
nl2ta	-	-	-	-	-
dastf2ta	-	-	-	-	WP
gdp	-	SP	-	WP	-
inf	-	SN	-	WN	-
d1	-	SN	-	-	-

Notes: ***(**, *) refers to statistical significance at the 1% (5%, 10%) significance level; [a] – Y – "yes", N – "no", "-" – a change in direction and strength of influence was assessed only in those cases when both the parameters were statistically significant at the 5% significance level; [b] – a change in direction was measured for the selected subsample in comparison to the rest of the banks; SP – stronger positive, SN – stronger negative; WP – weaker positive; WN – weaker negative.

Source: Authors' own study.

Our research shows that the type of bank determines the significance, the strength, and direction of the impact of selected variables on the bank's risk measured by the

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Z-score (zscore) (see Table 5), which confirms our third hypothesis. In particular, our estimates indicate that:

– income diversification (nfac2oi) has a positive impact on the stability of listed banks while in other banks this correlation is negative (Model 2.1),

– the stability of savings banks (Model 2.2) is negatively correlated with funding structure (dastf2ta) in contrast to not savings banks where the impact is positive (the same Altunbas et al. (2011)),

– impact of income diversification in cooperative banks (Model 2.3) is positive, while in other banks is negative,

– Z-score of commercial banks (Model 2.4) is positively correlated with income diversification, while in other banks this relation is negative,

– Z-score of investment banks (Model 2.5) is less dependent on the funding structure (dastf2ta) compared to not investment banks. The impact of income diversification on the Z-score is positive in investment banks while in other banks is negative.

Determinants of bank's stability in retail-oriented banks – empirical results for Model 3

Literature indicates that the specialization of the institution may not fully explain the translation of the bank's funding model into the probability of its collapse. According to Köhler (2015, pp. 195–212), this relationship may also depend on the profitability resulting from the generated income. Thus, the clustering due to the structure of liabilities and the structure of generated income seems to be more appropriate in explaining the factors determining the stability of banks. Based on Deposits to total assets ratio (dastf2ta) and Net fees and commissions to operating income ratio (nfac2oi), we have identified retail-oriented banks. In our study a retail-oriented bank is an institution in which two conditions are met together:

– Deposits to total assets ratio (dastf2ta) is above or equal median at least at four out of eight years included in the study,

– Net fees and commissions to operating income ratio (nfac2oi) is below or equal median at least at four out of eight years included in the study.

In respect to those criteria, 289 out of 1,132 banks may be referred to as retail-oriented and the rest of 843 – not retail-oriented banks.

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Table 5. Retail-oriented banks vs. not retail-oriented banks – descriptive statistics

		Retail-oriented banks	Not retail-oriented banks
ta (thousands of euro)	Mean	6901628.62	46810971.92
	Median	318622.00	717577.00
	St. dev.	45940091.20	176681271.00
nfac2oi (%)	Mean	18.30	28.18
	Median	19.61	26.44
	St. dev.	7.24	14.26
nim (%)	Mean	2.11	1.86
	Median	2.00	1.81
	St. dev.	0.71	0.86
coi (%)	Mean	71.83	68.68
	Median	72.28	68.46
	St. dev.	17.03	15.67
nl2ta (%)	Mean	60.05	56.96
	Median	61.23	59.63
	St. dev.	15.28	18.36
dastf2ta (%)	Mean	88.11	75.17
	Median	88.47	80.28
	St. dev.	4.07	15.46
z-score (%)	Mean	169.443	81.43
	Median	66.72	54.32
	St. dev.	290.80	138.06

Source: Authors' own study.

