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* Views expressed are those of the authors and do not necessarily reflect official positions of De Nederlandsche Bank.

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Bank-based versus market-based financing: Implications for systemic risk*

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Abstract

Against the background of the great financial crisis, this paper assesses the merits of bank-based versus market-based financing by exploring the relationship between financial structure and systemic risk. The findings indicate that bank-based financial structures are associated with higher systemic risk than market-based financial structures. In relatively bank-based financial structures, bank financing is found to increase systemic risk while market financing decreases systemic risk. By contrast, in relatively market-based financial structures, bank and market financing do not impact systemic risk. Together, the results signal that market-based financial structures are more resilient to systemic risk.

Keywords: financial structure, systemic risk, bank financing, market financing

JEL classifications: E44, G10, G21, O16

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1. Introduction

Bank-based and market-based financial structures mobilize savings, price risks, allocate capital and absorb shocks in different ways. Banks conduct financial intermediation and bear risks on their own balance sheet, generally on the basis of close relationships with their clients. By contrast, markets channel resources directly from savers to borrowers, serving as platforms where equity and debt securities are priced, distributed and traded.

In light of these differences, there is a long-standing debate on the real economic merits of bank-based versus market-based financial structures. The results have changed over time. The literature published before 2008 does not favor one particular financial structure over the other. Instead, these studies find that the degree of financial development and liberalization matters for the real economy (Demirgüç-Kunt and Levine, 2001c, Levine, 2002, Beck and Levine, 2002, Demirgüç-Kunt and Maksimovic, 2002, Bekaert et al. 2005) and that bank and market financing are similarly important for economic growth (Levine and Zervos, 1998, Boyd and Smith, 1998, World Bank, 2001, Beck and Levine, 2004). However, the literature published after the great financial crisis of 2008 generally prefers market-based systems. This is because a financial crisis is economically more severe in bank-based than in market-based financial structures (Gambacorta et al. 2014). Banks overextend and misallocate credit in financial upturns and ration credit in financial downturns more than markets (Pagano et al. 2015). Housing market crises may have a particularly large impact in bank-based systems, as evidenced by the European banking crisis (Langfield and Pagano, 2016). When the value of assets that banks use as collateral drops, banks may deleverage their balance sheet and implement more conservative lending approaches. This reduces bank financing.

The real economic benefits of a financial structure thus depend on the stability of the financial system, which can be disrupted by systemic risk. Systemic risk may be defined as a disruption to the flow of financial services that is (i) caused by an impairment of all or parts of the financial system; and (ii) has the potential to have serious negative consequences for the real economy (BIS, FSB and IMF, 2009). As banks conduct financial intermediation on their own balance sheets, bank financing can contribute to systemic risk for a number of reasons. First, banks are highly leveraged. When times are good – that is, when asset values are rising – leveraged institutions can extract higher returns on their equity. However, when times are bad – that is, when asset values are falling – these institutions may be required to raise capital, shrink their balance sheet or de-risk in order to meet regulatory requirements.[1] The latter may involve scaling back on higher risk exposures, such as credit to corporates and mortgages, and shifting to higher rated securitized assets (see for example Bidder et al. 2018). In a system of leveraged banks, excessive credit growth can lead to banking crises (Bonfiglioli, 2008, Bekaert et al. 2011, Jorda et al. 2011) as fire sales amplify downturns (Adrian and Shin, 2014).[2] Also, while higher bank leverage induces stronger creditor discipline, systemic risk rises on account of contagious bank runs prompted by creditors liquidating their claims (Acharya and Thakor, 2016). Second, the large asset-liability mismatches of banks' balance sheets can make them vulnerable to liquidity and interest rate shocks, and in the extreme to bank runs. This contributes to systemic risk. Third, banks trade with each other through many markets, intermediaries and payments and settlement systems. This creates long intermediation chains, adds complexity and leads banks to be highly interconnected (Craig and von Peter, 2014).[3] Interconnectedness is a key driver of systemic importance (Drehmann and Tarashev, 2013). Due to settlement, liquidity and funding risk, this interconnectedness can propagate losses through the financial system, as losses for one bank may cause losses for another. Fourth, banks are systemic as some of their services are essential to the real economy, but are not readily substitutable. This applies to the critical economic infrastructure provided by banks, notably payment and settlement systems.

By contrast, market financing may contribute less to systemic risk, since markets serve as platforms, directly channeling financial resources between savers and borrowers, rather than intermediating on separate balance sheets. Markets are thus less dependent on highly leveraged institutions for the financial intermediation process, have more asset-liability matching, are financially less interconnected and not directly linked to the payments infrastructure. Markets can also function as

[1] The failure of the UK bank Northern Rock is an example of how sudden de-risking in credit markets can create problems at highly leveraged banks (Shin, 2009).
[2] High credit growth prior to banking crises may also be associated with strong subsequent growth in non-performing loans. This was the case for example in Cyprus (Brown et al. 2018).
[3] The Financial Stability Board (FSB) identifies systemically important banks using an indicator-based measurement approach calibrated on the size, interconnectedness, substitutability, cross-border activity and complexity of banks (BCBS, 2013).

an alternative source of financing when bank financing is disrupted (Crouzet, 2018). To the extent market financing substitutes for bank credit when bank financing tightens, disruptions to the flow of financial services may be smaller and the default probability of the banking system may be lower. This reduces systemic risk. In this context, studies find that firms substituted corporate bonds for bank loans during the financial crisis of 2008 in the United States, a relatively market-based financial structure (Adrian et al. 2012, Becker and Ivashina, 2014). However, when financing is dominated by banks, borrowers may be dependent on bank lending and markets have less room to develop and function as a 'spare tire' in the financial intermediation process (Greenspan, 1999). By implication, systemic financial crises may be more severe in relatively bank-based financial structures. In fact, during banking crises, bank-dependent firms undergo larger valuation losses and higher declines in profitability than firms that have access to public-debt markets (Chava and Purnanandam, 2011).

Figure 1 shows that differences in countries' financial structure correspond to differences in the short-term dynamics of a banking system's probability of default. During the crisis (indicated by the shaded area), the banking system's default probability increased only little in the United States, which has a relatively market-based financing system, while it increased substantially in Germany and Japan, which have relatively bank-based financial systems.[4] The default probability of the Japanese banking system also rose during the dot-com bubble in early 2000. These developments suggest that differences in financial structure across countries may help to explain differences in the stability of financial systems.

[4] The level of the reciprocal of the banking system's Z-score differs between countries because it is based on individual institutions' accounting data (Čihák et al. 2012) and national accounting principles differ worldwide (see also Section 2). To highlight changes rather than levels, Z-scores have been indexed.

