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Are too-big-to-fail banks history in Europe? Evidence from overnight interbank loans

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Abstract

We investigate how European banks' overnight borrowing costs depend on bank size. We use the Eurosystem's proprietary interbank daily loan data on euro-denominated transactions from 2008-2014. We find that large banks have had a clear borrowing cost advantage over small banks and that this premium increases progressively with the size of the bank. This result is robust with respect to subsamples, subperiods, time aggregation, and control variables such as Tier 1 capital ratio and rating. During episodes of financial stress, the size advantage becomes several times larger. However, we also find evidence that the new recovery and resolution framework for banks may have slightly reduced the borrowing cost advantage of larger banks in Europe.

JEL classification: G21, G22, G24, G28
Keywords: overnight rates, too-big-to-fail, implicit government guarantee, borrowing costs

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1. Introduction

During the 2007-2008 financial crisis, and later in the euro crisis, the big issue was to what extent the government should support banks that are in financial distress. Governments try to avoid outright promises of support because market expectations of government guarantees to banks could weaken financial stability by reducing investors' incentive to monitor banks and by increasing banks' propensity to take risks (for recent evidence see Mariathasan et al. (2014)). Nonetheless, it is commonly thought that implicit government guarantees are relevant for large banks whose failure could jeopardize the overall stability of the financial system. In other words, large banks may be considered "too-big-to-fail". By contrast, the failure of small banks could be overlooked by the government. Their failure would constitute a warning signal for investors and force them to monitor more closely the lending activities of such institutions. The experience from the recent crises shows that especially the largest banks, both in the US and Europe, did get massive government support. As a result several regulatory reforms, including higher capital requirements for systemically important banks and bank recovery and resolution framework to handle failed banks with no recourse to public funds (at least not as a rule), have been agreed.

The issue of too big to fail or fall institutions (henceforth TBTF) goes back in history to long before the recent financial crisis and may apply not only to financial but also to non-financial firms. It has also been subject to intensive research, especially in the United States where bank failures have been much more common than in Europe where – even during the recent crisis – bankruptcies of financial institutions have been rare (cf. e.g. Brewer III and Jagtiani (2013), Hughes and Mester (2013), Noss and Sowerbutts (2012), Ueda and Weder di Mauro (2013), Wheelock and Wilson (2012) and Santos (2014)). Partly because of this asymmetry of research focus, we focus in this paper on European banks' borrowing costs and their relationship to bank size as a way to study the TBTF problem in Europe.

The previous literature has used several alternative measures to study the relationship between banks' borrowing costs and bank size such as deposit rates, bond returns, CDS rates, or the weighted average of these various borrowing costs. Combinations of rating and rate-based measures as well as equity returns have also been used in studying the effect of bank size on its financing costs more generally. For example, Bassett (2014) examines differences in the cost of deposits by large and small banks, Demirguc-Kunt and Huizinga (2013)) use CDS rates, and Santos (2014) uses bond spread differences between small and large banks. Kroszner (2013) provides a comparative review of results obtained with these alternative measures.

Empirical evidence on the relationship between bank size and bank borrowing costs seems to depend on the time period and the measure of the borrowing cost. The CDS data which are perhaps most often used suggest that prior to the global financial crisis financial firms generally had lower spreads but that they were less sensitive to firm size than spreads for several other industries (see Ahmed et al., 2015). This result actually appears consistent with the theory of Farhi and Tirole (2012) that many of the public sector's financial crisis fighting measures, including monetary policy operations, help the financial sector as a whole, not just the largest financial institutions. So, measuring the TBTF advantage of large banks from borrowing cost differentials of large and small banks may in actuality underestimate the full size of implicit government guarantees to the financial sector.

As regards industry comparisons, Kroszner (2013) provides some direct empirical evidence from the funding costs of the 3000 largest US firms in terms of market capitalization with debt/equity ratios above the 10th percentile (in order to eliminate outliers).[1] Similar results were recently obtained by Goldman Sachs (2013). Their study finds that the funding cost advantage of large firms is almost three times larger in trade & leisure, retail and technology, compared with banks. Only in industries like basic resources and utilities, the bond spreads for large firms are smaller than in the financial sector.

Large banks like large non-financial firms seem to have enjoyed a cost advantage prior to the Lehman crisis, but after the crisis the nature of the cost differential with smaller firms seems to have changed (cf. Ahmed et al (2015)). Similar results have been obtained with corporate bond returns (Ahmed et al (2015) and Goldman Sachs (2013)). In contrast, a study with deposit rates of large and small banks (Bassett 2014) fails to show very strong evidence of the perceived TBTF subsidy (cf. also O'Hara and Shaw, 1990). The result applies not only to ordinary deposits but also to interest bearing liquid deposits. Overall, the differences in deposit rates between small and large banks appeared to be small.

One difficulty in measuring the TBTF advantage from borrowing cost differentials is that bank size and its borrowing costs may be related also for other reasons than TBTF expectations. Most recent studies suggest that there are scale economies in banking even for the largest group of banks, for various reasons (cf. e.g. Hughes and Mester (2013) and Araten and Turner (2013)). Then again, Davies and Tracey (2014) show that what may seem like cost efficiency may actually be a cost advantage arising from a TBTF status: after controlling for the TBTF factor, the cost efficiency of the largest banks vanishes.[2]

In the current paper, we concentrate entirely on European banks to study the effect of a bank's size on its borrowing cost. We use a novel dataset that comprises most of the global euro-denominated interbank overnight market for the period from 2008 to 2014. The interbank overnight borrowing market is very liquid. This is a central reason for focusing on the shortest (overnight) interbank loan maturity[3]. The data are based on identification of transactions from the TARGET2 payment system, using a method similar to (Arciero et al., 2013). We have further extended the data to include loans with negative interest rates which may have resulted

[1] The WACC differential in basis points between the top ten and other firms are: energy 84, consumer non-cyclicals 53, industrials 40, consumer cyclicals 39, banks 35, communications 30, non-bank financials 28, basic 28, technology 16, and utilities 53.
[2] Deposit insurance may constitute another problem (O'Hara and Shaw 1990), particularly in Europe where certain cross-country differences exist or have existed.
[3] For longer maturities, there is much more heterogeneity e.g. in terms of collateral.

from the prevailing monetary policy stance. The total number of data points is 757,774 and the original number of banks is more than 1000. If we look only at banks that are engaged in typical banking activities, have BankScope data available, and are domiciled in the European Economic Area (EEA), the final number of banks ranges from 382 to 692, depending on which control variables are active. The number of data points then ranges from 430,000 to 560,000.

