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Individual, Systematic and Systemic Risks in the Danish Banking Sector*

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Abstract

This article discusses the relationship between micro-prudential variables and bank risk. For this purpose, we collect panel data on 21 Danish banks accounting for 88% of total market share in Denmark from 2000 to 2015 and reflect upon the contribution of these different variables to bank individual, systematic and systemic risks. Our results suggest that the factors size, capitalization, funding structure, organizational complexity and degree of market-based activities are key risk determinants. Moreover, we find evidence that the Danish case is relatively peculiar with respect to the effects of bank size and of degree of market-based activities: Bank size contributes positively to systematic and systemic risks, but not to individual risk. Degree of market-based activities contributes to counteract individual risk, but on the other hand intensifies systematic and systemic risks. The Danish case could be taken as an example for other small economies with a highly concentrated banking sector.

1. Introduction

In the aftermath of the financial crisis banking risk received central attention of policymakers and regulators. With the aim of preventing future crises, new institutions were created and financial regulations were strengthened. In the European Union, for example, the European System of Financial Supervision was established and in the Euro-area the Single Supervisory Mechanism which is part of the so-called banking union[1] was implemented. Similarly, in Denmark the Danish Systemic Risk Council was established in 2013 as an authority meant to monitor, identify and contribute to limiting systemic risk (Danish National Bank, 2014). According to the Systemic Risk Council Report (2014) "so far, experience with macroprudential policies is limited in Denmark and internationally, and the policy area is still at an early stage of development".

The main objective of this article is to understand the different drivers of banking risk and help policymakers and regulators with the development of tools to restrict it. Moreover, this research investigates whether these drivers affect the

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[1] Whereas some countries that are not members of the Euro-area like Denmark announced planning to join the banking union in the past, other countries like the Czech Republic follow a "wait and see" approach.

different categories of risk, namely individual, systematic and systemic risks, in a similar way. Thus, we discuss whether micro-prudential policies are suitable for macro-prudential purposes. The Danish case can be seen as example for other highly concentrated banking sectors like the Central and East European countries and Belgium to name another Western European economy.

Moreover, we discuss how our results can be used to evaluate the effectiveness of risk dampening policies taken by authorities. In order to reflect upon this effectiveness, we concentrate our analysis on the Danish economy by examining whether the rules set by the so-called "Supervisory Diamond" of the Danish Financial Supervisory Authority (DFSA) are consistent with our results. Usually bank size, capitalization, funding structure, involvement in market-based activities and organizational complexity are considered to be the key drivers of risk in the banking sector (*inter alia* Laeven et al., 2016).

The relationship between these risk drivers and banking risk are of major importance to prevent financial distress (*inter alia* Cipra and Hendrych, 2017). In this article, we distinguish between the three different crucial risk categories. We proxy individual risk by a banks' stock returns indicating higher individual risk in case of lower returns. For systematic risk we use the bank's beta factor, since it can be considered a transformation of all types of popular measures of systematic risk (*inter alia* Benoit et al., 2013) and because it is intuitive and easy to use. For systemic risk we use SRISK and LRMES,[2] the key variables in proxying systemic risk in Denmark and widely used by the Danish central bank (Grinderslev and Kristiansen, 2016).[3]

We follow Laeven et al. (2016) and apply panel regressions to 21 Danish banks representing 88% of market capitalization between the years 2000 and 2015 (see Appendix I). For our analysis we regress the banks' annual characteristics of risk in the crisis years of 2007, 2008, 2010 and 2011 on potential risk factors of the previous years 2006, 2007, 2009 and 2010, respectively.

The estimated regression models provide evidence that the variables capitalization (expressed by tier 1 capital ratio), funding structure (expressed by the relation between deposits and total assets) and market-based activities (expressed by the share of non-interest income) affect individual risk: the lower capitalization, the more unstable funding and the lower the degree of market-based activities the higher the banks' individual risk. Thus, in order to control individual risk, a higher tier 1 capital ratio, a higher relation between deposits and assets and a higher share of non-interest income should be required.

Our models of systematic risk indicate that bank size increases this type of risk. Besides, in line with the regressions for individual risk, we observe that a robust funding structure and a strong capitalization decrease systematic risk. Moreover, a higher ratio between deposits and assets and a higher tier 1 capital ratio interact with bank size. This means that a higher share of deposits and a higher tier 1 capital ratio counteract systematic risk more intensively in larger banks.

[2] Unfortunately, SRISK and LRMES data series are only available only for five Danish banks. However, these account for 70% of total market share.

[3] Notice that the choice of these variables to measure systemic risk is directly associated to their use by the Danish financial authorities. It is not our intention here to discuss the quality of the different systemic risk measurements. For more detail on this issue, see Adrian and Brunnermeier (2016) and Wosser (2017).

Our models of systemic risk[4] indicate that size and the ratio between loans and assets contribute to systemic risk. Besides, the interaction of size with leverage indicates that leverage increases the effect of size on systemic risk. The opposite is identified for the size interaction with the share of deposits and of loans in total assets. Consequently, big banks in Denmark should be required to have a lower leverage and a lower ratio between loans and assets.

Overall, our results are in line with Laeven et al. (2016) who show that systemic risk is higher for larger banks. However, in the case of Denmark, we find that bank size does not affect individual, but only systematic and systemic risks. This contradicts the positive effect of bank size on individual risk identified by Laeven et al. (2016) and Tchikanda (2017). Furthermore, the effect of the degree of market-based activities on risk is also peculiar in Denmark: while it decreases individual, it augments systematic and systemic risks. This could suggest a trade-off for the policy maker to control systemic and individual risks. Thus, if we consider macroeconomic stability a priority, the degree of market-based activities should be constrained.

We structure this article as follows: An overview of the literature and of how this paper relates to it is given in section 2; information on the three different risk categories and on how we measure them is provided by section 3; section 4 presents our data including descriptive statistics alongside a brief overview of the Danish banking system; section 5 summarizes our empirical results and their implications for policy makers are discussed in section 6. Finally, section 7 concludes.

2. Literature

The literature on banking risk has developed considerably during the past decade and is divided into three different strands: 1) the determination of the key drivers of risk; 2) the relationship between bank competition and overall financial stability; 3) the effectiveness of regulatory policies. Of course, the third strand is directly related to the former two. Our analysis is straightly related to the first one and evaluates the Danish regulation policies after the crises years.

According to Laeven et al. (2016) bank size, involvement in market-based activities, unstable funding and increased organizational complexity had a positive contribution to systemic risk during the financial crisis, leading to a global financial collapse in 2008. Problems in large banks tend to be more damaging to the financial system than in smaller ones, because of the liquidity stress they generate. This is consequence of their reliance on economies of scale and scope that cannot be replaced by small banks. Thus, larger banks, on average, create more individual and systemic risk in comparison to smaller ones. This is especially true when banks are insufficiently capitalized and have unstable funding, which are both common features of large banks. Besides, larger banks also require a larger support of taxpayers in case they need to be bailed out. Østrup (2010) uses the classical failure of Lehman Brothers as an example of this problem, when a considerable number of other financial institutions experienced financial distress.

[4] We acknowledge that due to data limitation, our sample for systemic risk regressions is much more restricted than in the studies of individual and systematic risks. Even though generally the effects of the different variables were found to be similar on the different concepts of risk, this issue can be seen as a limitation of our findings concerning systemic risk.

The positive effect of bank size on systemic risk was also confirmed by Pais and Stork (2013) for European banks. The authors analyzed the effect of bank size on univariate risk (measured by VaR) and on systemic risk. They found evidence of a small impact of size on univariate risk and a considerable impact of this variable on systemic risk. Besides, they showed that during the time period analyzed, systemic risk has risen for all banks. Kleinow et al. (2017) made a similar study for Latin America, in which the positive effect of bank size on systemic risk was verified. With respect to systematic risk, the research of Di Biase and D'Apolito (2012) as well as Viale and Madura (2014) can be mentioned. They identified a positive effect of bank size on systematic risk in Italy.

Whereas the first strand of literature investigates the key drivers of banking risk, the second reflects upon banking competition and its overall role on financial stability. Kohn (2004), for example, argues that fragmentation and interdependence within the banking industry may reduce stability. Historically, the fragmented banking systems have been more susceptible to bank runs and consequently to panic compared to those composed of fewer large banks. According to the author, fragmented systems try to apply economies of scale through interbank connections, which consequently poses a higher threat to overall stability. For example, if a bank with large interbank deposits fails, it consequently affects all other small banks holding deposits with it. The author further shows that liquidity problems became less frequent with the consolidation of the banking system.