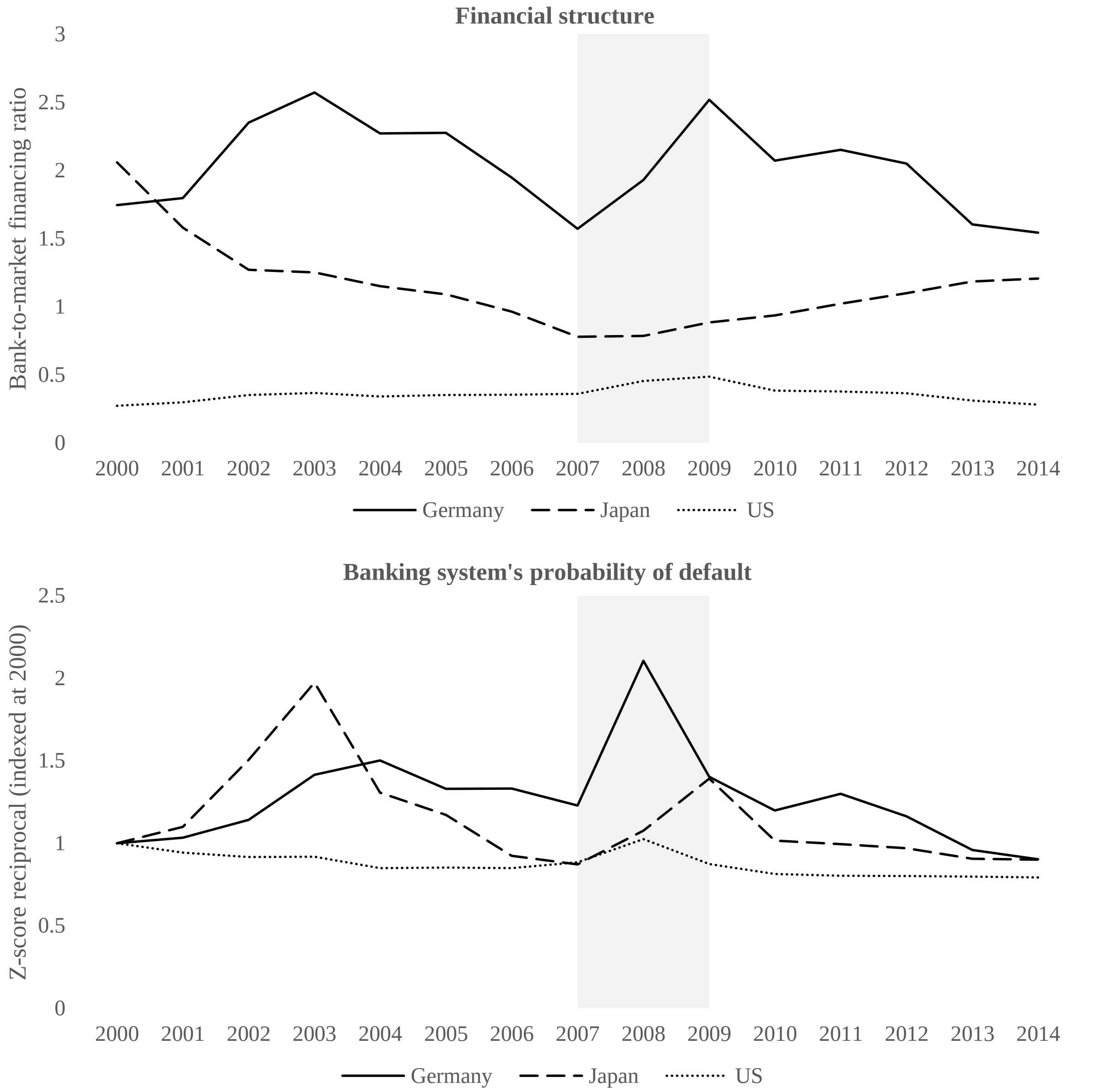

Figure 1: Banking systems default probability in bank- and market-based financial structures

Notes: This figure shows two time-plots of respectively a country's financial structural and the default probability of its banking system. Financial structure is represented by the ratio of a country's bank credit over the sum of non-financial sector debt and stock market capitalization. The banking system's probability of default is measured by the reciprocal of the Z-score of a country's banking system, indexed at 2000. The shaded area presents the global financial crisis. The data are from the World Bank's Global Financial Development Database (GFDD; July 2018 version).

The goal of this paper is to empirically explore the relationship between financial structure and systemic risk. The novelty of this study is not to test the impact of financial structure on economic growth; the existing empirical literature has already investigated this for business cycles with or without a financial crisis (e.g. Gambacorta et al. 2014). Instead, this study seeks to explain the recent changes in the results of the empirical literature by specifically determining the relationship between financial structure and systemic risk. Two hypotheses are tested. The first hypothesis is that bank-based financial structures are associated with higher systemic risk than market-based financial structures. The second hypothesis is that bank and market financing no longer relate to systemic risk when the financial structure is primarily market-based. The hypotheses are based on the relative contribution of bank financing to systemic risk, the 'spare tire' view of market financing and the potential impact of financial structure on the default probability of the banking system.

Linear, cubic and threshold regression models are estimated for a panel of 22 OECD countries over the period from 2000 to 2014. All estimations control for unobserved country and time fixed effects. In a separate robustness check, time fixed effects are substituted with country*time interacted fixed effects for European countries that experienced sovereign debt stress. The financial structure indicator distinguishes between the degree of bank, debt market and stock market financing. The systemic risk indicator follows the approach proposed by Acharya et al. (2012), Acharya et al. (2017) and Brownlees and Engle (2017). This indicator measures the nominal amount of the expected equity capital shortfall of a stock-listed financial institution in case of a financial crisis. Two other systemic risk indicators are used in separate robustness checks. As an additional robustness check, generalized method-of-moments (GMM) panel estimations are employed to address potential endogeneity of the explanatory variables.

The results lead to four key conclusions. First, financial structure relates to systemic risk. Bank-based financial structures are associated with higher systemic risk than market-based financial structures. Systemic risk rises more than proportionally when bank financing rises relative to market financing. Second, the relationship between financial structure and sytemic risk is non-linear. Systemic risk is minimized when the financial structure is relatively market-based. Third, bank financing no longer contributes to systemic risk in relatively market-based financial structures. A diversified financial structure is thus found to be important. Fourth, from a systemic risk perspective, stock market financing is preferable to debt market financing. This reflects the contribution of equity's loss-absorbing capacity to reducing systemic risk. These findings deserve consideration when designing public policies that impact financial structure.

The rest of this paper is organized as follows. Sections 2 and 3 present the methodology and the data. The empirical results are discussed in section 4. Section 5 concludes.

2. Methodology

The methodology is based on several econometric techniques. Linear fixed effects regressions estimate the linear effect of financial structure on systemic risk controlling for unobserved country- and time-specific effects. As a robustness check, GMM panel estimations address potential endogeneity of the explanatory variables. Cubic and threshold fixed effects regressions determine whether the relationship between financial structure and systemic risk is non-linear.

2.1 Linear estimations

The baseline regressions draw on the linear relationship between financial structure and systemic risk:

$$SRISK_{i,t} = \beta F_{i,t} + \gamma' X_{i,t} + u_i + \eta_t + \varepsilon_{i,t} \tag{1}$$

$$\ln SRISK_{i,t} = \beta \ln F_{i,t} + \gamma' X_{i,t} + u_i + \eta_t + \varepsilon_{i,t} \tag{2}$$

where $SRISK_{i,t}$ is the systemic risk measure, $F_{i,t}$ is the financial structure measure, $X_{i,t}$ comprises two control variables, u_i and η_t are country and time fixed effects respectively, $\varepsilon_{i,t}$ is the error term and the subscripts *i* and *t* represent the country and time period respectively. While model (1) is a regression in levels, model (2) evaluates elasticity by including the dependent variable and the explanatory variable of interest in logs. The country and time fixed effects take account of differences between countries and over time, in aspects such as financial, economic and corporate structure, speed of bank recapitalization, and the financial crisis. In a separate robustness check, time fixed effects are substituted with country*time interacted fixed effects for the GIIPS countries (i.e. Greece, Ireland, Italy, Portugal and Spain) to control for time-varying sovereign debt stress, which can lead to banking fragility (Acharya et al. 2014, Acharya and Steffen, 2015, Cooper and Nikolov, 2018).[5]

[5] Sovereign debt stress was particularly acute in Greece (see Alexakis et al. 2018).

The systemic risk measure follows the approach proposed by Acharya et al. (2012), Acharya et al. (2017) and Brownlees and Engle (2017). It measures the nominal amount of the expected equity capital shortfall of a stock-listed financial institution fin in country i at time t in case of a 40% broad stock market index decline during a 6 month time period ($CS_{fin,i,t+6\ months|t}$). The extreme scenario of a 40% broad stock market index decline is justified by the findings of Acharya et al. (2017). They show that the mean and median stock return of US financial institutions was respectively equal to -47% and -46% during the global financial crisis. The details are shown in Appendix A.

To aggregate the data and to calculate the extent to which the financial system as a whole is undercapitalized, the sum of the nominal amount of all institutions' equity capital shortfall within a country is divided by the sum of the nominal amount of all institutions' assets within a country per year:

$$SRISK_{i,t} = \frac{\sum_{fin} CS_{fin,i,t+6\ months|t}}{\sum_{fin} A_{fin,i,t}} \tag{3}$$

where $SRISK_{i,t}$ is the measure of systemic risk. This ensures that the results are not affected by the relative size of individual banks and allows countries' systemic risk values to be compared with each other. Furthermore, following Acharya et al. (2017), negative capital shortfall values are set at zero before aggregation, since these values do not reduce systemic risk. This is because in times of financial stress, a capital surplus in one institution cannot effectively compensate a capital shortfall in another.

For this study, the capital requirement for European financial institutions is set at 5.5% and for American financial institutions at 8%. These are comparable requirements due to differences in accounting principles between the institutions from which the data are obtained: European institutions follow the International Financial Reporting Standards (IFRS) and report derivatives on a gross basis; American institutions follow the Generally Accepted Accounting Principles (GAAP) and report derivatives on a net basis. Estimates by Engle et al. (2015) suggest that the total assets of large American institutions would be 40-60% larger under IFRS than under GAAP. If the capital requirement for European institutions were set higher than 5.5%, these institutions would have to raise relatively more capital than American firms, therefore favoring the latter.

Using $SRISK_{i,t}$ as a measure of systemic risk has several advantages. First, the calculation of $SRISK_{i,t}$ captures key dimensions considered relevant for systemic risk, such as an institution's interconnectedness and leverage. Second, $SRISK_{i,t}$ is a forward-looking measure as it indicates the degree of systemic risk that has not yet materialized, but can lead to economic losses in case of a severe financial market downturn. In this context, Brownlees and Engle (2017) show that $SRISK_{i,t}$ forecasts a significant fall in industrial production. Third, $SRISK_{i,t}$ is widely used in the literature, which allows for a comparison between the results of this and other studies.