The data are far more extensive than all the existing data sets that have been used thus far, in terms of both time periods and number of banks. The data include banks in all size categories. Thus the size and contents of the sample are much larger than of those that use CDS data which are usually available for large banks only, not to mention samples based on banks with public credit ratings.[4] The time period includes all interesting episodes of the recent banking crises. This allows us to assess potentially different regimes of perceived public support to large banks. Because the data are essentially continuous, we could in principle use any frequency, but for practical reasons we use daily data in the econometric analyses. For data reasons, we do not consider other industries.

Within the sample (or, in fact, the European population) of banks we control for variables other than size that affect banks' borrowing costs. Following previous studies the set of control variables include banks' Tier 1 capital ratio, banks' profitability, rating (when available), non-performing loan ratios, the bank's relative size, and home country sovereign CDS rate.

Given the control variables, we test two main hypotheses. First, the bank size variable, measured by total assets, should lead to lower bank borrowing cost particularly during periods of market turmoil when banks' default risks are well above normal and the relative TBTF advantage is at its strongest. In the data sample, such episodes coincide with the Lehman Brother bankruptcy of 2008 and the Euro crisis of 2011-2012. Moreover, we study whether the borrowing cost advantage of larger banks is progressively increasing in their size. We also repeat the test separately for financial institutions in the data other than banks.

We find that large banks have had a clear borrowing cost advantage over small banks, and that the advantage increases progressively with the size of the bank. The result is robust with respect to subsamples, subperiods, time aggregation, and control variables, and during episodes of financial stress the size advantage has become even several times larger.

Second, we test whether the new regulations aimed at limiting the need of taxpayers' money to handle failed banks have so far had any effect on banks' borrowing costs. We focus on the introduction of the bank recovery and resolution framework. By controlling for effects that may generally have led to a decrease in bank borrowing margins, we find a statistically significant weakening in the effect of bank size on bank borrowing cost. This suggests that the agreement on the recovery and resolution framework has reduced the TBTF subsidy in Europe.

[4] For comparison, the number of banking firms in e.g. the Ahmed et al (2015) study is less than 20 for each quarter.

In what follows, we first describe the main features of the data and explain the contents and steps of the estimation procedures in section 2. After that we report the results in section 3. Section 4 concludes.

2. Analysis

We start the description of our data by explaining the basic infrastructure of the Euro area interbank money market. The Euro area monetary policy operations as well as the majority of transactions in the Euro area interbank market are settled in the TARGET2 system, which is the large value payment system of the Eurosystem.[5] Access to TARGET2 is granted primarily to credit institutions, national central banks, and treasury departments of European Union member states, which are active in the money market, while most other financial firms and non-financials do not have access (see Heijmans et al., 2010). Money market transactions are a subset of bank-to-bank large value payments. In 2012, TARGET2 had a 92% market share in value terms of all large value payments in euro. Payments are settled in central bank money with immediate finality (i.e., in real time). TARGET2 and Fedwire Funds for the US dollar are the two largest real-time gross settlement systems in the world.

In the current paper, our analysis is based on access to the proprietary TARGET2 database of the Eurosystem. Computation of interest rates is explained in detail in Tölö et al (2015). The bank level data are from Bankscope and the sovereign CDS data from Bloomberg. This study concentrates on bank level data but we also have a much larger data set that could be called “financial institutions data” because in addition to banks it also includes different kinds of investment firms, mortgage banks and other credit intermediaries , , of which a sizeable part is of Non-EEA origin. There are also several government-linked entities in the big data set. We have carried out all the analyses also with this larger data set (including almost 1292 institutions), and the results are briefly reviewed in the first place (for details, see Table 1). Because the large data set includes a very heterogeneous set of banks with very widely differencing sample periods and a rather deficient set of control variables, we concentrate on the smaller set of EEA private banks. Notice that, even though we use a much smaller data sample than this very large bank sample, the number of observations does not decrease proportionately because the “excluded” banks have much shorter sample periods and the data for control variables is less available.

[5] The Eurosystem comproses the national central banks of the European countries belonging to the European Monetary Union (having euro as their common currency) and the European Central Bank (ECB). In addition, a number of non-euro European countries, six in 2010, were also connected to TARGET2.

In concrete terms, we examine the cost differential between large and small banks using the following reduced form equation

$$r_{it} = \beta_{0it} + \beta_{1t}Log(S_{it}) + \beta_2 X_{it} + u_{it} \qquad (1)$$

where r_{it} denotes the (difference of) overnight interest rates (from the corresponding EONIA rate), i indexes firms, t indexes time (days), and X_{it} denotes the control variable(s). β_{0it} is the constant term, which may change over banks and time (indicating fixed cross-section and time effects). $Log(S_{it})$ is the logarithm of book assets. The set of control variables X_{it} includes the following time-series indicators: net income/average equity, non-interest income/gross revenue, impaired loans/gross loans, country CDS rate, Tier 1 ratio, leverage ratio, customer deposits/total liabilities and cross loans/customer deposits. In addition, we have lender (bank), country and time fixed effects. The size of the bank is considered both in terms of absolute value and as a relative (relative to the individual country) value. In addition to these bank-specific controls, we use the conventional set of fixed effects in the context of panel data estimation. Some descriptive statistics for the key variables for the final data sample are reported in Table 2.

In the first phase, we estimate the basic equation in a (log) linear form (1). We start by estimating the simple bivariate equation with the “all banks included” sample. The results are reported in Table 3 while the results for the final data sample are presented in Tables 4 and 5.