In contrast to Kohn (2004), Leroy and Lucotte (2017) identified a dampening effect of competition on systemic risk. Although, the authors claim that higher competition increases individual risk, overall financial stability might benefit from higher competition due to a more synchronized risk-taking behavior of banks than when faced by weaker competition. Thus, the role of competition and thus concentration might be more complicated. For the Baltic countries, for example, Cuestas et al. (2017) found a U-shaped relationship between competition and stability.

3. Individual, Systematic and Systemic Risks

We define our models in different ways according to the type of risk we would like to analyze. We follow Laeven et al. (2016) in this exercise. The main idea here is to measure how the pre-crisis characteristics of banks contributed to individual, systematic and systemic risks during the crisis. In order to estimate the effect of the pre-crisis independent variables on the dependent variables during the crisis, lagged values of the independent variables are used.

Individual Risk

For estimating the individual bank risk, we regress each bank's stock return in the crisis years 2007, 2008, 2010 and 2011 (*period t*) on bank characteristics in 2006, 2007, 2009 and 2010 (*period t-1*), respectively. This way, we define the model that describes the relationship between stock returns in crisis periods according to the different bank characteristics in the prior periods as:

$$\begin{aligned} Ret_{i,t} = \beta_0 + \beta_1 Assets_{i,t-1} + \beta_2 Tier_{i,t-1} + \beta_3 DA_{i,t-1} + \beta_4 LA_{i,t-1} \\ + \beta_5 NI_{i,t-1} + \beta_6 LR_{i,t-1} + e_{i,t} \end{aligned} \tag{1}$$

where $Ret_{i,t}$ is the stock return of bank i and period t, $Assets$ is the log of total assets, $Tier$ is tier 1 capital ratio, DA is the fraction of funding of assets from deposits, LA is the share of loans in total assets, NI is the share of non-interest income in total income and LR is the leverage ratio.

Systematic Risk

For measuring the contribution of each of the bank's characteristics to systematic risk we use the following regression:

$$\begin{aligned} Bet_{i,t} = \beta_0 + \beta_1 Assets_{i,t-1} + \beta_2 Tier_{i,t-1} + \beta_3 DA_{i,t-1} + \beta_4 LA_{i,t-1} \\ + \beta_5 NI_{i,t-1} + \beta_6 LR_{i,t-1} + e_{i,t} \end{aligned} \tag{2}$$

where $Bet_{i,t}$ is the beta of bank i and at period t. It represents the covariance between the stock return of bank i and the return of the Danish market index OMXC20, divided by the variance of the latter. The measurement of beta is calculated according to the stock returns of the prior 12 months and those of the market index[5]. Thus, beta in period t corresponds to the beta registered for the last 12 month of the years 2007, 2008, 2010 and 2011 (*period t*), while the independent variables are computed as before for periods 2006, 2007, 2009 and 2010 (*period t-1*).

Systematic Risk and Interactions

When regressing systemic risk Laeven et al. (2016) find a reduced number of significant variables: only bank size and organizational complexity. Thus, they include the interactions of structural variables with bank size, which made the results more informative. We use the same type of technique for our regressions of systematic risk by regressing beta according to:

$$\begin{aligned} Bet_{i,t} = \beta_0 + \beta_1 Assets_{i,t-1} + \beta_2 Tier_{i,t-1} + \beta_3 DA_{i,t-1} + \beta_4 LA_{i,t-1} \\ + \beta_5 NI_{i,t-1} + \beta_6 LR_{i,t-1} + \beta_7 Assets_{i,t-1} Tier_{i,t-1} \\ + \beta_8 Assets_{i,t-1} NI_{i,t-1} + \beta_9 Assets_{i,t-1} LA_{i,t-1} \\ + \beta_{10} Assets_{i,t.1} DA_{i,t-1} + e_{i,t} \end{aligned} \tag{3}$$

where $Assets * Tier$ is the interaction between the log of total assets and tier 1 capital ratio, $Assets * NI$ *is* the interaction between the log of total assets and the share of non-interest income in total income, $Assets * LA$ is the interaction between the log of total assets and the share of loans in total assets and $Assets * DA$ is the interaction between the log of total assets and the fraction of funding from deposits.

[5] Beta is usually estimated using a period of 60 weeks of stock returns (Baker et al., 2013). First, the historical beta was computed using the 60 weeks period. Due to missing observations in data of weekly stock prices for some of the banks, however, part of the beta results obtained was inconsistent. The problem with using a 60 weeks period was the inability to calculate beta for all periods and for all the banks included in the sample. Therefore, to solve this problem, the monthly stock prices were used. This type of beta calculation follows Damodaran (1999) and was implemented by among others Acharya et al. (2012).

Systemic Risk

For measuring the contribution of each of the bank's characteristics to systemic risk, we use the following regression:

$$SYSRISK_{i,t} = \beta_0 + \beta_1 Assets_{i,t-1} + \beta_2 Tier_{i,t-1} + \beta_3 DA_{i,t-1} + \beta_4 LA_{i,t-1} + \beta_5 NI_{i,t-1} + \beta_6 LR_{i,t-1} + e_{i,t} \tag{4}$$

where $SYSRISK_{i,t}$ is a measurement of systemic risk of bank i in period t[6] that could is proxied in our case by SRISK or LRMES. The data series on SRISK and LRMES were provided by the NYU Stern School of Business. However, this measurement was only available for few Danish banks, so that our estimations of systemic risk are restricted to a small group of five banks (Danske Bank, Jyske Bank, Sydbank, Ringkjøbing Landbobank and Spar Nord Bank). Even though this restriction is not optimal, these banks represent together around 70% of Danish market share.

Systemic Risk and Interactions

As it was done for systematic risk, we also include interactions of bank size with other variables in the regression of systemic risk:

$$\begin{aligned} SYSRISK_{i,t} = \beta_0 &+ \beta_1 Assets_{i,t-1} + \beta_2 Tier_{i,t-1} + \beta_3 DA_{i,t-1} + \beta_4 LA_{i,t-1} \\ &+ \beta_5 NI_{i,t-1} + \beta_6 LR_{i,t-1} + \beta_7 Assets_{i,t-1} Tier_{i,t-1} \\ &+ \beta_8 Assets_{i,t-1} NI_{i,t-1} + \beta_9 Assets_{i,t-1} LA_{i,t-1} \\ &+ \beta_{10} Assets_{i,t.1} DA_{i,t-1} + e_{i,t} \end{aligned} \tag{5}$$

4. Data Description

4.1 The Danish Banking System

The Danish banking system is very concentrated. It consists of few large banking groups and many smaller institutions. These large groups are responsible for the majority of credit in the Danish economy. Thus, the Danish system is among the most concentrated ones in Europe (Danish National Bank, 2016). The Danish example is didactical considering highly-concentrated banking systems, which is a typical characteristic in small open economies. The Baltic countries, for example, also have a high level of concentration (Cuestas et al., 2017). Although to a lower level, the banking sector of Czech Republic is also highly concentrated (Stavárek and Repková, 2011, Heryán and Stavárek, 2012).

According to Carstensen (2011), Denmark, like many other countries, was affected by the financial crisis. Danish banks faced a liquidity crisis due to their high dependence on international financial markets and tight connectivity among each other. This resulted in a considerable number of banks experiencing financial distress. Some of the banks went bankrupt, such as Roskilde Bank, while some others have been acquired by the so called "winding-up" company, the Financial Stability Company. On the other hand, some banks were subjected to capital restructuring, brought forward by

[6] For more details on the definition of SRISK and LRMES, see Brownlees and Engle (2012) and Acharya et al. (2012).

mergers and acquisitions. These actions resulted in a concentration of the banking industry, which was constituted by 162 banks at the end of 2007 and only 110 banks in 2015 (Danish National Bank, 2012). If one excludes foreign banks, these numbers would reduce from 152 in 2007 to only 80 in 2015.

After the financial crisis new regulations were created in Denmark, including the improvement of the DFSA's power to intervene in financial institutions. The new regulations, however, favor the concentration of the banking system (Carstensen, 2011). Consequently, there are fewer and larger banks in Denmark, a development that has been observed internationally in North America and Europe after the financial crisis. This could pose higher risk to the financial system in the future. As discussed by Dowd (2009) the banking sector became generally more concentrated, but the effect of this concentration on financial stability in the future is unknown. The problem of concentration is even stronger with the lobbying of larger banks at governmental institutions and with politicians, which could even intensify the recent concentration process (Blau et al., 2013).