However, $SRISK_{i,t}$ also has caveats. First, $SRISK_{i,t}$ only includes a subset of a country's financial institutions, since the equity capital shortfall can only be calculated for institutions that are publicly listed and report equity market returns. Nonetheless, this may be considered a representative subset in terms of a country's financial structure, as these are generally institutions that conduct a substantial share of the financing to the real economy (for instance, SME's are largely dependent on these institutions for their financing). Relative to the banking system of all countries in the sample, the ratio of $SRISK_{i,t}$ institutions' total assets equals 155%. Finland constitutes the lower bound, where this ratio equals 45% relative to the Finnish banking system. For the US, the ratio equals 194% relative to the banking system and 50% relative to the aggregate of the banking and non-banking system (World Bank data on nonbanks' assets are only provided for a few countries). Second, most of the financial institutions included in the calculation of $SRISK_{i,t}$ are banks. However, for the more market-based financial structures, a substantial share of the $SRISK_{i,t}$ institutions relates to non-banks. For example in the US, the share of non-banks is more than half the total, also comprising insurance, investment and brokerage companies. Third, the capital requirement for banks may be different from the capital requirement for non-banks. For example, a difference between the risk density of banks and insurers may require a different capital requirement threshold. The capital requirements may in fact also vary between banks and over time, since risk densities are not necessarily linear and regulatory requirements are to a certain extent tailor-made. Given these complications, this paper uses one constant capital requirement for all financial institutions, fixed over time, recognizing that this is an approximation.

In view of the caveats of the $SRISK_{i,t}$ measure, this paper investigates two other systemic risk measures in separate robustness checks.[6] The first measure is $CISS_{i,t}$, a composite indicator of systemic stress in the financial system (Holló et al. 2012). In contrast to $SRISK_{i,t}$, the calculation of $CISS_{i,t}$ is not economically modelled across institutions, but takes a portfolio theory approach, emphasizing developments in systemic stress over time. It aggregates market-specific sub-indices based on 15 individual financial stress measures. These sub-indices are all relevant for systemic stress and involve money, equity, bond and foreign exchange markets. In effect, this measure is backward-looking, signaling systemic stress that has already materialized. It should be noted that this composite indicator of systemic stress has only been developed for a limited set of European countries in the sample. Therefore, $CISS_{i,t}$ only allows a limited comparison of the differences between bank- and market-based financial structures.

The third measure of systemic risk is a firm's marginal expected shortfall, $MES_{i,t}$, and follows the approach proposed by Acharya et al. (2017). This indicator represents the equal-weighted average of firms' expected fractional losses conditional on a systemic event, i.e. when the market portfolio declines by more than 2% in a day. $MES_{i,t}$ is different from $SRISK_{i,t}$, since the systemic event is short-term and lasts only one day, instead of six months. Moreover, $MES_{i,t}$ does not take an institution's leverage into account. The correlations of $MES_{i,t}$ and $CISS_{i,t}$ with $SRISK_{i,t}$ are 54% and 48%, respectively.

The financial structure measure is based on three financing indicators that are commonly used in the literature. It is defined as the ratio of bank credit over the sum of non-financial sector debt and stock market capitalization:

$$F_{i,t} = B_{i,t}/\left(DM_{i,t} + SM_{i,t}\right) \qquad (4)$$

where $B_{i,t}$ is the degree of bank-based financing, defined in terms of bank credit to the private sector as a ratio of GDP, $DM_{i,t}$ signals the degree of debt market financing (such as bonds, notes, and debentures)

[6] For an overview of 19 different measures of systemic risk, see Giglio et al. (2016).

and is defined as the ratio of total non-financial sector debt market capitalization to GDP, $SM_{i,t}$ reflects the degree of stock market financing and is defined as the ratio of stock market capitalization to GDP.[7] The higher this bank-to-market financing ratio, the more a financial system is bank-dependent; the lower this ratio, the more a financial system is market-dependent.

Bank credit and non-financial debt market capitalization are debt financing indicators whereas stock market capitalization is an equity financing indicator. The bank credit indicator includes all non-contingent claims of depository institutions on the private sector, such as loans and trade credits, and excludes interbank and derivative commitments. The indicator is thus primarily driven by real economic activity rather than financial sector exposures. This is because our hypotheses focus on how different ways of financing the real economy influence systemic risk. The debt indicator excludes financial sector debt to avoid double-counting: banks that extend credit may finance themselves via debt securities.[8]

The regressions include two control variables. The first control is for the relative size of banks (measured by the share of the three largest commercial banks in total commercial bank assets). Since relatively large banks tend to be less substitutable, more interconnected and more complex, they represent more systemic risk and are more likely to receive public support, thereby also inducing moral hazard (Afonso et al. 2014, Laeven et al. 2014 and Langfield et al. 2014). The second control is for the ratio of banks' noninterest income to total income. Banks' noninterest income mainly stems from capital market activities such as investment banking, trading and securitization that are not captured in real bank credit. This relates to the finding by Brunnermeier et al. (2012) that banks with higher non-interest income contribute more to systemic risk.

[7] An alternative to stock market capitalization is the stock market turnover ratio. However, in contrast to the other financial structure indicators, the turnover ratio is a *flow* measure, which does not facilitate a robust comparison with the other financial structure indicators, which are all *stock* measures.

[8] In our model, using total debt market capitalization produces spurious results for the impact of market-based debt financing on systemic risk.

2.2 GMM panel estimations

Both the calculation of the financial structure indicator and the systemic risk measure are based on stock market values. Moreover, systemic risk may have reverse effects on the relative size of banks and on the ratio of their noninterest income to total income. A simultaneity bias can therefore arise when the dependent and explanatory variables are jointly determined. To address this issue, two-step fixed effects (within group) GMM panel estimations are carried out using model (1) in a separate robustness check. The estimations are based on Arellano (2003).

The fixed effects GMM estimator is a generalization of the fixed effects instrumental variables (IV) estimator. The more general GMM estimator starts from the population moment conditions that the instruments are exogenous:

$$E(Z'\varepsilon) = 0 \tag{5}$$

where Z is a vector of instrumental variables. The third and fourth lag of the financial structure indicator and the control variables are included as instruments, also referred to as internal instruments. The internal instruments exclude shorter lags, since these may still be correlated with current observations of system risk; the financial crisis, which strongly affected the stock market, lasted several years. Longer lags are excluded to prevent a finite sample bias by an overfitting of instruments in a relatively small sample size. Shorter and longer lags are included in separate robustness checks. The additional moment conditions are:

$$E\left(F_{i,t-s}\varepsilon_{i,t}\right) = 0 \qquad \text{for } 3 \leq s \leq 4 \tag{6}$$

$$E\left(X'_{i,t-s}\varepsilon_{i,t}\right) = 0 \qquad \text{for } 3 \leq s \leq 4 \tag{7}$$

In order to obtain heteroscedasticity-consistent estimations, the weighting matrix uses White GMM weights. The Sargan test of over-identifying restrictions examines the validity of all instruments in the regression.

2.3 Non-linear estimations

It is questionable whether the relationship between financial structure and systemic risk is linear. When borrowers are less dependent on banks, market financing can more readily act as an alternative source of financing if bank financing is constrained. Therefore, the effects of a different financial structure on systemic risk may depend on the degree of bank financing in that financial structure. To find out whether the relationship between financial structure and systemic risk is non-linear, the baseline regression is transformed into a cubic model:

$$SRISK_{i,t} = \beta F_{i,t} + \zeta F_{i,t}^2 + \xi F_{i,t}^3 + \gamma' X_{i,t} + u_i + \eta_t + \varepsilon_{i,t} \quad (8)$$

Furthermore, a threshold model is constructed following Hansen (1999) that analyzes whether the separate effects of the bank and market financing indicators on systemic risk change according to the composition of the financial structure. Bank and market financing may no longer relate to systemic risk when this structure is primarily market-based, given that bank financing contributes to systemic risk and market financing provides 'spare tire' insurance. To establish a threshold (λ) around the financial structure measure, model (9) detects a break between the financing indicators and systemic risk:

$$SRISK_{i,t} = \begin{cases} \beta_{1,1} B_{i,t} + \beta_{1,2} DM_{i,t} + \beta_{1,3} SM_{i,t} + \gamma_1' X_{i,t} + u_i + \eta_t + \varepsilon_{i,t}, \ F_{i,t} > \lambda \\ \beta_{2,1} B_{i,t} + \beta_{2,2} DM_{i,t} + \beta_{2,3} SM_{i,t} + \gamma_2' X_{i,t} + u_i + \eta_t + \varepsilon_{i,t}, \ F_{i,t} \leq \lambda \end{cases} \quad (9)$$

The slopes of $\beta_{1,1}$, $\beta_{1,2}$, $\beta_{1,3}$, γ_1' and $\beta_{2,1}$, $\beta_{2,2}$, $\beta_{2,3}$, γ_2' are estimated separately to show the effect below and above the estimated thresholds. The threshold level is found by estimating model (9) for a range of different threshold values of $F_{i,t}$, equal to the financial structure measure. The threshold value in the regression with the smallest sum of squared residuals is chosen.