Because the (semi)elasticity β_1 is of special interest in this study, we estimate it also in such a way that the elasticity is allowed to vary with the size variable and also with time. In this respect the study differs from earlier studies that – mainly because of small sample size – use constant values of the parameter. When estimating the size-dependent coefficient we use several alternatives: First we use a simple higher-order polynomial for the coefficient of the size variable. Second, we use a fractional polynomial for the coefficient. Third, we divide the size variable into four categories (on the basis of frequencies) and estimate separate coefficients for each of them. As usual, higher-order polynomials are a bit difficult to handle because of multicollinearity. For illustrative purposes, the third specification provides the most straightforward alternative particularly when we look at developments over time. The idea is that we allow β_1 to vary over time, which in practice means allowing it (and the coefficients of the control variables) to vary along with severity of the banking/Euro crisis. The huge sample size allows us to use much more sophisticated specifications for β_{1t} than the usual subsample estimates. Thus, we may even use a moving daily window in scrutinizing the evolution of coefficient values over time.

3. Empirical results

We start with the basic results from a simple bivariate model. The results in Table 3 with the alternative data samples can be summarized quite easily: there is a strong inverse relationship between bank size and overnight interest rates. The semi-elasticity of bank size (total assets) is always negative, highly significant, and the parameter value is -0.03. This parameter value is strikingly robust for alternative data samples and even for various control variables (this can be seen later on from Table 4 below). The relationship between interest rate spreads and bank size for the main data sample is also illustrated in Figure 1. The corresponding scatter diagram shows that the (uncontrolled) relationship is indeed negative, although there is clearly considerable variability around the regression line.

Thus large banks have a clear cost advantage over small banks in the Euro area. To give a rough interpretation of the results, we reproduce the results from a simple bivariate regression between interest rate spread and log total assets:

$$r_{it} = .272 - .029\log(S_{it}),\ R^2 = 0.120,$$
$$(7.56)\quad (9.14)$$

where the numbers inside parentheses are robust t-values.

The coefficient of the size variable is always negative and highly significant, even if we use very conservative (robust) t-values. And the size of the coefficient is (almost exactly) 0.03. The same value turns up when we introduce the control variables in Table 4. The practical implications of this value can be illustrated by Figure 2 where the slope is graphed for the sample values of the bank-size variable (together with a nonlinear slope that we comment later on).

The value of the estimated coefficient seems to be larger than the estimates obtained in the US albeit the comparison is not easy because the estimated equations and the data are not exactly similar. For instance, when Kroszner (2013) reviews funding costs of eight Global Systemically Important Banks, he finds that the cost advantage or disadvantage is generally less than 50 basis points (advantages taking place after 2008). Bassett's (2015) results for customer deposit rates are even smaller, so that he concludes: "across the different definitions used to identify the largest banks and a control group of large regional banks, the point estimates typically fall between 4 and 12 basis points in the full sample and in the pre-crisis period". Goldman Sachs' s (2013) study finds the cost differential for the six biggest US banks on bond pricing almost nonexistent before the crisis but in 2009 the cost advantage was substantial (up to 400 basis points), but later on it turned into cost disadvantage while other (large) financial institutions enjoyed more persistent cost advantages. For 1999-2013, the cost advantage due to size for non-bank financials was nearly two and a half times the differential for banks—on average 77 basis points for non-bank financials compared to just 31 basis points for banks.

Figure 3 shows that the cost advantage has remained relatively constant over the sample period. Only in the latter half of 2012, we see a clear peak in all coefficient values, probably reflecting the Euro crisis that become acute in late-2011 along with developments in Greece[6]. The borrowing costs increased for all banks, but the small banks were even more subject to increased premiums. During the crisis, the coefficients of the other control variables like the Tier 1 ratio and the ratio of deposits to other funding sources reacted as expected so as not to nullify the bank-size effect (cf. Figure 4). Before and after crisis, the impact of control variables appears rather modest. In fact, time-varying parameters are most of the time not significantly different from zero.

By contrast, the coefficient of the size variable is always negative and statistically significant whatever the set of control variables and whatever the manner of computing robust t-values. Essentially, the same results comes up when we use absolute or relative (relative to the size of the banking sector in each country) values of the size variable. It is only that the relative size variable has somewhat lower explanatory power than the absolute size (log of total assets). Again, we see that the coefficient is systematically negative over the whole sample period, increasing only (in absolute values) during the banking crisis.

As for the control variables, in general they behave as expected but only some of them are statistically significant (Table 4). Net income, non-interest income, customer deposits/total liabilities and Tier-1 ratio belong to this latter group. But even if these and other controls are added, the coefficient of the bank size variable stays at the same level as in the simple two-variable regression. In terms of the sign of the coefficient, the Tier 1 capital ratio represents somewhat puzzling behavior. When time fixed effects are on, the coefficient is negative and it can be estimated fairly precisely, but when the time fixed effects are off (see e.g. the model in Table 5), the sign becomes positive and the coefficient rather imprecise. The corresponding time-varying coefficient is for the most of the time negative but becomes positive for the end of the sample period. Otherwise, the coefficient follows a similar pattern as the coefficient of bank-size variables, which suggests that these two variable do indeed play the same role in the determination of overnight interest rates. The country-CDS variable could also be seen as some sort of substitute for the bank- size and capital ratio variables, even though the time-varying coefficient of this variable looks different indeed (Figure 5). In any case, introducing the country-CDS rate to the model brings only a slight change to the size of the coefficient of the bank-size variable (see equation 5 in Table 4). As for the net income (to equity) and non-interest income (profit), their coefficients remain constant over the entire sample period (for the net income to equity variable, the immediate post-Lehman period represents a somewhat strange exception).

[6] On October 27 2011, members of the Eurozone agreed on details of Greek debt restructuring. On October 31, Prime Minister Papandreou shocked the financial world by calling a Greek referendum vote on the bailout proposal. Three days later, the call was withdrawn. This Greek turmoil continued the over rest of 2011.