Table 6. Empirical results – determinants of bank's stability in retail-oriented banks – Model 3

Size	log(ta)	Not retail-oriented banks	3.42424	2.94540	**
		Retail-oriented banks	45.13337	20.29100	***
Income diversification	nfac2oi	Not retail-oriented banks	-0.76567	-4.11140	***
		Retail-oriented banks	7.87405	12.88020	***
Operating efficiency	nim	Not retail-oriented banks	-3.26230	-1.01480	
		Retail-oriented banks	25.57395	3.94100	***
Cost efficiency	coi	Not retail-oriented banks	0.35289	2.23610	*
		Retail-oriented banks	3.01946	10.59350	***
Credit activity	nl2ta	Not retail-oriented banks	0.09563	0.72000	
		Retail-oriented banks	-1.63792	-5.39610	***
Funding	dastf2ta	Not retail-oriented banks	1.47689	7.65890	***
		Retail-oriented banks	-9.15287	-19.15940	***
Economic situation	gdp	Not retail-oriented banks	2.53857	1.18810	
		Retail-oriented banks	-1.62736	-0.47410	
Price stability	inf	Not retail-oriented banks	-7.89674	-1.92400	.
		Retail-oriented banks	-20.95255	-4.75300	***
Listing status	d1	Not retail-oriented banks	-34.51511	-4.40130	***
		Retail-oriented banks	-178.58509	-8.37290	***

Regressions are estimated with annual data from 2011 to 2018 using one way "time effects" "within" estimator from R package plm, *t* statistics with *p* values are marked as follows: *$p < 0.1$; **$p < 0.05$; ***$p > 0.001$.

Source: Authors' own study.

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According to descriptive statistics (Table 5), retail-oriented banks are less risky than not retail-oriented institutions. The median of the Z-score ratio is 66.7 for retail-oriented banks, while for not retail-oriented – 54.3. Moreover, retail-oriented banks have a higher share of deposits (median 88.5 vs. 80.3), and a lower share of non-interest income in operating income (median of Net fees and commissions to operating income is 19.6 vs. 26.4).

Retail-oriented banks differ from not retail-oriented also in the significance and strength of factors that determine the bank's risk (Table 6). It is worth noting that there are also two variables in which direction of impact differs across these two subsamples. Income diversification measured by Net fees and commissions to operating income has a positive impact on the stability of retail banks while in other banks this impact is negative. On the other hand, the impact of Deposits to total assets ratio on banks' stability is negative in retail-oriented banks and positive in others.

Robustness check

To avoid drawing misleading conclusions, we have performed a robustness check to confirm the stability of the results.

The study aims to identify the factors determining the risk in different types of banks. So that, it is of particular importance that the results of individual significance tests obtained from Model 1.1 can be confirmed using a model estimated with a parameter estimator other than the within-groups (which is equivalent to LSDV, Last Squares with Dummy Variables). An estimator which requires fewest assumptions relating to error term ϵ_{it} (as homogeneity and autocorrelation, also no specific ϵ_{it} distribution is assumed) is the generalized method of moments (GMM) estimator (which was not used as default in the present study because of short time sample constricting or in some cases even making impossible to find out proper instruments of original variables). The use of the GMM automatically entails the use of an alternative standard error estimator and, as a result, generates different individual significance test statistics. If the results of significance tests are confirmed by GMM, this may be treated as confirmation of the results previously obtained that is independent of the estimation method used. It is proposed that two-factors (two-ways) one-step GMM estimator be applied to a model constructed based on Model 1.1. Model 1.1 estimated via GMM is denoted as Model 4 and is reported in Table 7.

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Table 7. Model 4, $y_{it} = Zscore_{it}$

	Estimate	z-value	Pr(>|z|)	
log(ta)	74.24185	7.3431	2.09E-13	***
nfac2oi	0.25115	0.2954	0.76768	
nim	37.84281	2.3032	0.02127	*
coi	4.10315	5.0815	0.00000	***
nl2ta	-0.22922	-0.3355	0.73726	
dastf2ta	6.37823	6.5153	7.25E-11	***
gdp	-27.05066	-4.7974	1.61E-06	***
inf	-30.32403	-3.2436	0.00118	**
d1	-130.40194	-4.7731	1.81E-06	***
d2	209.14943	6.264	3.75E-10	***
d3	162.94747	7.0021	2.52E-12	***
d5	3.34509	0.1138	0.90938	

Regression is estimated with annual data from 2011 to 2018 using one-way "time effects" GMM estimator from R package plm, *t* statistics with *p* values are marked as follows: *$p < 0.1$, **$p < 0.05$, ***$p > 0.001$.