In *Figures 1* to *7* (see Appendix III), we use statistics provided by the DFSA. Bank size is expressed by the natural logarithm of total assets. Even though Denmark is a relatively small country, the size of Danish banks varies from very large (with assets over 65 billion DKK) to very small ones (with assets under 500 million DKK). The DFSA divides banks into different groups according to their size and location, so that we can also observe the evolution in size in small banks. Group 1 includes banks that have over 65 billion DKK in assets, Group 2 includes those with over 12 billion DKK and Group 3 those with over 500 million DKK. The DFSA also has further data for Group 4, with assets under 500 million DKK, Group 5 with foreign banks branches in Denmark, and Group 6 with banks from Faroe Islands. However, none of the banks studied in this article are part of these latter groups.

Figures 1 to *3* show the increase in banking size and concentration in Denmark between 2000 and 2014. Bank size increased considerably over the last 10 years of our data. The figures show a considerable growing trend for most of the banks until the financial crisis in 2008, when some of the banks experienced a decrease in total assets. However, after the crisis years of 2008 and 2009, the growing trend continues for most of the banks.

Market concentration is reflected by the fraction of banking assets held by the three largest banks in the country, which increased intensively in most advanced economies including Denmark. Group 1 is of particular interest in this case as it is constituted by the Systemically Important Financial Institutions (SIFIs). The difference between market participation of Danske Bank (56.6% in 2014) and the rest is significant.

Figures 4 to *6* show a shift towards market-based activities as there is a tendency of reduction in loans as share of assets for all three groups. This decline, however, starts in the crisis years of 2008 and 2009. In the prior period one can observe a growing trend in this variable, when an intensive increase in lending took place in Denmark, particularly after 2003 (Østrup, 2010).

Considering the crisis circumstances, the regulator decided to impose some restrictions including one to lending. The volume of loans decreased after 2008 and this decreasing trend continued due to these restrictions, which targeted the excessive risk-taking in terms of lending. As result, banks found their profits squeezed, which led them to resort to other sources of income such as market-based activities.

Figure 7 gives a good picture of this phenomenon: non-interest income increased considerably after 2000, but showed an abrupt fall during the period 2007-2008 with the crisis. Afterwards, it increased again, but not as intensively as previously, and reduced again in 2011 to the same level of 2007 and 2008. Thereafter, it grows again, but with a much higher intensity than prior to 2008. *Figure 7* shows an intensive and fast increase of non-interest income after 2011, when the lending restrictions were imposed. This leads us to the assumption that there is a relationship between the decrease in the share of loans and the increase in the share of non-interest income.

We also analyze the Pearson's correlation coefficients between the different variables. Appendix IV reports the resulting correlation matrix. Notice that most of the bank characteristics are related to each other, with some exceptions. There is a negative correlation between bank size and the variables tier 1 capital and share of deposits in assets. Bigger banks are associated with lower tier 1 capital as well as with a lower share of deposits in assets (unstable funding). Besides, there is a positive correlation between size and leverage (unstable funding). Furthermore, there is a negative correlation between the share of non-interest income and the share of loans in total assets, which supports the assumption that a reduction in the share of loans increases the share of non-interest income. These results go in line with the observation of Laeven et al. (2016) that "there is a structural reason why some banks become large, with lower capital, fragile funding and more market-based activities at the same time".

Sources and Descriptive Statistics

We collected data from the following sources:

- Yahoo Finance was used to collect historical stock prices adjusted for dividends and splits, for each of the publicly-traded bank and for the market index OMX Copenhagen 20. Even though most of the data used required annual returns, we also collected monthly returns in order to find the betas for our regressions of systematic risk.
- The Danish Financial Supervisory Authority was used to collect the yearly financial accounts in the period 2000-2015. Specifically, this source was used to collect bank characteristics such as total assets, total loans, interest receivables, dividend on investments, charges and commissions receivables, market value adjustments, other operating income, income from holdings in associated and affiliated enterprises as well as other significant holdings, equity capital and total deposits. These data were then used to calculate our independent variables.
- Bloomberg was used for collecting the tier 1 capital ratios.
- Banks' annual reports were collected from the different banks' websites. These were used for verifying and collecting several bank characteristics that were neither available in the DFSA online database nor in Bloomberg.

- NYU Stern School of Business was used to collect the data series of SRISK and LRMES.[7]

We concentrate our analysis on the 21 banks that cover 88% of total market capitalization. We, however, excluded banks that failed during the time of investigation. With the exception of Roskilde Bank, these banks were rescued by the government or acquired by larger banks. Thus, in the end, most of these failed banks are represented in our data sample indirectly. Descriptive statistics for our data sample are provided in the tables of Appendices II, IV and V.

5. Empirical Analysis

Before we run our regressions, it is important to test the variables for stationarity (Dreyer, 2012; Dreyer and Schmid, 2017). We ran the panel unit root test of Hadri (2000) and stationarity is confirmed for all variables. This makes sense due to the short period of the data series used in our regressions of 4 years.

5.1 Test of Significance of Single Variables

One can observe that equations (1), (2), (3), (4) and (5) have many variables and the estimations of them all together in a single regression could raise concerns about the robustness of our estimates. A typical example is the so-called Simpson's Paradox (Clifford, 1982), that could happen when two correlated variables are used in a single regression as independent variables and end up removing significance or even reverting the signal of one of their coefficients.

Thus, we first decided to run simple pooling regressions of the dependent variables on each of the independent variables separately. The idea in this case is to make sure that the independent variables selected really have an effect on the different categories of risk before using them in the final estimations. This way we avoid the use of non-significant variables in the final estimations, something that would inflate the variances of the models. Secondly, after estimating the different models, we would like to compare the signs of each resulting coefficient to the prior signs of the simple regressions so that we can make sure that our results are robust.

Results for simple regressions of stock returns (individual risk), betas (systematic risk), SRISK and LRMES (systemic risk) on the different variables are given by tables 1, 2 and 3. Notice that in order to simplify the presentation we decided to only present the estimated coefficients and their significances[8].

In table 1, from the six variables listed in the model of individual risk, only three proved to be significant: tier 1 capital, the ratio of deposits and assets and non-interest income. The positive signals of the first two coefficients are expected: a higher tier 1 ratio increases returns in stressful scenarios as well as a higher relation between deposits and total assets. This means that bank capitalization and funding structure are key variables for increasing stability of the individual banks. On the other hand, the variable non-interest income is significant and positive in Denmark, which implies that banks that generate more income from non-interest activities are less likely to experience financial distress.

[7] Unfortunately, NYU Stern only provides SRISK and LRMES data series for 5 Danish banks. However, these account for 70% of total market share.
[8] Complete results for each regression including intercepts, R^2, etc. are available upon request.

This positive result is an exception when compared to other countries (Demirgüç-Kunt and Huizinga, 2010). Likely, this happens because Danish banks do not participate significantly in the mortgage credit, which is supposed to be a low risk interest income market. This means that the type of interest income of Danish banks is more related to higher risk credit, what explains partly the controversial positive relation between market-based activities and stock returns in stressful scenarios.

Table 1 Simple Regressions of Individual Risk

Dependent Variable: Stock Returns				
	Coef.	*St. Err.*	*p-value*	
$Assets_{t-1}$	0.00	0.02	0.88	
$Tier_{t-1}$	0.02	0.01	0.03	*
DA_{t-1}	0.00	0.00	0.10	.
LA_{t-1}	0.00	0.00	0.23	
NI_{t-1}	0.02	0.01	0.00	**
LR_{t-1}	0.00	0.01	0.46	

Notes: The dependent variables are Stock Returns in t period (crisis period). '***', '**', '*', and '**.**' indicate significance at 0.001, 0.01, 0.05 and 0.1 levels. Sources: The Danish Financial Supervisory Authority Statistics, Yahoo Finance Historical Prices, Bloomberg and authors' own calculation.