It is somewhat surprising that impaired loans/gross and the leverage ratio play rather secondary roles in the results. The coefficients are in most cases correct but the statistical significance is rather poor. The reason cannot be the fact that the variables had been constant. By contrast, there has been much variation in the respective time series (see Figure 1 in appendix for details). Eventually, it turns out that the insignificance is explained by multicollinearity with the other control variables, and especially the time fixed effects steal most of the explanatory power.

We next investigate whether the coefficient (semi-elasticity) of the bank-size variable is in fact constant. In another words, we consider the question whether the model is indeed linear in terms of the bank size? The nonlinearity issue is scrutinized in Table 5 and Figure 2. Table 5 reports the results for a model where the size variable is specified as four percentage size category dummies (size1d and so on), alternatively as linear and quadratic terms (size and $size^2$). Figure 2 shows an estimate for the whole sample representing a fractional polynomial formulation for the coefficient of the size variable (compared with the log-linear case). The time-varying coefficients of the dummies with a moving weekly window are presented in Figure 3.

Figure 2 already indicates that the linear model is outperformed by a nonlinear structure. And when we tested a linear model against a fraction polynomial alternative, the respective F statistic had a p-value of 0.000. In economic terms, this result means that the smaller the bank, the higher the (overnight market) funding costs. Thus, the cost disadvantage seems to increase progressive with very small banks. This sounds like bad news not only for very small banks but also for new market entrants.

Finally, we analyze recent policy effects. It would be interesting to interpret the movements of the estimated coefficients from the point of view of changes in banks' supervision and regulation after the financial crisis. Figures 3 and 4 do not, however, give any indication of major changes in the impact of bank size, nor of the Tier 1 ratio or sovereign CDS rate on overnight rates. The time-varying coefficient of the sovereign CDS rate (Figure 5) turns out to be significant only during the acute period of the Euro crisis, 2011-2012 (plus the immediate aftermath of Lehman) but otherwise it is very difficult to identify a change in the role of this variable. Thus, one might surmise that the practical importance of these changes is not very great, or that the changes have been anticipated long before.

To reach a somewhat more affirmative conclusion, we re-estimated the model so that two dummy variables D12 and D14 were introduced into the estimating equation both as additive variables and as multiplicative terms with the bank size variable[7]. The results (Table 6) suggest that the additive terms make little difference but a somewhat different result emerges

[7] D14 corresponds to the EU Council agreement on December 19, 2013 on a general approach on single resolution mechanism while D12 corresponds to EU Commission proposal on June 2012 for new recovery and resolution tools for banks in crisis

when we add the multiplicative terms in terms of the size variable. The dummy starting from December 2013 (i.e. beginning of 2014) is significant and the multiplicative terms effectively reduce the size of the bank-size variable even though its significance does not change. Thus, maybe policy response has had some effect via the “too big to fail” channel.
Of course, there are several caveats to this kind of investigation. To mention one, recent monetary policy operations of the ECB make interpretation of recent developments of overnight rates somewhat tedious because of the exceptionally large amount of liquidity in the Eurosystem. Also if the “too big to fail” channel is strongest during periods of high financial stress, it may be that we need to wait for the next high financial stress period to really see if the channel is still active.

4. Concluding remarks

Large banks, potentially enjoying the biggest implicit government guarantees, seem to have a very large borrowing cost advantage over small banks in Europe, clearly bigger than in the United States. It is possible that the too big to fall factor could be particularly strong in Europe. This is because, in the absence of a federal government, individual country governments might be more willing to support the players in their own financial system (the “national champions”) than in a large genuinely federal country like the US in which financial integration is more advanced.

The borrowing cost advantage of larger banks is robust in terms of various control variables and time periods, suggesting that the size differences represent the most important element of the European banking sector. The persistence of the borrowing cost advantage up to now (Fall 2015) suggests that recent changes in banking supervision and regulation in Europe have not removed the TBTF subsidy, but we find evidence that the introduction of the bank recovery and resolution framework may have reduced it. It is also likely that the new Basel III capital requirements have helped reduce the size of the implicit government guarantee subsidy of larger banks, but this potential effect may well be subsumed into the Tier 1 capital ratio, used as a control variable.

To conclude, there certainly remains some uncertainty over the reasons for the empirical finding that large banks enjoy a borrowing cost advantage even after taking into account evidence from the control variables, including the size of the bank in relation to the size of the banking sector in each individual country. In particular, the finding in previous literature that large firms in all industries tend to enjoy a borrowing cost advantage suggests that other factors than implicit government guarantees also play a role.

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Table 1. Description of the data sample

Specialisation	Non-EEA	EEA	Total	Have total asset data Non-EEA	EEA	Total	Have the other controls Non-EEA	EEA	Total
Bank Holding & Holding Companies	0	7	7	0	7	7	0	7	7
Commercial Banks	295	501	796	246	422	668	178	221	399
Cooperative Banks	8	86	94	8	83	91	5	60	65
Investment Banks	13	32	45	12	29	41	5	16	21
Savings Bank	6	151	157	4	151	155	3	78	81
Sub total	322	777	1099	270	**692**	**962**	191	**382**	573
Government entities	23	45	68	23	45	68	6	31	37
Other types of banks	13	26	39	12	25	37	9	12	21
Other financial entities	18	76	94	18	73	91	4	21	25
Total	368	924	1,292	315	835	**1,150**	210	446	656

Table 2. Descriptive data on key variables

Variable	mean	sd	skewness	kurtosis	p10	p50	p90	N
Rate premium	-0.045	0.175	1.452	11.390	-0.203	-0.052	0.094	608,356
Total assets	195,123	355,119	2.843	12.107	2,769	37,523	639,221	562,852
Relative size	0.065	0.105	2.579	10.276	0.001	0.017	0.202	562,852
Net income / Average equity	0.039	0.249	-9.982	138.095	-0.053	0.059	0.162	553,809
Non-interest income / Gross revenues	0.303	0.515	-7.983	156.634	0.115	0.328	0.653	556,249
Impaired loans / Gross loans	0.056	0.054	3.841	33.445	0.009	0.044	0.110	495,921
Country CDS spread (%)	1.565	1.680	3.623	25.518	0.325	1.042	3.531	553,378
Tier 1 ratio	0.106	0.038	1.963	16.338	0.071	0.099	0.154	495,047
Equity / Total assets	0.067	0.060	9.105	137.415	0.026	0.063	0.103	562,277
Customer deposits / Total liabilities	0.491	0.201	-0.272	2.841	0.222	0.510	0.753	555,587
Gross loans / Customer deposits	1.510	0.941	3.484	25.491	0.683	1.390	2.166	542,796