Hansen's (1999) F-test is used to test the significance of all possible fixed threshold values λ.[9] The following constraints are tested:

[9] The estimation and significance tests of the **t**hreshold are conducted on data containing no missing values by interpolating the data as a function of time and do not incorporate fixed effects. However, the estimation of (9) includes country and time fixed effects and an interpolation of the data is not applied.

$$H_0 : \begin{cases} \beta_{1,1} = \beta_{2,1} \\ \beta_{1,2} = \beta_{2,2} \\ \beta_{1,3} = \beta_{2,3} \\ \gamma_1' = \gamma_2' \end{cases} \tag{10}$$

where under null hypothesis H_0 the threshold value λ is not identified. To compare the fit of the two models (a model where λ is identified and one where it is not), Hansen's (1996) bootstrap procedure is used to simulate the asymptotic distribution of the following likelihood ratio test of H_0 :

$$F_1 = (S_0 - S_1(\hat{\lambda}))/\hat{\sigma}^2 \tag{11}$$

where S_0 and $S_1(\hat{\lambda})$ denote the sum of squared errors under the null hypothesis of no threshold and the alternative hypothesis of a threshold respectively.[10]

3. Descriptive data

The analysis relies on four different data sources. Data for the systemic risk variable $SRISK_{i,t}$ and the alternative systemic risk variable $MES_{i,t}$ are provided by New York University (NYU) Stern's Volatility Laboratory.[11] Data for the alternative systemic risk variable $CISS_{i,t}$ are taken from the European Central Bank (ECB) Statistical Data Warehouse. Data for non-financial debt market capitalization to GDP are obtained from the Bank for International Settlements (BIS) debt securities statistics. Data for all other independent variables (bank credit to GDP, stock market capitalization to GDP, the concentration of a country's banking sector and banks' noninterest income to total income) are obtained from the World Bank's Global Financial Development Database (GFDD; July 2018 version).[12] As the $SRISK_{i,t}$ values start in 2000 and data for banks' noninterest income end in 2014, the panel covers the timespan from 2000 to 2014, with yearly observations for all variables. To distinguish between different financial structures, the main panel focuses on the following 22 OECD countries for which $SRISK_{i,t}$ data are available: Australia, Austria, Belgium, Canada, Denmark, Finland, France,

[10] The bootstrap procedure is repeated 5000 times. P-values constructed from the bootstrap are asymptotically valid. The percentage of draws for which the simulated F_1 value exceeds the actual value is calculated and the resulting value is the bootstrap estimate of the asymptotic p-value.

[11] The group of financial institutions including in the SRISK measure can be found on NYU Stern's Volatility Laboratory's website - https://vlab.stern.nyu.edu/welcome/risk.

[12] Data on the ratio of bank credit to GDP for Canada is obtained from the credit statistics of the BIS since the World Bank's Global Financial Development Database provides no bank credit data for Canada after 2008.

Germany, Greece, Ireland, Italy, Japan, Luxembourg, Netherlands, Norway, Poland, Portugal, Spain, Sweden, Turkey, the United Kingdom and the United States.

As the composite indicator for systemic stress $CISS_{i,t}$ has only been developed for a more limited set of European countries, this robustness check is based on 15 countries: Austria, Belgium, Denmark, Finland, France, Germany, Greece, Ireland, Italy, Netherlands, Poland, Portugal, Spain, Sweden and the United Kingdom. The marginal expected shortfall indicator contains relatively few observations for some countries in the sample. The robustness check on $MES_{i,t}$ is therefore based on 18 countries: Australia, Belgium, Canada, Denmark, Finland, France, Germany, Greece, Ireland, Italy, Japan, Netherlands, Norway, Poland, Spain, Sweden, the United Kingdom and the United States.

Table 1 gives a summary of the statistics and a listing of the data sources, including the indicator codes of the data from the GFDD. Table 1 shows that there are missing values for the independent variables. For non-financial debt market capitalization, missing values relate mostly to Ireland, Luxembourg, and Turkey. For stock market capitalization, the GFDD does not provide data for the last two years in Denmark, Finland, Sweden and the United Kingdom. Importantly, there are no missing gaps in the data series of countries. To see how the missing values impact the results, the regressions are also estimated on a complete panel dataset, where missing values of all independent variables are replaced with multiple sets of simulated values using multiple imputation. The imputation is repeated 20 times and involves 2000 iterations. Table 2 provides a correlation matrix.

To illustrate the difference in financial structures and systemic risk between countries and their evolution over time, Figure 2 presents time-plots for the ratio of bank credit to the sum of non-financial debt and stock market capitalization, the ratio of bank credit to GDP, the ratio of non-financial debt market capitalization to GDP and the ratio of stock market capitalization to GDP. The time-plots for the European average are based on the 16 European countries in the sample: Austria, Belgium, Denmark, Finland, France, Germany, Greece, Ireland, Italy, Luxembourg, Netherlands, Norway, Poland, Portugal, Spain and Sweden. The United Kingdom is treated separately. The shaded time-plots for the European bound present the minimum and maximum observations of the European countries with financial structures larger than 5% of the European total (these countries are France, Germany, Italy, Netherlands, Spain and Sweden). Table 1 and Figure 2 show that there is sufficient time variation in all financial structure indicator variables for all coefficients to be identified.

Table 1: Descriptive statistics

Variables	Data source	Unit of measurement	Obs	Mean	Std dev	Min	Max
Dependent variable							
Systemic risk	NYU Stern's V-lab	% of assets	330	1.8	1.6	0.0	5.6
Financial structure							
Bank credit	GFDD.DI.01	% of non-fin debt and stock market cap	297	145.8	102.1	20.7	749.5
Bank credit	GFDD.DI.01	% of GDP	330	94.1	38.6	12.2	211.9
Non-fin debt market cap	BIS	% of GDP	305	11.4	8.8	0.0	52.6
Stock market cap	GFDD.DM.01	% of GDP	322	73.0	40.2	13.8	247.2
Control variable							
Noninterest income	GFDD.EI.03	% of income	329	39.9	12.0	14.1	81.3
Concentration banks	GFDD.OI.01	% of assets	326	67.8	20.4	21.4	100.0

Notes: This table presents the descriptive statistics for all variables. The first variable represents the dependent variable systemic risk and reports the descriptive statistics for a country's systemic risk per unit of financial asset. The second, third, fourth and fifth variables are financial structure indicators for bank credit as a percentage of the sum of non-financial debt and stock market capitalization, bank credit as a percentage of GDP, non-financial debt market capitalization as a percentage of GDP and stock market capitalization as a percentage of GDP. The last two variables are control variables banks' noninterest income as a percentage of banks' total income and the total assets of the three largest commercial banks as a percentage of total commercial bank assets.

Table 2: Correlation matrix

Variables	Bank credit	Debt market cap	Stock market cap	Noninterest income	Concentration banks
Bank credit	1.000				
Non-fin debt market cap	0.038	1.000			
Stock market cap	0.052	0.510	1.000		
Noninterest income	-0.004	0.224	0.208	1.000	
Concentration banks	0.224	-0.318	-0.164	-0.038	1.000

Notes: This table presents the correlation matrix for all independent variables in the fixed effects and threshold regression models. The variables are: bank credit as a percentage of GDP, non-financial debt market capitalization as a percentage of GDP, stock market capitalization as a percentage of GDP, banks' noninterest income as a percentage of banks' total income and the total assets of the three largest commercial banks as a percentage of total commercial bank assets.

Figure 2.1 shows that the European financial structure is bank-based and that the American and Canadian financial structures are market-based. The other countries are in the middle. Figure 2.2 shows that the United Kingdom experienced a sharp rise in bank credit preceding the financial crisis and a sharp decline thereafter. This explains the evolution of the financial structure ratio for the United Kingdom in Figure 2.1. Bank credit to GDP is also high for the European maximum bound (Spain). It is lowest for Turkey and the United States. The European average is in the upper half. Figure 2.3 demonstrates that non-financial debt market capitalization to GDP is highest in the United States, Canada and the United Kingdom. It is lower in Europe and Turkey.