In table 2, from the six variables listed in the models of systematic risk without interactions, five proved to be significant: log of total assets, tier 1 capital, the ratios between deposits and loans with total assets and leverage. The positive sign of log of total assets is no surprise. Bigger banks increase systematic risk during times of crisis. The negative sign of tier 1 capital shows that undercapitalized banks are frequently associated with higher systematic risk. The negative signs of the share of deposits and loans in total assets indicate that funding structure and the higher engagement of a bank in lending activities (not market-based activities) reduce systematic risk. This characteristic of lending activities is verified in Denmark the same way it is for the international setting (see Leavin et al. 2016) even though Danish banks do not participate significantly in the mortgage credit as explained earlier. Finally, the positive sign of leverage indicates that it increases systematic risk. When explaining systemic risk in table 3, these variables present the same characteristics, except for tier 1 capital, which in this case is not significant. Notice that results are very similar no matter the type of variable we choose to measure systemic risk (SRISK or LRMES).

Table 2 Simple Regressions of Systematic Risk

Dependent Variable: Betas				
	Coef.	*St. Err.*	*p-value*	
$Assets_{t-1}$	0.19	0.03	0.00	***
$Tier_{t-1}$	-0.08	0.02	0.00	***
DA_{t-1}	-0.03	0.00	0.00	***
LA_{t-1}	-0.02	0.01	0.02	*
NI_{t-1}	-0.01	0.01	0.28	
LR_{t-1}	0.07	0.01	0.00	***
$Assets_{t-1}*Tier_{t-1}$	0.00	0.00	0.01	**
$Assets_{t-1}*NI_{t-1}$	0.00	0.00	0.30	
$Assets_{t-1}*LA_{t-1}$	0.00	0.00	0.54	
$Assets_{t-1}*DA_{t-1}$	0.00	0.00	0.00	***
$Assets_{t-1}*LR_{t-1}$	0.00	0.00	0.00	***

Notes: The dependent variables are Betas in t period (crisis period). '***', '**', '*', and '**.**' indicate significance at 0.001, 0.01, 0.05 and 0.1 levels. Sources: The Danish Financial Supervisory Authority Statistics, Yahoo Finance Historical Prices, Bloomberg and authors' own calculation.

The same analysis can be made for interactions. In table 2, the interaction of log of total assets with tier 1 capital is significant and negative when explaining systematic risk. Thus, there is an extra stabilizing effect of tier 1 capital in bigger banks. This effect, however, is not verified for systemic risk (see table 3). On the other hand, we can observe in table 3 that the interaction between log of total assets and the ratio between loans and assets is significant and negative when explaining systemic risk. This shows that the engagement of banks in lending activities (not market-based) has an extra stabilizing effect in bigger banks when we look at systemic risk. This is, however, not verified for systematic risk (table 2).

Interactions that are significant to explain both systematic and systemic risks are those between log of total assets and leverage and the ratio between deposits and assets. The former interaction has a negative sign, an indication that capitalized banks have an extra stabilizing effect when they are bigger. The latter has a positive sign and indicates that there is an extra positive effect of leverage on systematic and systemic risks when banks are bigger.

Table 3 Simple Regressions of Systemic Risk

	Dependent Variable: SRISK				***Dependent Variable: LRMES***			
	Coef.	*St. Err.*	*p-value*		*Coef.*	*St. Err*	*p-value*	
$Assets_{t-1}$	5403.75	649.41	0.00	***	2.47	0.52	0.00	***
$Tier_{t-1}$	394.93	1045.23	0.71		0.37	0.53	0.50	
DA_{t-1}	-811.71	208.32	0.00	**	-0.27	0.15	0.10	.
LA_{t-1}	-819.44	163.18	0.00	***	-0.40	0.10	0.00	**
NI_{t-1}	-515.20	647.27	0.00		-0.45	0.31	0.19	
LR_{t-1}	2040.20	398.93	0.00	***	1.00	0.23	0.00	**
$Assets_{t-1}$*$Tier_{t-1}$	43.95	34.95	0.24		0.03	0.02	0.16	
$Assets_{t-1}$*NI_{t-1}	5.93	26.21	0.83		-0.01	0.01	0.71	
$Assets_{t-1}$*LA_{t-1}	-46.77	10.79	0.00	**	-0.02	0.01	0.00	**
$Assets_{t-1}$*DA_{t-1}	-35.77	12.49	0.02	*	-0.01	0.01	0.27	
$Assets_{t-1}$*LR_{t-1}	66.74	10.50	0.00	***	0.03	0.01	0.00	***

Notes: The dependent variables are SRISK as well as LRMES in t period (crisis period). '***', '**', '*', and '.' indicate significance at 0.001, 0.01, 0.05 and 0.1 levels. Sources: The Danish Financial Supervisory Authority Statistics, Yahoo Finance Historical Prices, Bloomberg and authors' own calculation.

5.2 Estimating Our Models

We decided to run pooling estimations for panel data in all cases for different reasons:

- Among others, Laeven et al. (2016) use fixed effects to run this type of regressions that include different countries. This allows each country to have its own intercept so that the different characteristics of countries can be considered by their models. Thus, in each country banks are estimated together. In our case, tests are made solely for banks in Denmark so that it would be natural to choose directly the pooling technique. To put it simple: should brand matter for the size of a bank's risk so that a group of banks in a single country would have different intercepts? If the answer for this question would be "yes", risk metrics would be influenced by the brand of a bank with all other risk factors constant, but this seems unrealistic.
- In all our regressions (tables 4 to 8), the LMBP (Lagrange Multiplier Breusch-Pagan) test is not significant suggesting that we do not need to resort to techniques of panel effects (fixed and random) for our estimations[9]. However, in order to be careful, we decided to rerun all our regressions using fixed effects. Afterwards, we compared these results against those of the pooling regressions using the F-test for individual effects. Confirming our initial thoughts, in none of the regressions the F-statistic is significant, so that the fixed effects methodology should not be preferred against the pooling estimations. Results for the F-tests are available in tables 4 to 8 and complete results for the fixed effects estimations are available upon request.

We started our estimations by including year dummies (time dummies) in order to allow for any specific time effects. In most of the cases these time dummies proved not to be significant, such that we decided to continue our estimations without them. Moreover, in all our regressions, there is no evidence against neither normality nor homoscedasticity of our residuals, since both Jarque-Bera and Breusch-Pagan tests suggest not to reject their respective null hypotheses.

It is also common to observe the problems of residual autocorrelation in estimations that use a panel data setting. Our data frame, however, consists of only four years, such that autocorrelation tests on residuals would make little sense. In order to be conservative, we decided to use a HAC covariance matrix anyway (heteroskedasticity autocorrelation consistent) to adjust the standard deviations of our estimates.

5.2.1 Individual Risk

In our analysis, we consider that the lower the stock return during stress periods, the higher its individual risk. In other words: the larger the loss, the riskier the bank. We decided to run 3 different regressions for individual risk (equation 1). In regression 1, we only selected those variables that were significant in the earlier simple regressions of individual risk. Afterwards, we included total assets in regression 2, as

[9] This way of choosing the most reliable panel technique for our data setting goes in line with Dreyer and Schmid (2015).

this variable is of major concern in banking risk. Then we decided to run regression 3 with all variables. Table 4 summarizes the results of these three OLS regressions.

Regression 1 estimates the relation between stock returns and tier 1 capital, the relation between deposits and assets and non-interest income. In this case, the tier 1 ratio and non-interest income are positive and significant at the 10% significance level, confirming the positive relation they have with stock returns found in the earlier simple regressions. The tier 1 ratio is a variable that is associated to bank capitalization and non-interest income to the bank's involvement in market-based activities. Thus, these positive coefficients reveal that the higher the capitalization and the higher the participation of the bank in market-based activities, the lower the individual risk. For every 1%-point increase in the tier 1 capital ratio and in the share of non-interest income, returns increase by 1.51% and 1.81% points respectively. Notice that a positive relation between non-interest income and stock returns in the Danish case during crises periods go against the international evidence exemplified by Demirgüç-Kunt and Huizinga (2010). Likely, this happens because Danish banks do not participate significantly in the mortgage credit as explained earlier.

Regression 2 includes the log of total assets in the regression. Results confirm the lack of significance found for this variable in the earlier simple regression and indicate that this variable does not drive individual risk in Denmark. Further coefficients confirm results of regression 1 with an extra significant and positive coefficient, the one associated with the relation between deposits and assets. This result indicates that funding structure matter in the case of individual risk. We can say that for every 1% point increase in tier 1 capital ratio, in the relation between deposits and assets and in the share of non-interest income, returns increase by 1.46%, 0.59% and 1.83% points respectively.