Table 3. Estimation results with alternative financial market institution data

variable	full data set	specific specializations	EEA & specializations	EEA & specializations
Constant	.271	.281	.273	-.022
	(8.60)	(7.99)	(7.56)	(2.46)
Log total assets	-.030	-.030	-.030	
	(10.71)	(9.57)	(9.14)	
Relative size				-.303
				(3.72)
Number of observations	708655	575207	562852	562852
Number of banks	1150	962	692	692
R^2	0.126	0.121	0.120	0.033

For definition of data sets, see Table 1. All estimates are OLS estimates. Numbers inside parentheses are robust t-values (clustered at bank level). Relative size denotes the bank's total assets in relation to total assets of all banks in the respective country.

Table 4. Estimates with different control variables

	(1) Rate premium	(2) Rate premium	(3) Rate premium	(4) Rate premium	(5) Rate premium	(6) Rate premium
log(Total assets)	-0.031 (-9.15)	-0.031 (-8.13)		-0.026 (-8.05)	-0.030 (-9.52)	-0.030 (-9.18)
Relative size			-0.400 (-4.74)			
Net income / Average equity	-0.021 (-2.66)	-0.012 (-1.17)	-0.020 (-1.84)	-0.012 (-0.91)	-0.025 (-1.82)	-0.028 (-2.59)
Non-interest income / Gross revenues	-0.021 (-3.28)	-0.019 (-4.09)	-0.015 (-2.91)	-0.019 (-2.74)	-0.024 (-1.71)	-0.016 (-2.84)
Impaired loans / Gross loans	0.043 (0.057)	-0.036 (-0.50)	-0.003 (-0.03)	-0.056 (-0.86)	0.061 (0.81)	0.099 (1.02)
Country CDS spread				0.026 (6.74)		
Tier 1 ratio	-0.341 (-2.66)	-0.535 (-4.79)	-0.124 (-0.97)	-0.272 (-2.00)	-0.202 (-1.74)	
Leverage ratio						-0.003 (-0.01)
Customer deposits / Total liabilities	-0.058 (-2.00)	-0.070 (-2.52)	-0.038 (-1.47)	-0.073 (-2.83)		-0.057 (-1.63)
Gross loans / customer deposits					0.018 (2.23)	
Time fixed effects	yes	yes	yes	yes	yes	yes
Country fixed effects	no	yes	yes	no	no	no
Borrower banks	383	383	383	364	379	465
Observations	462,370	462,370	462,370	432,383	451,535	491,502
R2	0.291	0.339	0.333	0.317	0.264	0.245

Robust t-values adjusted for clustering at the borrower bank level are reported in parentheses.

Table 5. Estimates for different bank-size variables

	(1)	**(2)**
Constant	-.120	.048
	(4.51)	(0.66)
Size		3.785
		(0.66)
$Size^2$		-.001
		(3.25)
Size1d		
Size2d	.054	
	(2.94)	
Siz23d	.107	
	(7.01)	
Size4d	.140	
	(7.12)	
Net income /average equity	-.019	-.039
	(1.31)	(3.50)
Non-interest income /gross revenues	-.018	-.010
	(2.23)	(1.51)
Impaired loans/gross loans	.274	
	(1.96)	
Tier 1 ratio	.135	.060
	(1.14)	(0.58)
Customer deposits/total liabilities	-.039	-.024
	(1.22)	(0.87)
Number of observations	462370	489686
R^2	0.125	0.127
Fixed effects	none	none

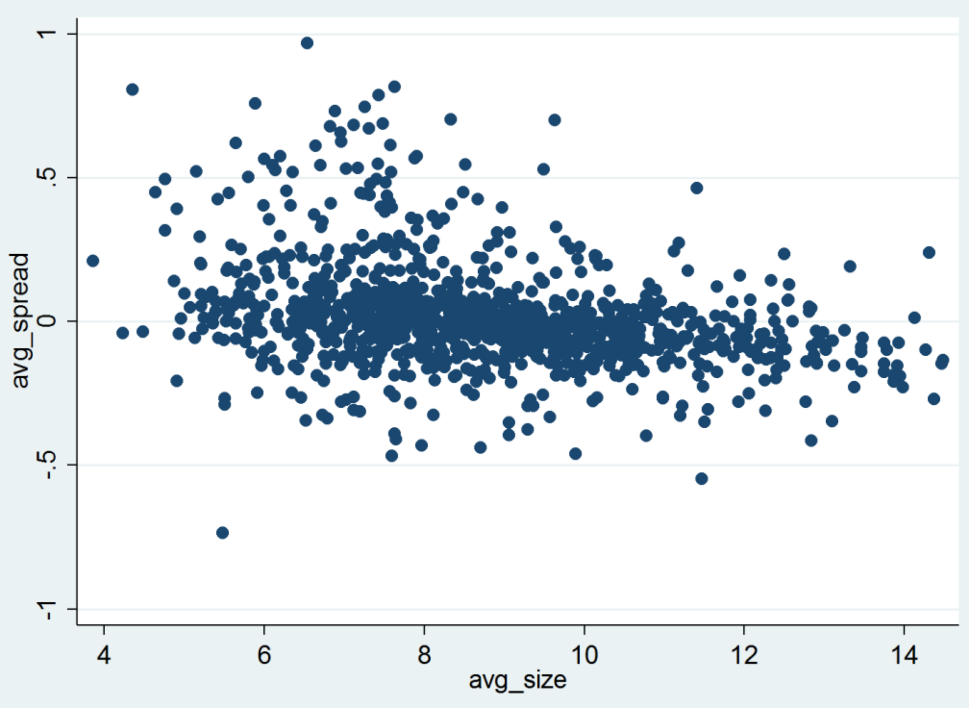
The omitted group is *size1d* which corresponds to the largest 25 per cent of banks. The time-varying coefficient values are displayed in Figure 3. If we drop the constant, the size dummies get the following values: d1; -.110 (10.44), d2 -.067 (5.16), d3 -.021 (2.87) d4: +.038 (2.58), where the numbers inside parentheses are again robust t-values.