Source: Authors' own study.

It should be noted that the GMM estimated version of Model 1.1, i.e. the estimated Model 4, confirms the results previously obtained (cf. Model 1.1):

– parameter estimate signs are consistent for both models excluding insignificant in Model 4 variable nfac2oi,

– excluding nfac2oi and nl2ta, significance test results are consistent,

– Model 4 fits empirical data slightly less well due to the use of instruments instead of original variables.

As concerns the comparison between the results of both estimates, it should be stated that the results obtained (parameter signs, the significance of variables) do not depend on the estimation methods used.

Discussions and conclusions

The financial crisis has highlighted the importance of a funding model for maintaining the bank's stability. Numerous studies show that banks relying on deposit funding proved to be more resilient to financial market turmoil during the crisis (Demirgüç-Kunt & Huizinga, 2010, pp. 626–650; Huang & Ratnovski, 2009; Acharya et al., 2011, pp. 1177–1209), which is a contradiction of earlier observations pointing to the "bright side" of wholesale funding (Calomiris & Kahn, 1991, pp. 497–513). Therefore, we wanted to check whether the structure of funding sources continues to play an important role in maintaining the bank's stability.

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In the study, we also take into account other control variables affecting the bank's stability measured by the Z-score, including, among others, the differentiation of income sources. As Köhler (2015, pp. 195–212) points out, banks differ not only in the funding structure but also in the sources of generated income, which may have a different impact on the bank's stability. For this reason, our study includes an analysis of the factors determining the Z-score broken down by bank specialization (savings, cooperative, commercial, and investment banks), listing status, and adopted funding model (retail-oriented and not retail-oriented banks).

First of all, our research indicates that the funding model is one of the statistically significant determinants of a bank's stability measured by the Z-score. For the whole sample of banks, there is a positive correlation between the Deposits to total assets ratio and the dependent variable. This indicates that like during the period of tension in the financial market, in the post-crisis period, deposits play a stabilizing role for banks.

The strength and direction of this impact depend, however, on the type of bank. We prove that there is a weaker positive impact of Deposits to total assets ratio for the bank's risk in investment banks in reference to not investment ones. This means that the increase in the share of deposits in the structure of investment banks' liabilities will have a positive effect on the bank's stability, but to a lesser extent than in other banks. This is partly in line with the results of Demirgüç-Kunt and Huizinga (2010, pp. 626–650), who show that in most cases a greater reliance on non-deposit sources of funding is associated with increased bank instability. What is interesting, the impact of funding models on banks' stability is negative in saving banks, while in other banks is positive. The results are in line with the Altunbas et al. research (2011), which shows that a strong deposit base lowers the risk of bankruptcy in high-risk banks compared to less risky banks for which savings banks are considered. Similarly, deposit funding is negatively correlated with the Z-score of retail-oriented banks and positively in others. This means that in retail-oriented banks further growth in the Deposits to total assets ratio may lead to an increase in the bank's risk while in not retail-oriented institutions deposits have a stabilizing effect. The negative impact of deposit funding model on Z-score in retail-oriented banks can be combined with different funding and income structure in those banks. Similar results were observed by Demirgüç-Kunt and Huizinga (2010, pp. 626–650), suggesting that banks with a low level of non-interest income and non-deposit funding may achieve some benefits from risk diversification resulting from increasing these shares to a certain level.

To conclude, our research allows us to confirm the stabilizing function of deposits in the post-crisis period, but also the non-linear nature of the impact of the funding structure on the bank's stability, depending on the bank's specialization. Although they are considered as a stable source of funding, their excessive growth in some types of banks may, however, lead to an increase in the risk level.

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