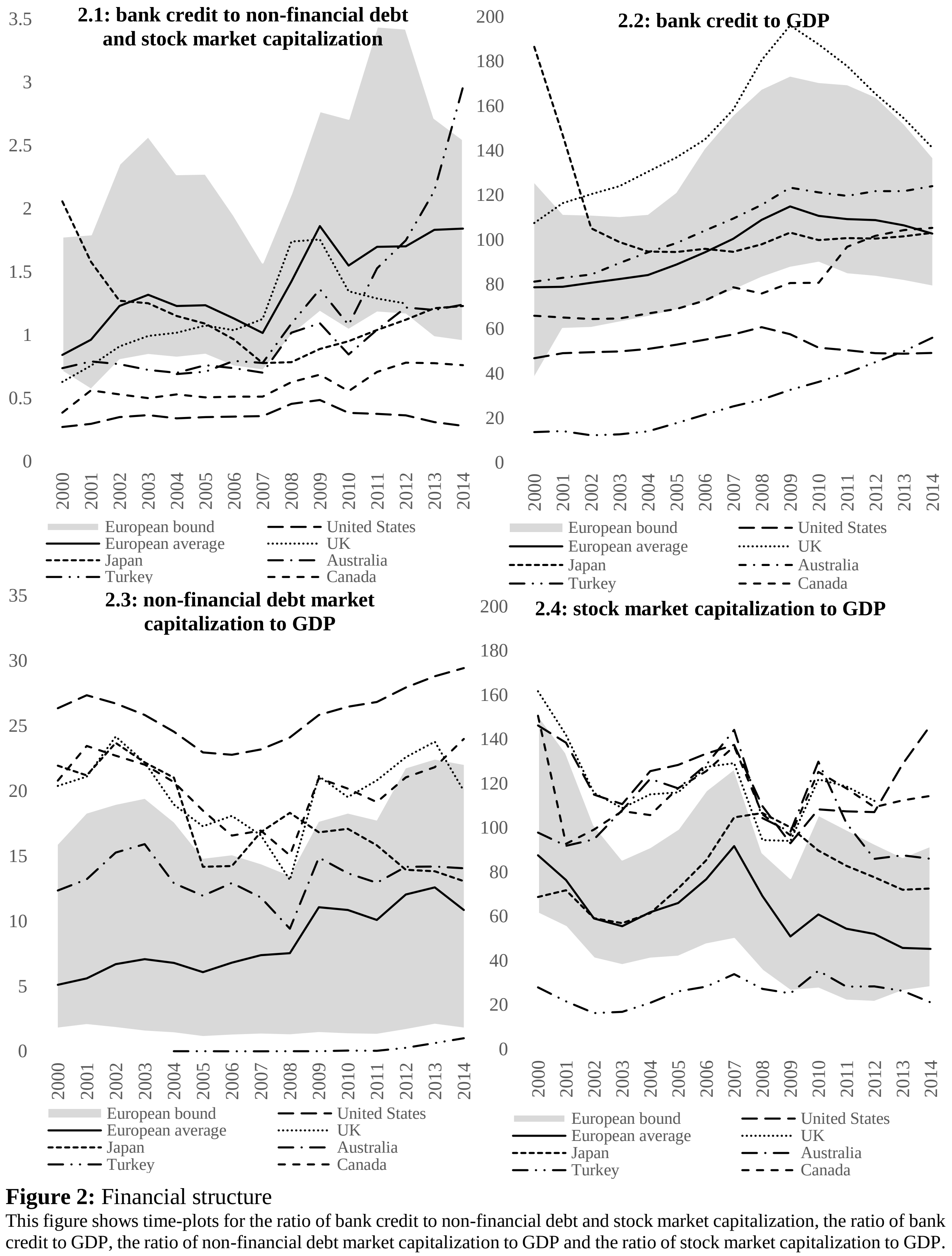

Figure 2: Financial structure

This figure shows time-plots for the ratio of bank credit to non-financial debt and stock market capitalization, the ratio of bank credit to GDP, the ratio of non-financial debt market capitalization to GDP and the ratio of stock market capitalization to GDP. The time-plots for the European average are based on the following 16 countries: Austria, Belgium, Denmark, Finland, France, Germany, Greece, Ireland, Italy, Luxembourg, Netherlands, Norway, Poland, Portugal, Spain and Sweden. The United Kingdom is plotted separately. The shaded area presents the minimum and maximum observations of the European countries with financial structures larger than 5% of the European total (France, Germany, Netherlands, Spain and Sweden).

During the crisis, non-financial debt financing increased substantially in almost all countries. This signals the importance of market-based debt financing in times of financial distress. Figure 2.4 shows that stock market capitalization to GDP is particularly low in Turkey, and to a lesser extent also in Europe. Stock market capitalization to GDP is highest in the United States, Canada and the United Kingdom. Figure 2 indicates that the composition of the financial structure is dependent on the degree of both bank and market financing. While the United States has a relatively high degree of market financing, and Europe a relatively high degree of bank financing, the United Kingdom has both.

Figure 3 presents a time-plot of systemic risk as a percentage of financial institutions' total assets. The data show that systemic risk rose in both bank-based and market-based financial structures during 2006-2008. After the financial crisis however, market-based economies, such as the United States, Australia, Canada, and to a lesser extent the United Kingdom, experienced a decrease in systemic risk. By contrast, systemic risk remained elevated for several years in Europe and Japan, which are relatively bank-based.

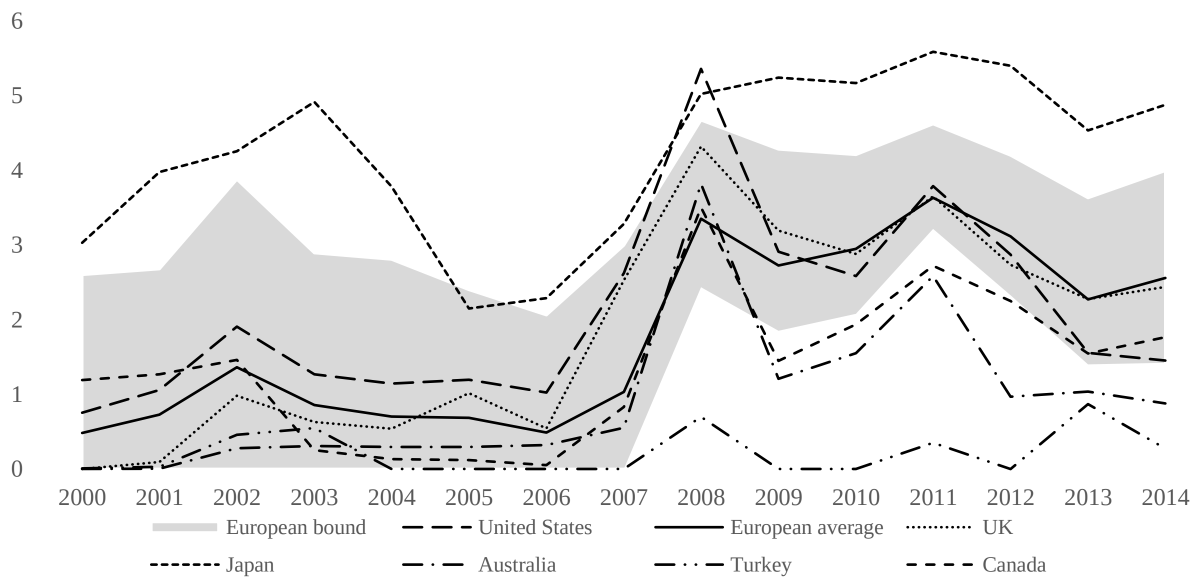

Figure 3: Systemic risk

Notes: This figure shows time-plots of a country's systemic risk as a percentage of its financial institutions' total assets. The time-plot for the European average is based on the following 16 countries: Austria, Belgium, Denmark, Finland, France, Germany, Greece, Ireland, Italy, Luxembourg, Netherlands, Norway, Poland, Portugal, Spain and Sweden. The United Kingdom is plotted separately. The shaded area presents the minimum and maximum observations of the European countries with financial structures larger than 5% of the European total (France, Germany, Italy, Netherlands, Spain and Sweden).

4. Results

This section presents the results of the linear and non-linear estimations.

4.1 Linear estimations

Table 3 presents the estimations for models (1) and (2). Country fixed effects are excluded in the first two columns. The table also reports the outcomes of multicollinearity tests. The severity of multicollinearity is measured via the variance inflation factor (VIF).[13] The VIF of the bank-to-market financing ratio equals 3.56 and 1.22 for model (1) and (2), respectively. Therefore, multicollinearity does not create major issues for the results. Additionally, Table 2 shows no strong correlations. All regressions include robust standard errors clustered at the country level.

The results indicate there is a relationship between financial structure and systemic risk. The bank-to-market financing ratio increases the systemic risk measure at the 1% significance level in all columns, indicating that bank-based financial structures are associated with higher systemic risk and market-based financial structures are associated with lower systemic risk.[14] The effect of the bank-to-market financing ratio on systemic risk remains statistically significant when the time fixed effects are substituted with country*time interacted fixed effects for Greece, Ireland, Italy, Portugal and Spain (available upon request). The results differ from those of Langfield and Pagano (2016), who find no significant effects of financial structure on systemic risk outside crisis dummies. Columns 1 and 2 show that excluding country fixed effects does not change the results. Columns 5 and 6 show that systemic risk increases more than proportionally when bank financing rises relative to market financing. Note that in case of $SRISK_{i,t}$, 44 observations equal zero; the log of these observations is undefined and they are thus excluded in columns 3 and 4. Regressing $SRISK_{i,t}$ (without taking the log) on the log of the bank-to-market ratio gives statistically similar results (available upon request).