Table 6. Effect of resolution mechanisms

	(1)	(2)	(3)	(4)
Constant	-.277	.265	.159	.169
	(8.45)	(8.42)	(5.06)	(5.34)
Size	-.031	-.031	-.023	-.024
	(10.53)	(10.68)	(8.79)	(9.14)
D14	-.087	-.096	-.065	
	(3.18)	(2.18)	(2.40)	
D12	.010	.020		-.062
	(4.29)	(0.35)		(1.11)
D14*Size		.007	.010	
		(1.86)	(3.90)	
D12*Size		.003		.010
		(0.54)		(1.97)
Net income /average equity		-.039	-.017	-.017
		(3.50)	(1.32)	(1.33)
Tier 1 ratio		.060	-.007	-.051
		(0.58)	(0.10)	(0.77)
country CDS		-.024	.027	.025
		(0.87)	(9.13)	(9.08)
Number of observations	708655	708655	571914	571914
R^2	0.129	0.155	0.138	0.138
Fixed effects	none	none	none	none

D14 corresponds to the EU Council agreement on December 19, 2014 on a general approach on single resolution mechanism while D12 corresponds to EU Commission proposal on June 2012 for new recovery and resolution tools for banks in crisis. Numbers in parentheses are robust t-values.

Figure 1. Average overnight rate spread vs size of institution



$R^2 = 0.33$ for a linear trend regression. The values are sample period averages. Bank size is measure by total assets.

Figure 2. Size-variable coefficient estimated with fractional polynomial vs linear model