Regression 3 includes all variables and estimation results go in line with the prior two. Capitalization, funding structure and the degree of the bank's involvement in market-based activities matter to define individual risk. The sign of the coefficients confirm those of the prior simple regressions and indicate that these variables should be taken into consideration by the regulator in order to control individual risk. For every 1% point increase in tier 1 capital ratio, in the relation between deposits and assets and in share non-interest income, returns increase by 1.9%, 0.61% and 1.98% points respectively.

One further result is interesting to be discussed and has to do with the lack of significance of bank size in defining individual risk. For the international setting, bigger banks are usually associated with lower stock returns during crisis periods and thus with higher individual risk. This contra-intuitive result constitutes an individual characteristic of the Danish economy and is further discussed by Buchholst and Rangvid (2013). These authors point out for a longer time period that the bigger the bank, the lower the individual risk in Denmark, what again constitutes a very specific Danish characteristic.

Table 4 Regressions Estimations: Individual Risk

	OLS regression 1				*OLS regression 2*				*OLS regression 3*			
	Dependent Variable: Stock Return in t period (crisis periods)											
	Coef.	***St. Err.***	***p-value***		***Coef.***	***St. Err.***	***p-value***		***Coef.***	***St. Err.***	***p-value***	
Intercept	-1.04	0.18	0.00	***	-2.14	0.73	0.00	**	-2.61	1.21	0.00	*
$Assets_{t-1}$	-	-	-		0.04	0.02	0.13		0.04	0.04	0.35	
$Tier_{t-1}$	0.02	0.01	0.08	.	0.01	0.01	0.09	.	0.02	0.01	0.09	.
DA_{t-1}	0.00	0.00	0.43		0.01	0.00	0.09	.	0.01	0.00	0.1	.
LA_{t-1}	-	-	-		-	-	-		0.00	0.00	0.48	
NI_{t-1}	0.02	0.01	0.00	***	0.02	0.00	0.00	***	0.02	0.01	0.00	***
LR_{t-1}	-	-	-	-	-	-	-	-	0.01	0.00	0.73	
R2	0.22	-	-		0.24	-	-		0.25	-	-	
BP	4.18	-	0.24		6.66	-	0.16		7.02	-	0.32	
JB	3.57	-	0.17		3.51	-	0.17		3.44	-	0.18	
Panel Tests:												
LMBP	0.84	-	0.36		0.65	-	0.42		0.62	-	0.43	
F-test	1.00		0.47		1.21	-	0.28		1.32	-	0.21	

Notes: The dependent variable is Stock Return in t period (crisis period). Standard errors have been corrected for autocorrelation by using heteroskedasticity and autocorrelation consistent (HAC) estimators. '***', '**', '*', and '.' indicate significance at 0.001, 0.01, 0.05 and 0.1 levels. BP is the Breusch-Pagan test, LMBP is the Lagrange Multiplier Breusch-Pagan test and JB is the Jarque-Bera test. All regression were run with n = 84 observations. Sources: The Danish Financial Supervisory Authority Statistics, Yahoo Finance Historical Prices, Bloomberg and authors' own calculations

5.2.2 Systematic Risk

In order to analyze systematic risk, we regress beta according to equations (2) and (3).

5.2.2.1 Systematic Risk: When Interactions are not Considered

We decided to run three different regressions for systematic risk (equation 2). In regression 4, we only selected those variables that were significant in the earlier simple regressions of systematic risk. In regression 5, we removed those variables that were not significant in regression 4 and finally added all remaining variables in regression 6. Table 5 summarizes results of these three OLS regressions.

Regression 4 estimates the relation between beta and the characteristics of the banks, excluding non-interest income that was not significant in the prior simple regressions of systematic risk. Results show that the variables bank size, tier 1 capital ratio and share of deposits in total assets are significant at the 10% significance level.

Our estimate related to bank size has a positive sign, which reveals that for every 1% increase in total assets, the beta of a bank increases by 0.0017. Thus, bank size is a determinant factor of systematic risk. Besides, the estimate related to tier 1 is also significant, what reveals that undercapitalized banks have a higher systematic risk. For every 1% point increase in tier 1 capital ratio, beta decreases by 0.047.

The coefficient related to the ratio between deposits and total assets shows that for a 1% point increase in this variable, beta would decrease by 0.011. This means that deposits (funding structure) have a stabilizing effect, reducing systematic risk.

In regression 5 those variables that are not significant in regression 4 are excluded. All other coefficients remain significant: bank size, tier 1 capital and the share of deposits in total assets. For every 1% increase of total assets, beta increases by 0.0014. On the other hand, for a 1% point increase in tier 1 and in the share of deposits in total assets, systematic risk decreases by 0.042 and 0.013. Thus, our estimates for regression 5 indicate that bank size affect systematic risk positively while capitalization and funding structure negatively.

Regression 6 confirms prior results. Here, for a 1% increase of total assets, a 1% point increase in tier 1 and in the share of deposits in total assets, systematic risk increases by 0.0017, decreases by 0.046 and decreases by 0.011 respectively. Thus, our estimates for regression 6 also indicate that bank size affects systematic risk positively while capitalization and funding structure negatively.

Generally, regressions 4 to 6 show that size, tier 1 (capitalization) and the relation between deposits and total assets (funding structure) are key determinants of systematic risk. The larger the amount of assets, the lower the capitalization measured by tier 1 capital and the higher the weight of other sources of funding for assets than deposits, the higher the beta during shock periods.

Table 5 Regressions Estimations: Determinants of Systematic Risk

	OLS regression 4				*OLS regression 5*				*OLS regression 6*			
	Dependent Variable: Beta in t period (crisis periods)											
	Coef.	***St. Err.***	***p-value***		***Coef.***	***St. Err.***	***p-value***		***Coef.***	***St. Err.***	***p-value***	
Intercept	-2.49	1.54	0.36		0.05	1.23	0.96		-2.53	2.05	0.22	
$Assets_{t-1}$	0.18	0.04	0.01	*	0.14	0.08	0.04	*	0.18	0.07	0.02	*
$Tier_{t-1}$	-0.05	0.02	0.09	.	-0.04	0.01	0.00	**	-0.05	0.02	0.02	*
DA_{t-1}	-0.01	0.00	0.00	***	-0.01	0.01	0.02	*	-0.01	0.01	0.08	.
LA_{t-1}	0.01	0.01	0.10		-	-	-		0.01	0.01	0.27	
NI_{t-1}	-	-	-		-	-	-		0.00	0.01	0.95	
LR_{t-1}	-0.02	0.02	0.36		-	-	-	-	-0.02	0.02	0.38	
R2	0.53	-	-		0.51	-	-		0.53	-	-	
BP	3.32	-	0.65		5.29		0.15		6.89	-	0.33	
JB	1.78	-	0.41		1.49	-	0.47		1.82	-	0.40	
Panel Tests												
LMBP	0.19	-	0.66		0.12	-	0.73		0.19	-	0.66	
F-test	0.82	-	0.68		0.98	-	0.50		0.80	-	0.66	

Notes: The dependent variable is Beta in t period (crisis period). Standard errors have been corrected for autocorrelation by using heteroskedasticity and autocorrelation consistent (HAC) estimators. '***', '**', '*', and '.' indicate significance at 0.001, 0.01, 0.05 and 0.1 levels. BP is the Breusch-Pagan test, LMBP is the Lagrange Multiplier Breusch-Pagan test and JB is the Jarque-Bera test. All regression were run with n = 84 observations. Sources: The Danish Financial Supervisory Authority Statistics, Yahoo Finance Historical Prices, Bloomberg and authors' own calculation.

5.2.2.2 Systematic risk: Considering Interactions

In order to test the influence of our interaction terms in systematic risk (equation 3), we first selected those of them that were significant in the prior individual simple regressions of systematic risk. In order to start our tests (regression 7), we included those terms alongside the variables that where significant in the prior regressions 4 to 6: log of total assets, tier 1 capital and the relation between deposits and assets. Results for regression 7 are provided in table 6. Notice that estimation results using the interaction terms along with these three variables proved to be weak. None of the coefficients are significant, except for the log of total assets.