Furthermore, including the concentration of the banking sector as an interaction with the financial structure indicator does not give significant results (available upon request). This suggests that

[13] Non-linear variables are excluded in the calculation of the VIF.
[14] Figure 2 shows that Australia, Japan and Turkey are outliers with respect to systemic risk, but they do not drive the results. Excluding these countries from the sample does not change the outcomes.

the relationship between financial structure and systemic risk is not dependent on the concentration of the banking sector. The regressions are also estimated on a complete panel dataset, using multiple imputation to replace missing values. Similar to Table 1, the bank-to-market financing ratio and bank credit are significantly associated with higher systemic risk (available upon request).

Table 3: The linear relationship between financial structure and systemic risk

	Dependent variable					
Regressors	SRISK	SRISK	SRISK	SRISK	SRISK (log)	SRISK (log)
Bank-to-market financing ratio	0.0055***	0.0057***	0.0058***	0.0061***		
	(0.0009)	(0.0008)	(0.0010)	(0.0009)		
Bank-to-market financing ratio (log)					1.1452***	1.1852***
					(0.2163)	(0.2191)
Banking sector concentration		-0.0034		-0.0010		0.0496
		(0.0087)		(0.0095)		(1.1742)
Banks' noninterest income		0.0058		0.0051		-0.6625
		(0.0093)		(0.0091)		(0.9468)
Country fixed effects	No	No	Yes	Yes	Yes	Yes
Time fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
R-sqr (within) [1]	0.750	0.750	0.750	0.794	0.439	0.442
N	297	293	297	293	251	249
Mean VIF [2]	1.28	2.76	1.28	2.76	1.03	2.96
Bank-to-market financing ratio VIF [3]	3.08	3.56	3.08	3.56	1.22	1.43

Notes: This table presents the fixed effects estimations for models (1) and (2). The dependent variable is systemic risk per unit of financial asset and the log of systemic risk per unit of financial asset. Robust standard errors clustered at the country level are given in parentheses. All columns control for time fixed effects. The last four columns also control for country fixed effects. In addition, columns 2, 4 and 6 control for banking sector concentration and banks' noninterest income to total income. Columns 1 to 4 show the linear effects of the bank-to-market financing ratio on systemic risk and columns 5 and 6 show the effects of the log of the bank-to-market financing ratio on the log of systemic risk. Significance levels: * p<0.1, ** p<0.05, *** p<0.01. [1] Regressing systemic risk on lagged regressors changes the R-squared and coefficients little, but excluding time fixed effects more than halves the R-squared. [2] Reports the mean variance inflation factor of all variables (including control variables and time dummies) to quantify the severity of multicollinearity. [3] Reports variance inflation factor of the bank-to-market financing ratio to quantify the severity of multicollinearity.

To check whether the exogenous component of financial structure is significantly associated with systemic risk, Table B.1 in Appendix B presents fixed effects GMM panel estimations for model (1). This paper uses a heteroscedasticity-consistent GMM estimator. The last row in Table B.1 reports the p-values from the Sargan test of over-identifying restrictions. The null hypothesis that the instruments are valid cannot be rejected in both columns. The regressions include White standard errors. The GMM estimations suggest that bank-based financial structures are associated with higher systemic risk and that market-based financial structures are associated with lower systemic risk. The bank-to-market financing ratio increases systemic risk at the 1% significant level. Including shorter or longer lags of the internal instruments produces statistically similar results (available upon request). The results validate the results of the fixed effects estimations in Table 3.

As an additional robustness check, the effect of the bank-to-market financing ratio is tested on two alternative indicators for systemic risk, the dependent variables $MES_{i,t}$ and $CISS_{i,t}$. Similar to Table 3, fixed effects estimations (Table B.2 in the Appendix) and fixed effects GMM estimations (Table B.3 in the Appendix) show that bank-based financial structures are associated with higher systemic risk and market-based financial structures are associated with lower systemic risk.[15]

4.2 Non-linear estimations

Table 4 presents the estimations for the non-linear model (8). The VIF outcomes are similar to Table 3, as non-linear variables are excluded in the calculation of the VIF. All regressions include robust standard errors clustered at the country level.

The results suggest that a cubic relationship exists between financial structure and systemic risk. Both the squared and cubic term of the financial structure measure are statistically significant at the 5% level when the control variables are excluded and at the 10% level (but close to 5%) when they are included. The signs of the slopes show that the relationship is concave. The relationship is more clearly illustrated in Figure 4, where the vertical axis represents the predicted value of the systemic risk measure and the horizontal axis indicates the financial structure measure.[16] The figure shows that, in terms of systemic risk, countries benefit from more bank financing to the extent that the ratio of bank credit to non-financial debt and stock market capitalization is below 1. Above 1, systemic risk rises. This is indicated by the vertical dotted line. This suggest that a threshold exists beyond which the effect of financial structure on systemic risk changes.

[15] The first two lags of the explanatory variables are included as instruments in the fixed effects GMM estimations.
[16] The financial structure measure is larger than 6 for three observations. These are excluded from Figure 4.

Table 4: The non-linear relationship between financial structure and systemic risk

	Dependent variable	
Regressors	SRISK	SRISK
Bank-to-market financing ratio	-0.0099	-0.0094
	(0.0075)	(0.0089)
Bank-to-market financing ratio (squared)	0.0051**	0.0051*
	(0.0023)	(0.0027)
Bank-to-market financing ratio (cubed)	-0.0004**	-0.0005*
	(0.0002)	(0.0002)
Banking sector concentration		-0.0040
		(0.0102)
Banks' noninterest income		0.0078
		(0.0089)
Country fixed effects	Yes	Yes
Time fixed effects	Yes	Yes
R-sqr (within) [1]	0.763	0.763
N	297	293
Mean VIF [2]	1.28	2.76
Bank-to-market financing ratio VIF [3]	3.08	3.56

Notes: This table presents the non-linear fixed effects estimations for model (8). The dependent variable is systemic risk per unit of financial asset. Robust standard errors clustered at the country level are given in parentheses. Both columns control for country and time fixed effects. Column 2 controls for banking sector concentration and banks' noninterest income to total income. Both columns show the linear, squared and cubed effects of the bank-to-market financing ratio on systemic risk. Significance levels: * p<0.1, ** p<0.05, *** p<0.01. [1] Regressing systemic risk on lagged regressors changes the R-squared and coefficients little, but excluding time fixed effects more than halves the R-squared. [2] Reports the variance inflation factor of all variables (including control variables and time dummies; excluding non-linear variables) to quantify the severity of multicollinearity. [3] Reports the variance inflation factor of the bank-to-market financing ratio to quantify the severity of multicollinearity.

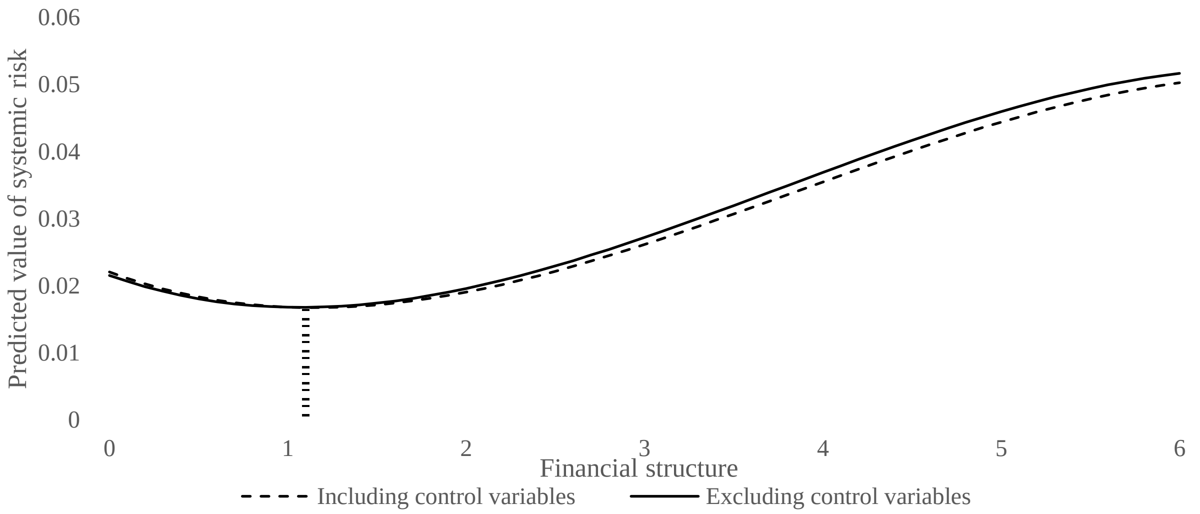

Figure 4: Non-linear relationship between financial structure and systemic risk

This figure shows the non-linear relationship between financial structure and the predicted value of systemic risk as estimated by model (8). The vertical axis represents the predicted value of systemic risk as a percentage of financial institutions' total assets. The horizontal axis is the ratio of bank credit to non-financial debt and stock market capitalization. The plotted lines reflect the cubic estimations in Table 4. The vertical line indicates that systemic risk is minimized when the ratio of bank credit to non-financial debt and stock market capitalization is slightly above 1.