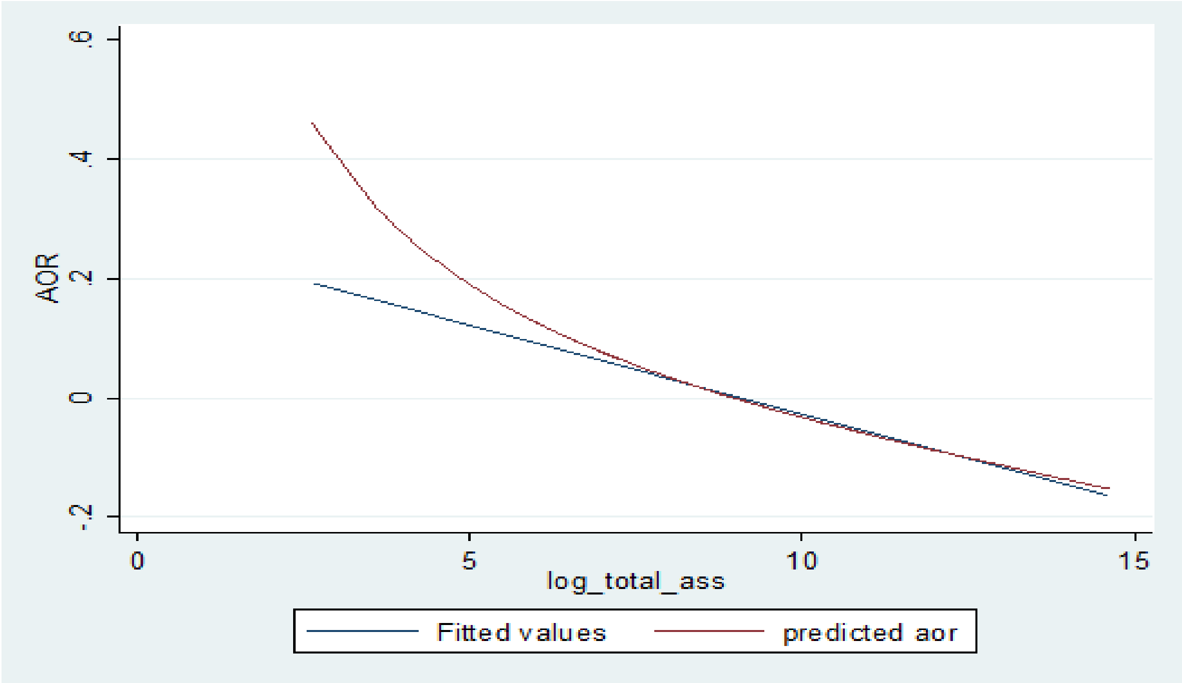
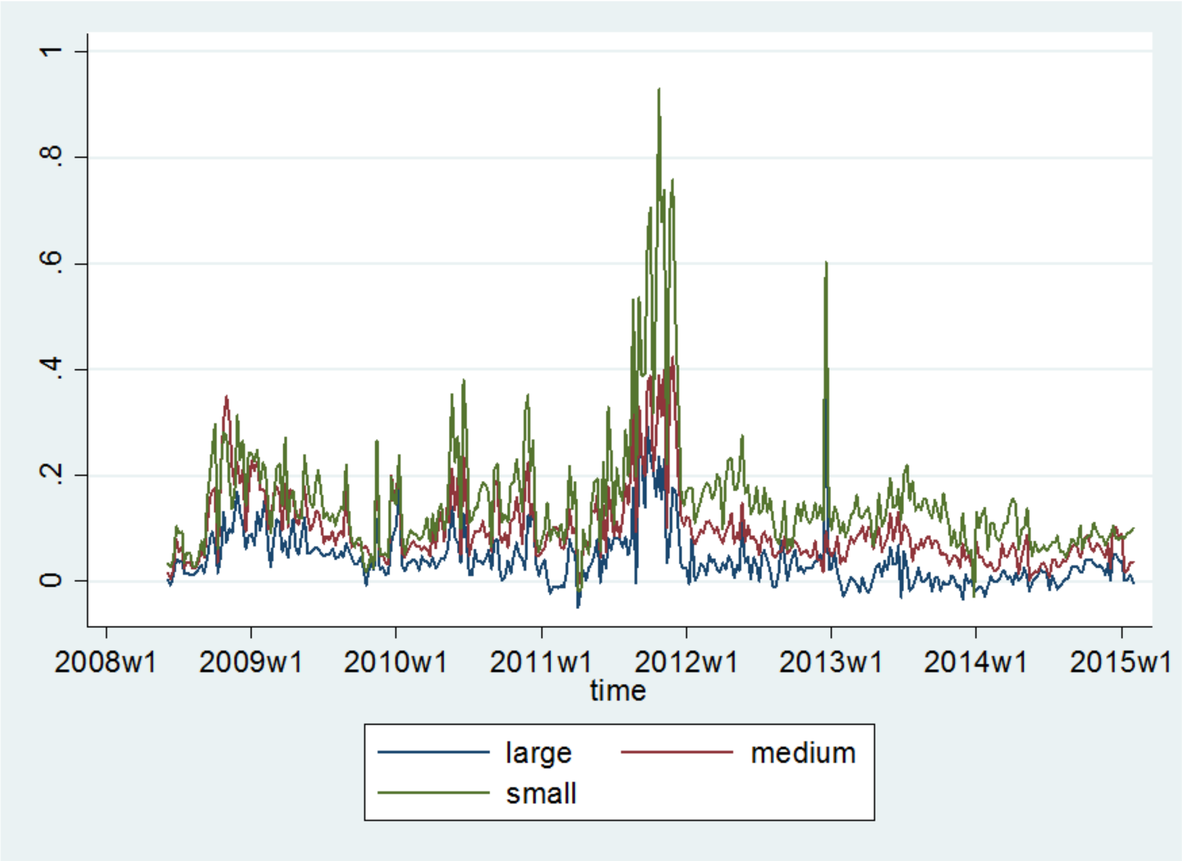
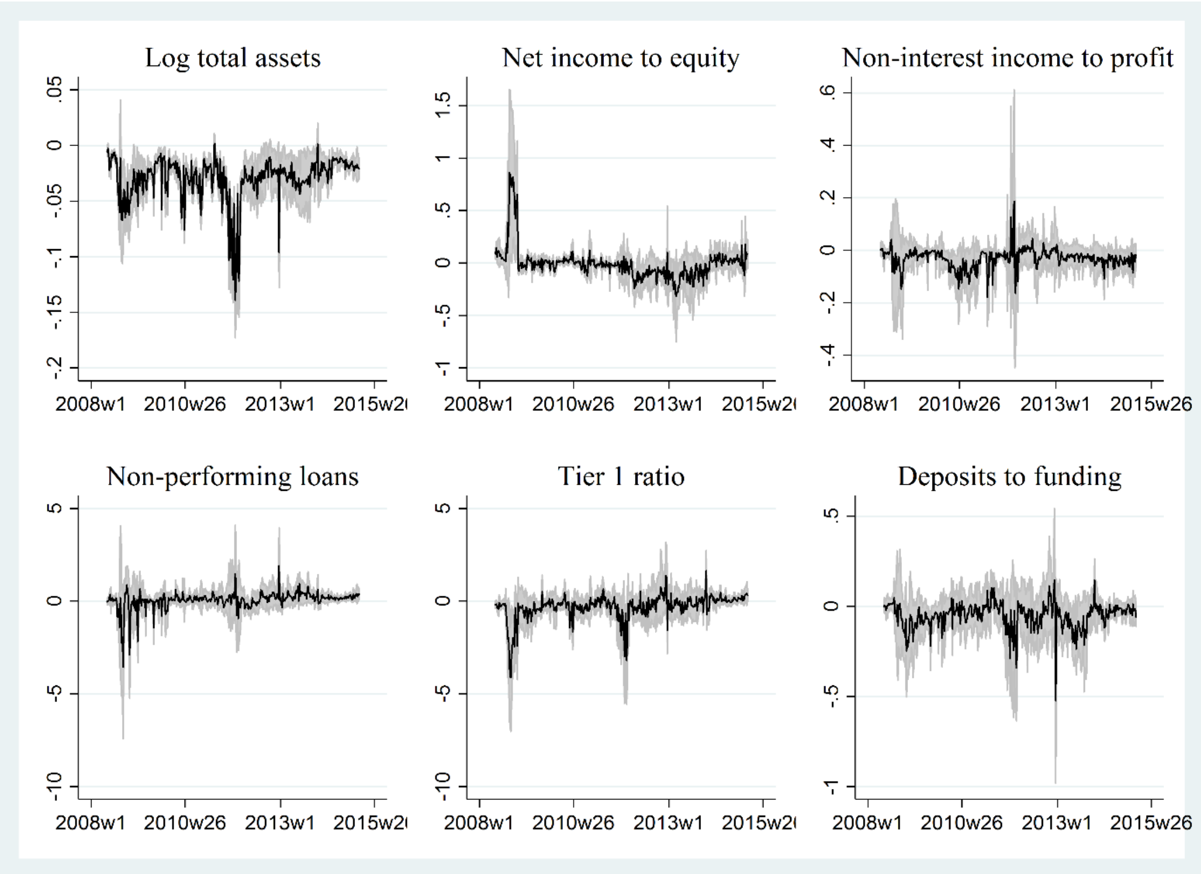