We thus suspected of problems of multicollinearity and decided to run the correlation matrix of our independent variables to search for an ideal non-interaction candidate to be removed. This matrix is given in Appendix IV. The correlation between log of total assets and the relation between deposits and assets seems to be highest of almost 80%. Thus, we decided to remove the last variable and run regression 8, where again the variable log of total assets is significant. In this case, the interaction between log of total assets and the relation between deposits and assets is significant, indicating that the bigger the bank, the more a higher relation between deposits and assets (funding structure) decreases beta.

We also ran regression 9, where we leave all interaction terms alongside total assets (significant variable of regressions 7 and 8). Here, we further notice the significant and negative effect of the interaction between tier 1 capital and bank size, which reveals that tier 1 capital in bigger banks tends to decrease systematic risk more intensively.

Table 6 Regressions Estimations: Determinants of Systematic Risk with Interactions

	OLS regression 7				*OLS regression 8*				*OLS regression 9*			
	Dependent Variable: Beta in t period (crisis period)											
	Coef.	***St. Err.***	***p-value***		***Coef.***	***St. Err.***	***p-value***		***Coef.***	***St. Err.***	***p-value***	
Intercept	-6.15	3.53	0.09	.	-3.56	2.38	0.14		-2.42	1.66	0.15	
$Assets_{t-1}$	0.37	0.16	0.02	*	0.26	0.11	0.02	*	0.21	0.08	0.00	**
$Tier_{t-1}$	0.09	0.15	0.56		0.09	0.15	0.50					
DA_{t-1}	0.05	0.05	0.33									
$Assets_{t-1}$*$Tier_{t-1}$	-0.01	0.01	0.32		-0.01	0.01	0.30		0.00	0.00	0.00	**
$Assets_{t-1}$*DA_{t-1}	0.00	0.00	0.21	-	0.00	0.00	0.02	*	0.00	0.00	0.03	*
$Assets_{t-1}$*LR_{t-1}	0:00	0.00	0.21		0.00	0.00	0.31		0.00	0.00	0.29	
R2	0.53	-	-		0.53	-	-		0.52	-	-	
JB	1.28	-	0.53		1.32	-	0.52		1.25		0.54	
BP	7.63	-	0.27		6.39	-	0.27		5.29		0.26	
Panel Tests												
LMBP	0.39	-	0.53		0.29	-	0.59		0.13		0.72	
F-test	0.83		0.67		0.82		0.68		0.84		0.65	

Notes: The dependent variable is Beta in t period (crisis period). Standard errors have been corrected for autocorrelation by using heteroskedasticity and autocorrelation consistent (HAC) estimators. '***', '**', '*', and '.' indicate significance at 0.001, 0.01, 0.05 and 0.1 levels. BP is the Breusch-Pagan test, LMBP is the Lagrange Multiplier Breusch-Pagan test and JB is the Jarque-Bera test. All regression were run with n = 84 observations. Sources: The Danish Financial Supervisory Authority Statistics, Yahoo Finance Historical Prices, Bloomberg and authors' own calculations.

5.2.3 Systemic Risk

Systemic risk is measured by SRISK and LRMES. In this section we test the significance of the different variables described in equations 4 and 5 for explaining systemic risk.

5.2.3.1 Systemic Risk: When Interactions are not Considered

Table 7 shows the estimation results for equation 4, where SRISK and LRMES are regressed the same way as beta in the systematic analysis. Regression 10 estimates the relation between systemic risk and those bank characteristics that proved to be significant in the earlier simple regression analysis of systemic risk: log of total assets, the shares of deposits and loans in total assets and leverage. From those, log of total assets and the share of loans in total assets proved to be significant. When LRMES is used, the share of deposits in total assets and leverage are also significant.

The higher the level of log of total assets, the higher the systemic risk, which was expectable according to our earlier simple regressions analysis. The same is valid for the positive relation of leverage with systemic risk when the dependent variable is LRMES.

However, the positive signs of the share of loans in total assets (both in the regression of SRISK and LRMES) and of the share of deposits in total assets (when LRMES is regressed) look strange because it goes against our results when each individual variable is regressed. This lack of robustness could be linked to the so called Simpson's paradox, which could happen when using very correlated data series as described earlier. Therefore, it is mandatory in this case to analyze the correlation matrix between our variables. This is offered in Appendix V.

Notice that the correlation between the share of loans in total assets with total assets and with the share of deposits in total assets equal 0.96 and 0.81 respectively. Besides, leverage presents also high correlations with total assets and with the share of deposits in total assets: 0.91 and 0.85 respectively. Thus, we decided to rerun our regression removing the share of loans in total assets and leverage (regression 11) and then removing total assets and leverage (regression 12) to observe results.

In the case of regression 11, only log of total assets is significant. Notice that even though the share of deposits in total assets remains non-significant, its sign reversed and now is according to what we would expect. As it was the case for systematic risk, bank size contributes to systemic risk positively. For every 1% increase in total assets, SRISK increases by 50.97 and LRMES by 3.94. Thus, bank size is a determinant factor of systemic risk.

In the case of regression 12, the share of loans in total assets is significant and has a "correct" negative sign when compared to the initial simple regressions of systemic risk. For every 1% point increase in the relation between loans and assets, SRISK decreases by 581 and LRMES by 0.47. The lower systemic risk implied from lending activities in this case indicate that the participation of banks in market-based activities increase systemic risk. It is interesting to note that in the study of individual risk, the participation of banks in market-based activities had the opposite effect (higher non-interest income acted to stabilize individual risk).

So, we can conclude that a higher engagement of banks in market-based activities contributes to systemic risk even in Denmark, where banks do not participate so much in the more secure type of lending which is related to mortgage securities.

Thus, generally, regressions 10 to 12 show that size and the relation between loans and total assets can be seen as key determinants of systemic risk. The larger the amount of assets, and the lower the weight of loans in total assets, the higher the value of systemic risk during shock periods.

5.2.3.2 Systemic risk: Considering Interactions

Table 8 shows the results for the estimations of systemic risk using the interaction variables that were significant in the prior individual regressions of banks characteristics on systemic risk according to equation 5. These significant interactions are those between total assets and the following variables: share of loans in total assets, share of deposits in total assets and leverage[10].

We start with regression 13, where all these significant interactions are used alongside those variables that were significant in the prior regressions 10 to 12, which include total assets and the share of loans in total assets. These two variables as well as all three interactions are significant at the 10% significance level. Confirming our prior results, bank size increases systemic risk and this effect is now even stronger for banks that have higher leverage and weaker for banks with a higher relations between loans and assets and between deposits and assets. On the other hand, a higher relation between loans and assets decreases systemic risk. This effect is even stronger the bigger the bank is, indicating that the involvement of banks in lending activities reduce systemic risk.

We try to add the relation between deposits and total assets in our final regression 14, but no additional conclusions can be taken as this variable does not prove to be significant.

The evidence of these interaction effects goes in line with Laeven et al. (2016) and supports the idea of the presence of economies of scale and scope in banking. The larger the size of a bank and the lower the loan share of assets (degree of market-based activities), the larger the systemic risk. This also indicates that larger banks that generate more income from non-interest activities are more likely to contribute to systemic distress.

[10] Notice that in the case of the variable LRMES, the interaction between assets and the share of deposits in assets was not significant in the simple regressions, but we used anyway this interaction term in the regressions of LRMES in order to be able to compare results with those of SRISK.