To detect why a threshold exists around the financial structure measure, Table 5 shows the results for the structural break model (9). All regressions include robust standard errors clustered at the country level and control for country and time fixed effects. The null hypothesis of no threshold effect is rejected using Hansen's (1999) F-test and Hansen's (1996) bootstrap procedure with a p-value lower than 1 % for the threshold regression in column 1, which excludes the control variables. A break in the data is thereby detected. The null hypothesis of no threshold cannot be rejected for the threshold regression in column 2, which includes the control variables.

The slopes and constants are estimated separately for the bank-to-market financing ratio above and below/equal to its threshold value. Table 5 indicates that bank financing does not impact systemic risk when the bank-to-market financing ratio is below 122% and 137%, respectively. Thus, some bank financing may be seen as desirable, for instance to cater for small and medium-sized enterprises that face excessive costs when accessing market-based financing. When the bank-to-market financing ratio is above 122% and 137%, the relationship between bank financing and systemic risk turns positive and is statistically significant. In short, the positive association between bank financing and systemic risk is negligible when the financial structure is relatively market-based.

Financing via debt securities has no significant effect on systemic risk above the threshold value. Below the threshold value, debt market financing decreases systemic risk when the control variables are excluded. By contrast, stock market financing does not impact systemic risk below the threshold value. Above the threshold value, stock market financing reduces systemic risk, significant at the 1% level.[17] This suggests that, in financial structures with large banking systems, the potential contribution of market-based finance to lower systemic risk primarily stems from stock market finance.

[17] This beneficial impact of equity financing comes on top of its contribution to promoting innovation (Claessens, 2016).

Table 5: Financial structure and the effects of financing indicators on systemic risk

Regressors	Dependent variable SRISK	SRISK
Threshold (λ) [1]	1.2222	1.3708
$FINSTR_{i,t} > \lambda$		
Bank credit	0.0245***	0.0301***
	(0.0060)	(0.0056)
Non-financial debt market capitalization	-0.0269	-0.0111
	(0.0442)	(0.0386)
Stock market capitalization	-0.0492***	-0.0542***
	(0.0081)	(0.0086)
Banking sector concentration		-0.0035
		(0.0129)
Banks' noninterest income		0.0147
		(0.0151)
Country fixed effects	Yes	Yes
Time fixed effects	Yes	Yes
$FINSTR_{i,t} \leq \lambda$		
Bank credit	-0.0109	-0.0078
	(0.0125)	(0.0123)
Non-financial debt market capitalization	-0.0329**	0.0017
	(0.0136)	(0.0102)
Stock market capitalization	-0.0046	-0.0074
	(0.0035)	(0.0053)
Banking sector concentration		-0.0037
		(0.0098)
Banks' noninterest income		-0.0014
		(0.0059)
Country fixed effects	Yes	Yes
Time fixed effects	Yes	Yes
Bootstrap P-value [2]	0.00	0.29
N for $FINSTR_{i,t} > \lambda$	151	117
N for $FINSTR_{i,t} \leq \lambda$	163	176

Notes: This table presents the fixed effects estimations for model (9). The dependent variable is systemic risk per unit of financial asset. Robust standard errors clustered at the country level are given in parentheses. Both columns show the effects of the bank and market financing indicators on systemic risk and control for banking sector concentration, banks' noninterest income to total income, country and time fixed effects. Significance levels: * p<0.1, ** p<0.05, *** p<0.01. [1] The threshold is bank credit to non-financial sector debt and stock market capitalization. [2] Reports p-values from Hansen's (1996) bootstrap procedure for the null hypothesis (10) with a bootstrap sample of 5000.

The results of the threshold regressions suggest that bank financing no longer contributes to systemic risk in relatively market-based financial structures. This paper finds that this may be caused by a lower probability of default of the banking system in more market-based financial structures, in line with Figure 1. Table B.4 in Appendix B regresses several indicators for the default probability of the banking system on the right hand side of equation (1). The results suggest that bank-dependent financial structures are, at the country level, negatively associated with the banking system's regulatory capital to risk weighted assets, bank Z-score (% before tax), net interest margin and return on assets. The greater resilience of market-based financial structures to systemic risk therefore seems to stem from both bank and market financing.

The insignificant effect of bank financing on systemic risk in relatively market-based financial structures is not explained by the asset portfolio composition nor the degree of competition within the banking system. Table B.5 in Appendix B regresses additional indicators on the right hand side of equation (1).[18] The results suggest that financial structure is, at the country level, not associated with the degree of banks' nonperforming loans to gross loans (NPLs) and liquid assets to deposits and short term funding. The same holds for the Lerner index measuring the degree of monopoly power and the Boone indicator measuring competition within a country's banking system.

5. Conclusion

Financial structure matters. Bank financing may contribute more to systemic risk than market financing, due to its more leveraged nature, larger asset-liability mismatches and greater interconnectedness. Moreover, markets can provide 'spare tire' insurance against problems within the banking sector turning into economy-wide distress. This reduces the depth and length of a systemic crisis. Indeed, the data show that systemic risk decreased relatively quickly after the financial crisis of 2008 in more market-based financial structures, when compared to more bank-based financial structures. The less dominant banks are, the easier banks' financial intermediation can be substituted for by markets.

[18] The indicators used as dependent variables in Table B.4 and Table B.5 are all obtained from the World Bank's Global Financial Development Database (July 2018 version). The indicator codes are respectively: GFDD.SI.05, GFDD.SI.01, GFDD.EI.01, GFDD.EI.09, GFDD.SI.02, GFDD.SI.06, GFDD.OI.04 and GFDD.OI.05.

The greater systemicness of bank-based financial structures is evident in data on financial structures since the turn of the century; while bank financing and bank-based financial structures are associated with higher systemic risk, market financing and market-based financial structures are associated with lower systemic risk. Moreover, the results confirm that from a systemic risk perspective, stock market financing is to be preferred over debt market financing. However, bank financing no longer contributes to systemic risk when the financial structure is relatively market-based. Diversity within the financial sector is thus important. The recent empirical literature on the effects of financial structure on economic growth shows that market-based financial structures outperform bank-based financial structures once the data cover the period spanning the financial crisis of 2008. The relationship between financial structure and systemic risk helps to explain this economic underperformance in times of financial instability.

The findings indicate that market-based financial structures are more resilient in terms of systemic risk. Bank-based financial structures may increase their resilience to systemic risk by reducing the share of bank financing and by further developing their bond and especially stock markets. The design of financial sector and fiscal policies can take this into account. The introduction of the European capital markets union is a case in point. However, financial structures are path dependent and changes require time. The findings may also be relevant for regulators. Regulation may reduce banks' contribution to systemic risk by requiring decreases in leverage, asset-liability mismatches and financial interconnectedness. Adjustments in regulatory requirements change the inherent contribution of different financial structures to systemic risk. In particular, the recently tightened regulatory framework for banks, including higher capital requirements, new liquidity requirements and bail-in rules, may make banks more resilient and systemically less relevant. By the same token, the systemicness of market financing may increase when shadow banking systems involve more leverage, maturity transformation and interlinkages with banks. Further research should determine to what extent these changes lower the contribution of bank financing and raise the contribution of market financing to systemic risk.

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Appendix

A. The expected equity capital shortfall

The expected capital shortfall is defined as:

$$CS_{fin,i,t+6\,months|t} = E_t\left[\theta A_{fin,i,t+6\,months} - W_{fin,i,t+6\,months} \mid Marketdecline_{t:t+6\,months}\right] \quad (A.1)$$

where $A_{fin,i,t+6\,months}$ and $W_{fin,i,t+6\,months}$ denote the value of assets and equity of a financial institution *fin* in country *i* at time *t+6 months* respectively, and θ is a prudential ratio of equity to assets. This prudential ratio represents the fraction of assets that satisfies the minimum unweighted capital requirement, which is in line with the non-risk based leverage ratio introduced under Basel III.

To account for differences between book and market values in equation (A.1), the quasi-market value of assets ($A_{fin,i,t+6\,months}$) is defined as the book value of assets ($BA_{fin,i,t+6\,months}$) plus the difference between the market value of equity ($W_{fin,i,t+6\,months}$) and the book value of equity ($BW_{fin,i,t+6\,months}$):

$$A_{fin,i,t+6\,months} = BA_{fin,i,t+6\,months} + \left(W_{fin,i,t+6\,months} - BW_{fin,i,t+6\,months}\right) \quad (A.2)$$

which can be rewritten as:

$$A_{fin,i,t+6\,months} = D_{fin,i,t+6\,months} + W_{fin,i,t+6\,months} \quad (A.3)$$

where the book value of debt is $D_{fin,i,t+6\,months} = BA_{fin,i,t+6\,months} + BW_{fin,i,t+6\,months}$.[19] Substituting identity (A.3) into equation (A.1) gives:

$$CS_{fin,i,t+6\,months|t} = E_t\left[\theta D_{fin,i,t+6\,months} - (1-\theta) W_{fin,i,t+6\,months} \mid Marketdecline_{t:t+6\,months}\right] \quad (A.4)$$

Assuming the book value of debt is not affected by the crisis and remains constant in the short run implies that:

$$E_t\left[D_{fin,i,t+6\,months} \mid Marketdecline_{t:t+6\,months}\right] = D_{fin,i,t} \quad (A.5)$$

[19] In case of bank stress tests, the book value of assets (BA) falls with the value of expected loan portfolio losses. Note that the book value of debt (D) is unaffected, as the book value of equity (BW) fully absorbs this shock.