Figure 3. Estimates of bank-size coefficients for each time period



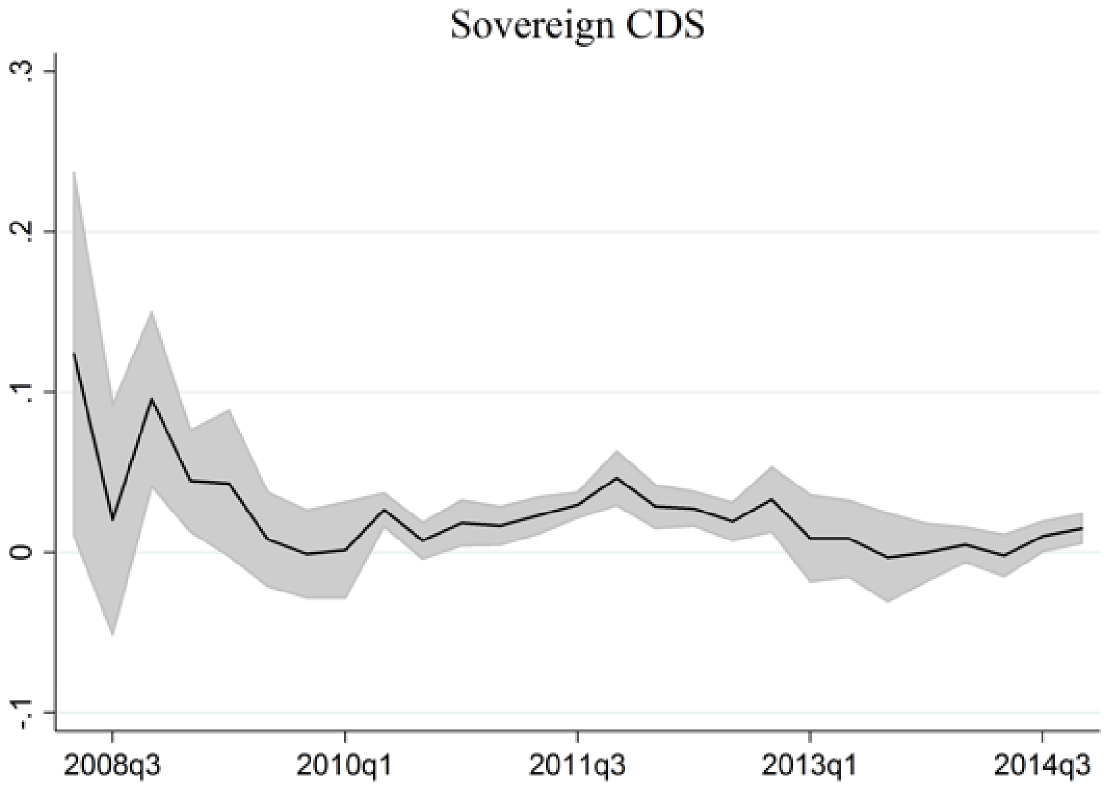
The displayed series correspond to equation (1) in table 5. Units are percentage points, 1 percentage point = 100 basis points.

Figure 4. Coefficient estimates with a weekly moving window.



Shadowed areas denote 95 % confidence bands. Daily frequency graphs are practically identical but – for obvious reasons - more noisy.

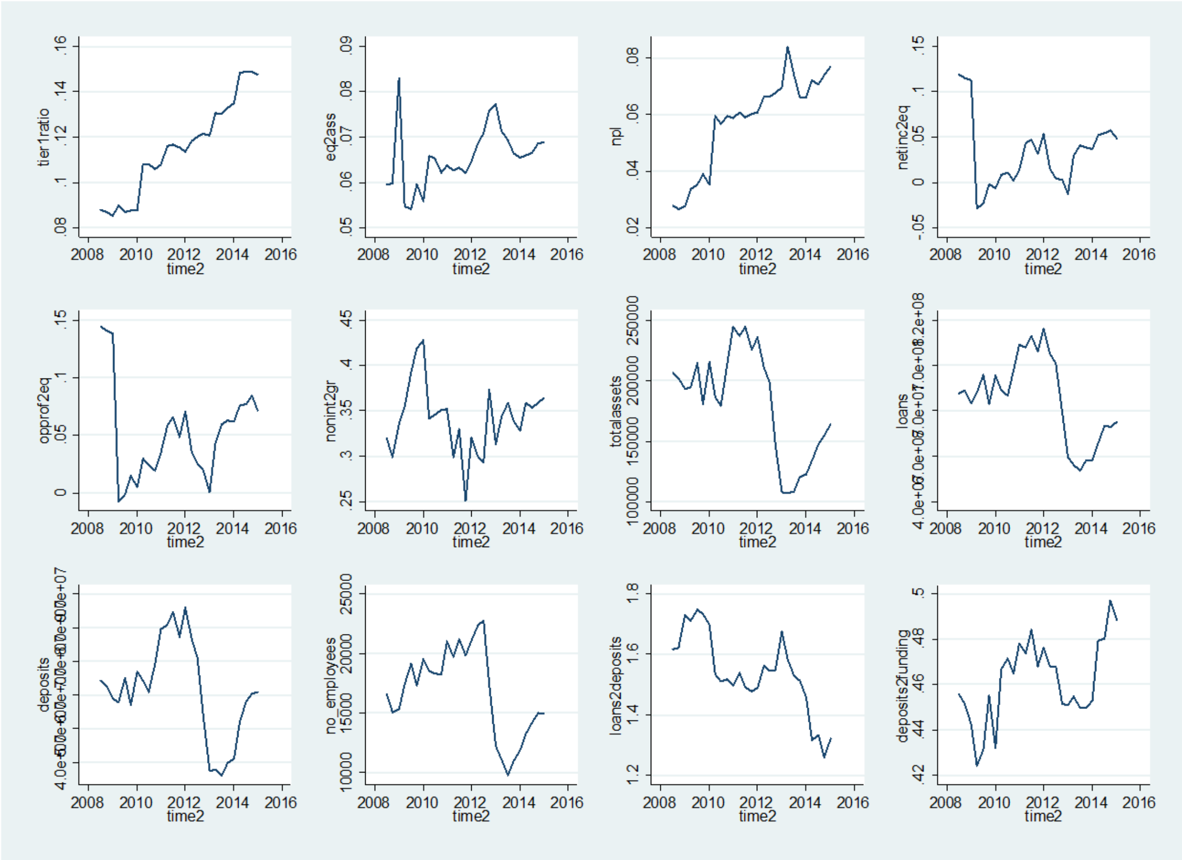
Figure 5. Coefficient estimates for Sovereign CDS with quarterly window.



Shadowed area denotes 95 % confidence bands.

Appendix

Figure 1. Time-evolution of the independent variables.



Values are averages over 382 banks.

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