Table 7 Regressions Estimations: Determinants of Systemic Risk

	OLS regression 10				*OLS regression 11*				*OLS regression 12*			
	Dependent Variable: SRISK											
	Coef.	**St. Err.**	**p-value**		**Coef.**	**St. Err.**	**p-value**		**Coef.**	**St. Err.**	**p-value**	
Intercept	-390126.00	101525.00	0.00	**	-119615.00	37673.00	0.01	*	57980.00	9476.10	0.00	***
$Assets_{t-1}$	11602.00	2541.00	0.00	**	5097.96	1149.60	0.00	**				
DA_{t-1}	128.28	183.82	0.51		-68.60	207.90	0.75		-346.32	251.36	0.20	
LA_{t-1}	1359.02	527.12	0.04	*					-581.67	232.85	0.03	*
LR_{t-1}	981.84	950.11	0.34									
R2	0.94	-	-		0.88	-	-		0.77			
JB	2.71	-	0.26		0.14	-	0.93		0.45		0.80	
BP	1.68	-	0.79		3.39	-	0.18		1.21		0.55	
P - Tests												
LMBP	0.97	-	0.32		0.38	-	0.54		0.62		0.43	
F-test	4.11		0.11		2.06		0.24		5.94		0.03	
	Dependent Variable: LRMES											
Intercept	-211.50	75.38	0.03	*	-74.03	26.06	0.02	*	54.21	5.93	0.00	***
$Assets_{t-1}$	5.77	1.88	0.02	*	3.65	0.70	0.00	**				
DA_{t-1}	0.42	0.14	0.02	*	0.26	0.14	0.1		0.11	0.16	0.50	
LA_{t-1}	0.88	0.39	0.06	.					-0.47	0.15	0.01	*
LR_{t-1}	981.84	0.71	0.06	.								
R2	0.88	-	-		0.77	-	-		0.65			
JB	0.46	-	0.79		0.64	-	0.72		0.76		0.68	
BP	3.34	-	0.50		3.34	-	0.19		4.26		0.12	
P - Tests												
LMBP	1.09	-	0.20		1.82	-	0.18		0.50		0.48	
F-test	2.8		0.15		3.65		0.09		1.38		0.31	

Notes: The dependent variable is SRISK in t period (crisis period). Standard errors have been corrected for autocorrelation by using heteroskedasticity and autocorrelation consistent (HAC) estimators. '***', '**', '*', and '.' indicate significance at 0.001, 0.01, 0.05 and 0.1 levels. BP is the Breusch-Pagan test, LMBP is the Lagrange Multiplier Breusch-Pagan test and JB is the Jarque-Bera test. All regression were run with n = 20 observations. Sources: The Danish Financial Supervisory Authority Statistics, Volatility Institute of the NYU Stern School of Business, Bloomberg and author's own calculations.

Table 8 Regressions Estimations: Determinants of Systemic Risk with Interactions

	OLS regression 13				*OLS regression 14*			
	Dependent Variable: SRISK							
	Coef.	**St. Err.**	**p-value**		**Coef.**	**St. Err.**	**p-value**	
Intercept	-619120.00	114220.00	0.00	**	-640126.00	106400.00	0.00	**
$Assets_{t-1}$	19893.00	4025.40	0.00	**	21054.00	3801.75	0.00	**
DA_{t-1}					5701.07	3983.75	0.21	
LA_{t-1}	-9629.70	3058.80	0.02	*	-7641.50	3145.66	0.06	.
$Assets_{t-1}*LA_{t-1}$	-347.42	128.12	0.04	*	-274.79	128.64	0.09	.
$Assets_{t-1}*DA_{t-1}$	-13.87	6.04	0.06	.	-222.05	164.95	0.24	
$Assets_{t-1}*LR_{t-1}$	124.83	38.59	0.02	*	154.82	41.32	0.01	*
R2	0.98	-	-		0.98	-	-	
JB	0.57	-	0.75		1.26	-	0.53	
BP	5.38	-	0.37		8.34	-	0.21	
Panel Tests								
LMBP	1.88	-	0.17		1.98	-	0.16	
F-test	0.60		0.55		0.59		0.61	
	Dependent Variable: LRMES							
Intercept	-363.43	75.04	0.00	**	-360.65	82.51	0.00	**
$Assets_{t-1}$	11.36	2.64	0.00	**	11.20	2.95	0.01	*
DA_{t-1}					-0.75	3.09	0.82	
LA_{t-1}	-7.41	2.01	0.01	*	-7.67	2.44	0.03	*
$Assets_{t-1}*LA_{t-1}$	-0.28	0.08	0.02	*	-0.29	0.09	0.03	*
$Assets_{t-1}*DA_{t-1}$	-0.02	0.00	0.00	***	0.06	0.03	0.01	
$Assets_{t-1}*LR_{t-1}$	0.13	0.03	0.00	**	0.12	0.13	0.68	*
R2	0.96	-	-		0.96	-	-	
JB	0.95	-	0.62		0.74	-	0.69	
BP	4.74	-	0.45		5.98	-	0.43	
Panel Tests								
LMBP	1.99	-	0.16		1.99	-	0.16	
F-test	0.01		0.99		0.00		0.99	

Notes: The dependent variable is SRISK in t period (crisis period). Standard errors have been corrected for autocorrelation by using heteroskedasticity and autocorrelation consistent (HAC) estimators. '***', '**', '*', and '.' indicate significance at 0.001, 0.01, 0.05 and 0.1 levels. BP is the Breusch-Pagan test, LMBP is the Lagrange Multiplier Breusch-Pagan test and JB is the Jarque-Bera test. All regression were run with n = 20 observations. Sources: The Danish Financial Supervisory Authority Statistics, Volatility Institute of the NYU Stern School of Business, Bloomberg and authors' own calculatios.

6. Discussion of Results

Our results do not indicate that bank size contributes to stock performance during the crises periods. The lack of a negative significant effect of bank size on stock returns can be seen as a particular result for Denmark. Although counterintuitive, the nonexistence of this negative effect is confirmed by Buchholst and Rangvid (2013), who show that larger banks performed even better during these periods than smaller banks in Denmark. Thus, size is not a driver of individual risk.

Significant variables that influence stock returns positively in crisis environments are tier 1 capital, the share of deposits in total assets and market-based activities expressed by non-interest income.

This last variable however indicates something peculiar: The involvement of the bank in market-based activities reduces individual risk. As we discussed, this is special in our example in which bank loans have a relatively higher risk than in other countries. In Denmark, this may be explained by the lack of banking participation in mortgages securities, which are supposed to be the type of loan that has lowest risk.

Results of the regressions of beta indicate that bigger banks (size) are bound to higher systematic risk. Variables that decrease systematic risk are depository funding (funding structure) and tier 1 capital ratio (capitalization). This last variable reduces even more systematic risk in bigger banks. Moreover, when analyzing the effects of single variables on systematic risk we can also observe the negative effects of higher lending activity (lower market-based operations) and of higher leverage, which is even stronger for bigger banks. This partly confirms for the Danish case the effects of bank size, loans and leverage on systematic risk previously identified for Italian banks by Di Biase and D'Apolito (2012).

Our results on determinants of systemic risk are to some extend in line with Laeven et al. (2016) and Pais and Stork (2013). No matter whether we use SRISK or LRMES to proxy systemic risk, bank size and the degree of market-based activities (relation between loans and assets) are significant variables. Bigger banks and those more involved in market-based activities have higher systemic risks. When systemic risk is proxied by LRMES, leverage is also significant and increases risk. Besides, bigger banks with higher leverage have an even higher systemic risk while the contrary is verified for those bigger banks with a higher share of deposits in total assets and higher shares of loans in total assets. When analyzing the effects of single variables on systemic risk (simple regressions) we can also observe the negative effects of a higher share of deposits in total assets (stable funding) and positive effect of leverage in systemic risk.

Thus, the regulator should take into consideration bank size, funding structure, lending growth, involvement of banks in market-based activities, and capitalization structure when deciding upon the policy to be taken for reducing banking risk. Notice that the participation in market-based activities influence individual and systemic risk differently and could pose a trade-off to the regulator. These results apply to the Danish case, but might be expanded to other small economies with a highly concentrated banking sector.

This discussion leads us to the reflection upon the efficiency of the measurements of the Danish regulative authorities after the financial crisis. They focused on ensuring financial stability of the entire financial system, employing both micro- and macro-prudential strategies. They monitored certain indicators with the purpose of determining when or whether systemic risk was rising. The main intention was to increase the banks' resilience to financial distress (The Systematic Risk Council, 2014). Therefore, the Systemic Risk Council decided to monitor systemic risk by controlling credit growth and leverage. According to our results, this makes sense, since capitalization is a key driver of both individual and systematic risk, while the share of loans in total assets decreases systemic risk. Leverage has an interaction effect with bank size and thus intensifies systemic risk in bigger banks. Tier 1 capital ratio is also one of the key indicators used in assessing the banks' systemic risk, even though in our case it only proved to be significant for explaining individual and systematic risks.

The Council further concentrates on excessive maturity mismatches and market illiquidity, which involves monitoring the continuous funding requirement of the sector and its composition and the financing provided by the capital markets. One indicator used for that is the customer funding surplus, "*the difference between banking sector deposits and loans vis-à-vis counterparties that are not monetary financial institutions*" (The Systemic Risk Council, 2014). To some extend in our analysis, the results on the fraction of funding of assets from deposits show this variable's contribution to reduce all types of risk. Thus, there is a need for monitoring the funding structure of the financial system.