Hence equation (A.4) can be rewritten as:

$$CS_{fin,i,t+6\,months|t} = \left\{\theta\left(L_{fin,i,t} - 1\right) - (1-\theta)E_t\left[\frac{W_{fin,i,t+6\,months}}{W_{fin,i,t}} \mid Marketdecline_{t:t+6\,months}\right]\right\}W_{fin,i,t} \quad \text{(A.6)}$$

where $L_{fin,i,t} = A_{fin,i,t}/W_{fin,i,t}$ denotes a financial institution's leverage, so that $D_{fin,i,t} = \left(L_{fin,i,t} - 1\right)W_{fin,i,t}$.[20] The equity capital shortfall is thus dependent on the financial leverage of an institution and the long-run marginal expected shortfall of an institution's return in the hypothetical event of a 40% broad stock market index decline.

To construct the long-run marginal expected shortfall predictions, 6-month arithmetic returns of the institution and the broad market index are simulated many times using a GARCH-DCC model (Engle, 2002, 2009), conditional on the information set at time *t*. The long-run marginal expected shortfall is then the average of the fractional equity returns of the institution whenever the broad market return fell by 40% over the 6-month time period. As the book value of debt is unaffected by the crisis, an institution's equity falls by the long-run marginal expected shortfall. A more detailed description of this simulation is presented in Brownlees and Engle (2017).

[20] The assumption that the book value of debt is not affected by a financial crisis will be violated in the extreme scenario of a bail-in, in which creditors absorb losses.

B. Robustness checks and additional regression output

Table B.1: GMM panel estimations

	Dependent variable	
Regressors	SRISK	SRISK
Bank-to-market financing ratio	0.0060**	0.0083**
	(0.0024)	(0.0035)
Banking sector concentration		-0.0090
		(0.0288)
Banks' noninterest income		0.0393
		(0.0420)
Country fixed effects	Yes	Yes
Time fixed effects	Yes	Yes
N	209	203
Sargan test [1]	0.28	0.41

Notes: This table presents the fixed effects GMM panel estimations for the robustness check as described in section 4.1. The dependent variable is systemic risk per unit of financial asset. White standard errors are given in parentheses. The third and fourth lag of the explanatory variables are included as instruments. The regressions control for time and country fixed effects in both columns. Both columns show the effect of the bank-to-market financing ratio on systemic risk. Column 2 controls for banking sector concentration and banks' noninterest income to total income. Significance levels: * p<0.1, ** p<0.05, *** p<0.01. [1] Reports p-values from the Sargan test for the null hypothesis that the instruments are valid.

Table B.2: Linear fixed effects estimations

	Dependent variable	
Regressors	MES	CISS
Bank-to-market financing ratio	0.0042*	0.0810***
	(0.0020)	(0.0179)
Banking sector concentration	0.0373	-0.0133
	(0.0430)	(0.1790)
Banks' noninterest income	0.0026	-0.1601
	(0.0153)	(0.2042)
Country fixed effects	Yes	Yes
Time fixed effects	Yes	Yes
R-sqr (within)	0.080	0.664
N	245	196
Mean VIF [1]	2.69	3.20
Bank-to-market financing ratio VIF [2]	3.42	4.01

Notes: This table presents the fixed effects estimations for the robustness checks as described in section 4.1. The dependent variables are the marginal expected shortfall (MES) and the composite indicator of systemic stress (CISS). Robust standard errors clustered at the country level are given in parentheses. The regressions control for time and country fixed effects in both columns. Both columns show the effect of the bank-to-market financing ratio on systemic risk and control for banking sector concentration and banks' noninterest income to total income. Significance levels: * p<0.1, ** p<0.05, *** p<0.01. [1] Reports the mean variance inflation factor of all variables (including control variables) to quantify the severity of multicollinearity. [2] Reports the variance inflation factor of the bank-to-market financing ratio to quantify the severity of multicollinearity.

Table B.3: GMM panel estimations

	Dependent variable	
Regressors	MES	CISS
Bank-to-market financing ratio	0.0019*	0.1113***
	(0.0011)	(0.0233)
Banking sector concentration	0.0183	-0.3731
	(0.0123)	(0.2677)
Banks' noninterest income	-0.0255	0.2592
	(0.0264)	(0.3395)
Country fixed effects	Yes	Yes
Time fixed effects	Yes	Yes
N	207	171
Sargan test [1]	0.05	0.41

Notes: This table presents the fixed effects GMM estimations for the robustness checks as described in section 4.1. The dependent variables are the marginal expected shortfall (MES) and the composite indicator of systemic stress (CISS). White standard errors are given in parentheses. The first two lags of the explanatory variables are included as instruments. The regressions control for time and country fixed effects in both columns. Both columns show the effect of the bank-to-market financing ratio on systemic risk and control for banking sector concentration, banks' noninterest income to total income. Significance levels: * p<0.1, ** p<0.05, *** p<0.01. [1] Reports p-values from the Sargan test for the null hypothesis that the instruments are valid.

Table B.4: Financial structure and the probability of default of the banking system

	Dependent variable			
Regressors	Bank capital	Z-score	Net interest	ROA
Bank-to-market financing ratio	-0.8508***	-1.5093**	-0.2766***	-0.7638***
	(0.2377)	(0.6664)	(0.0508)	(0.1716)
Banking sector concentration	3.1875	-6.1765	-0.1425	-1.4339
	(2.2727)	(5.9439)	(0.7388)	(1.1014)
Banks' noninterest income	2.2983**	0.4844	-0.6403	-1.0705
	(1.0364)	(5.6117)	(0.4550)	(0.9006)
Country fixed effects	Yes	Yes	Yes	Yes
Time fixed effects	Yes	Yes	Yes	Yes
R-sqr (within)	0.472	0.193	0.315	0.420
N	290	293	293	291
Mean VIF [1]	2.78	2.76	2.76	2.82
Highest VIF [2]	3.54	3.56	3.56	3.88

Notes: This table presents the fixed effects estimations for the relationship between financial structure and probability of default of the banking system as described in section 4.2. The dependent variables are, at the country level, the bank regulatory capital to risk-weighted assets, the Bank Z-score, bank net interest margin, the return on assets (ROA). Robust standard errors clustered at the country level are given in parentheses. All columns control for banking sector concentration, banks' noninterest income to total income, country and time fixed effects. Columns 1, 2, 3 and 4 show the effects of the bank-to-market financing ratio on the bank regulatory capital to risk-weighted assets, Bank Z-score, bank net interest margin and ROA, respectively. Significance levels: * p<0.1, ** p<0.05, *** p<0.01. [1] Reports the mean variance inflation factor of all variables (including control variables) to quantify the severity of multicollinearity. [2] Reports the variance inflation factor of the bank-to-market financing ratio to quantify the severity of multicollinearity.

Table B.5: Financial structure and the asset portfolio composition and banking market competition

	Dependent variable			
Regressors	NPLs	Liquid assets	Lerner index	Boone indicator
Bank-to-market financing ratio	1.1937	-2.2007	-0.0044	-0.0808
	(1.2028)	(1.5959)	(0.0187)	(0.0776)
Banking sector concentration	4.9970	29.9153	-0.0116	1.3622
	(4.1201)	(21.6370)	(0.1038)	(1.4511)
Banks' noninterest income	3.4513	35.9036*	-0.0330	-1.3987
	(3.0088)	(19.5431)	(0.0966)	(1.1762)
Country fixed effects	Yes	Yes	Yes	Yes
Time fixed effects	Yes	Yes	Yes	Yes
R-sqr (within)	0.247	0.130	0.127	0.051
N	285	293	276	290
Mean VIF [1]	2.77	2.76	2.80	2.77
Highest VIF [2]	3.59	3.56	4.10	3.56

Notes: This table presents the fixed effects estimations for the relationship between financial structure and the asset portfolio composition, and competition within the banking system as described in section 4.2. The dependent variables are, at the country level, the bank nonperforming loans to gross loans (NPLs), liquid assets to deposits and short term funding, Lerner index and Boone indicator. Robust standard errors clustered at the country level are given in parentheses. All columns control for banking sector concentration, banks' noninterest income to total income, country and time fixed effects. Columns 1, 2, 3 and 4 show the effects of the bank-to-market financing ratio on the NPLs, liquid assets to deposits and short term funding, Lerner index and Boone indicator, respectively. Significance levels: * p<0.1, ** p<0.05, *** p<0.01. [1] Reports the mean variance inflation factor of all variables (including control variables) to quantify the severity of multicollinearity. [2] Reports the variance inflation factor of the bank-to-market financing ratio to quantify the severity of multicollinearity.

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