The Systemic Risk Council considers that some of the banks are too large and complex so that these characteristics may increase systemic risk and its consequences when they are in distress. Thus, the Council monitors the business model of the Systemically Important Financial Institutions, the largest banks in Denmark (The Systemic Risk Council, 2014). However, they acknowledge that other large institutions could also become more vulnerable with size and organizational complexity, which suggests that not only the SIFIs should be considered.

They further monitor whether the banks are involved in more risky lending activities, have higher capital leverage or a more risky funding structure. In this case, banks are also required to meet specific capital requirements to strengthen their positions against any possibility of financial distress (The Systemic Risk Council, 2014).

Our results reveal that an increase in bank size intensifies systematic and systemic risks. Thus, it is crucial to consider bank size in the regulation of the financial system. In addition to that, large banks with unstable funding structure need to be specially observed by the regulator. The Systemic Risk Council targets the interconnection among banks, which is considered an important factor in controlling systemic risk. Our results did not consider this interaction effect, even though other studies such as the one from Elsinger et al. (2012) confirm it.

In summary, the Danish regulation generally controls systemic risk taking into consideration the measures expressed by the independent variables used in this article. Thus, our findings can be seen as a support for the implementation of the so-called countercyclical capital buffer introduced by Basel III and measurements the European Systemic Risk Board is working on in the capital requirements directives.

However so far, the key indicators used by the Systemic Risk Council do not include the monitoring of market-based activities, which according to our analysis constitute one of the key variables that define systemic risk (share of loans in total assets). The regulation of market-based activities in order to contain systemic risk can be very fruitful to our results. This micro-prudential policy could, however, increase individual risk. This trade-off has to be considered in Denmark and comparable cases.[11]

7. Conclusion

Embedded in the context of the financial crisis in a highly concentrated Danish banking sector and on the systemic risk debates, this paper examines the contributions of bank size, capitalization, funding structure, market activities and organizational complexity to individual, systematic and systemic risks.

By analyzing the bank's stock returns, beta factors and SRISK as well as LMRES, as measurements of individual, systematic and systemic risks respectively, our results reveal that:

(1) Banks with more unstable funding showed higher individual risk during the shock periods that followed the financial crisis. The contrary was observed for capitalized banks and for those involved with market-based activities.

(2) The size of banks does not affect their individual stock performance during the crisis, but increase their systematic and systemic risks. Tier 1 capital smooths the size effects on systematic risk. The same is valid for the share of deposits in assets in both systematic and systemic risks. Besides, leverage increases the effect of size in systemic risk while the opposite is valid for the relation between loans and total assets.

(3) The degree of market-based activities (measured by non-interest income) increases stock performance during the crisis, acting as a stabilization in terms of individual risk. However, the degree of market-based activities (measured by a decrease of the loans-to-assets-ratio) increases systemic risk. Thus, an increase in the level of market-based activities has a destabilization effect on systematic and systemic risks. For the regulator, this may be seen as a trade-off between controlling the individual and systemic risks. If the idea of the regulator is to secure macroeconomic stability, we should expect that the degree of market-based activities should be controlled at the expense of reducing effects on individual risk.

These results are consistent with the methods used for monitoring systemic risk carried out by the Systemic Risk Council in Denmark, with the purpose of detecting the build-up of potential systemic threats and consequently support the policy of countercyclical capital buffer.

The Council focuses on bank's lending growth, leverage, capitalization, funding structure, size and organizational complexity when assessing systemic risk. However, the market-based activities are not included as one of their key indicators monitored.

Considering the magnitude of the effect of bank size and of market-based activities on systemic risk, it is crucial to acknowledge the shift towards a higher involvement in market-based activities as a potential threat to the financial system.

[11] It has to be mentioned, of course, that we use two different manifest variables for the latent variable market-based activities, these are non-interest income and the loans-to-assets-ratio. Whereas non-interest income is significant in the case of individual risk, the loans-to-asset-ratio is significant with respect to systemic risk.

Therefore, the regulator should also take into consideration measures of market-based activities in order to limit the risk they may pose to the entire system.

APPENDIX

Table A1 Sampled Banks

Reg nr.	*Bank Name*	*Market Share (%)*
3000	Danske Bank A/S	56.60%
2222	Nordea Bank Danmark A/S	14.53%
7858	Jyske Bank A/S	7.86%
8079	Sydbank A/S	3.80%
9380	Spar Nord Bank A/S	1.98%
7730	Vestjysk Bank A/S	0.54%
7670	Ringkjøbing Landbobank, Aktieselskab	0.53%
7681	Alm. Brand Bank A/S	0.36%
9217	Jutlander Bank	0.35%
400	Lån og Spar Bank A/S	0.34%
8099	Nordjyske Bank A/S	0.22%
7320	Djurslands Bank A/S	0.17%
844	Fynske Bank A/S	0.14%
7780	Skjern Bank, Aktieselskabet	0.13%
7230	Østjydsk Bank A/S	0.11%
6520	Lollands Bank, Aktieselskab	0.07%
7890	Salling Bank A/S	0.07%
7930	Kreditbanken A/S	0.06%
6880	Totalbanken A/S	0.06%
6860	Nordfyns Bank Aktieselskabet	0.06%
6140	Møns Bank, A/S	0.05%
		88.03%

Source: The Danish Financial Supervisory Authority. The market share was calculated using the data reported on 31st of December, 2014, and was computed as the share of each bank's assets in total assets of the entire banking sector.

Table A2 Descriptive Statistics of Sampled Banks

Variable Name	*Mean Value*	*Standard Deviation*	*Minimum Value*	*Maximum Value*
Total Assets (DKK)	174931800000	529436700000	1276555000	2678868000000
Log of Total Assets	23.38	2.04	20.97	28.62
Tier 1 Capital Ratio (%)	13.22	4.22	4.50	22.80
Deposits/Assets (%)	60.61	14.31	28.60	84.40
Loans/Assets (%)	63.35	9.90	37.80	78.70
Non-interest Income share in Total Income (%)	22.50	5.18	12.80	34.10
Leverage ratio	12.29	5.60	5.02	26.79
Stock Price (DKK)	301.39	493.99	8.06	3244.07
Stock Return (decimals)	-0.27	0.30	-0.84	0.36
Beta	0.75	0.69	-0.36	2.55
Restricted Sample for Systemic Risk				
SRISK	6106.00	10937.00	-470.00	31542.00
Log of Total Assets	25.71	1.76	23.57	28.50
Leverage ratio	15.8	4.34	7.89	22.53
Non-interest Income share in Total Income (%)	22.3	5.43	12.81	29.48
Loans/Assets (%)	55.6	13.06	37.79	77.19
Deposits/Assets (%)	47.6	11.66	28.60	72.68
Tier 1 Capital Ratio (%)	13.9	3.7	8.33	20.9

Sources: The Danish Financial Supervisory Authority Statistics, Yahoo Finance Historical Prices, Bloomberg.

Table A3 Correlation Matrix for Variables used in Individual and Systematic Risk Models

	Log Assets	*Tier 1 Ratio*	*Deposits/Assets*	*Loans/Assets*	*Non-interest income / Total Income*	*Leverage*
Log Assets (size)	*****					
Tier 1 Ratio (capitalization structure)	-0.26	*****				
Deposits/Assets (funding structure)	-0.78	0.39	*****			
Loans/Assets (degree of market-based activities)	-0.71	-0.02	0.55	*****		
Non-interest income / Total Income (degree of market-based activities)	0.00	0.18	0.21	-0.30	*****	
Leverage (capitalization structure)	0.83	-0.57	-0.68	-0.57	-0.08	*****

Source: Complete data series for 21 Danish banks

Table A4 Correlation Matrix for Variables used in Systemic Risk Models

	Log Assets	*Tier 1 Ratio*	*Deposits/Assets*	*Loans/Assets*	*Non-interest income / Total Income*	*Leverage*
Log Assets (size)	*****					
Tier 1 Ratio (capitalization structure)	0.02	*****				
Deposits/Assets (funding structure)	-0.88	0.16	*****			
Loans/Assets (degree of market-based activities)	-0.96	-0.08	0.82	*****		
Non-interest income / Total Income (degree of market-based activities)	0.16	0.28	-0.06	-0.33	*****	
Leverage	0.92	-0.32	-0.86	-0.883	0.04	*****

Source: Systemic Risk Data available only for five banks.

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