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Drivers of systemic risk: Do national and European perspectives differ?

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Non-technical summary

Research Question

Since the establishment of the European Banking Union, macroprudential power has rested at both the national and the supranational level. While macroprudential policy is a national responsibility, the European Central Bank can impose stricter capital requirements on banks in the event of a threat to systemic stability that is not addressed by national policies. Understanding whether the assessment of systemic risk of national supervisors may differ from that of supranational supervisors is thus of interest. In this paper, we analyze a bank's contribution to systemic risk at the national as opposed to the euro-area level. We then ask whether the drivers of systemic risk differ at the national and at the euro-area level.

Contribution

We contribute to the literature by analyzing whether the determinants of banks' contributions to systemic risk differ between the national and the euro-area level. Our analysis is based on a sample of listed euro-area banks and the period 2005-2013. We compute banks' contribution to systemic risk based on the SRISK measure by Brownlees and Engle (2017). SRISK is a commonly used systemic risk measure which captures banks' capital shortfall in times when the whole financial system is in distress. We then set banks' SRISK in relation to possible risk factors.

Results

Systemic risk increased during the financial crisis. Larger and more profitable banks have, on average, contributed more to systemic risk. The impact of a more "traditional" business model characterized by a dominance of retail activity and interest income is not clear-cut: banks with a high loan share contribute less to systemic risk, but this also holds for banks with a high share of non-interest income. While the qualitative determinants of systemic risk are similar at the national and euro-area level, the quantitative importance of some determinants differs. For example, banks with a higher loan share contribute less to systemic risk, but this effect is stronger at the national level compared to the euro-area level.

Nichttechnische Zusammenfassung

Fragestellung

Mit der Umsetzung der europäischen Bankenunion ist die Zuständigkeit für Finanzstabilitätspolitik und makroprudentielle Überwachung sowohl auf nationaler wie auch auf supranationaler Ebene angesiedelt. Makroprudentielle Überwachung fällt grundsätzlich in den Verantwortungsbereich nationaler Institutionen. Jedoch kann die Europäische Zentralbank im Rahmen ihrer Funktion in der Bankenaufsicht die Kapitalanforderungen für Banken verschärfen, wenn die Stabilität des Finanzsystems gefährdet ist. Deshalb ist es wichtig zu verstehen, ob sich die Einschätzung systemischen Risikos und dessen Einflussfaktoren auf der nationalen und supranationalen Ebene unterscheidet. Dieser Frage gehen wir in diesem Papier nach.

Beitrag

Die Studie untersucht, welche Faktoren das von einer Bank ausgehende systemische Risiko treiben, wobei sowohl der nationale als auch der europäische Markt als Referenz genommen werden. Die Studie basiert auf Daten für börsennotierte Banken im Euroraum und dem Zeitraum von 2005 bis 2013. Basierend auf dem SRISK Maß von Brownlees und Engle (2017) wird das systemische Risiko einer Bank berechnet. SRISK misst dabei die Kapitallücke einer Bank während einer systemischen Krise. Im Anschluss wird der Zusammenhang zwischen SRISK und anderen Risikofaktoren getestet.

Ergebnisse

Während der Finanzkrise ist das systemische Risiko angestiegen. Größere und profitablere Banken sind im Schnitt bedeutender für das Risiko des gesamten Finanzsystems. Der Einfluss eher traditioneller Geschäftsmodelle mit einem hohen Anteil von zinsabhängigem Geschäft und von Krediten ist nicht eindeutig: Während das systemische Risiko mit dem Anteil der Kredite an der Bilanzsumme sinkt, weisen auch Banken mit einem höheren Anteil an zinsunabhängigen Erträgen tendenziell ein geringeres systemisches Risiko auf. Die qualitativen Bestimmungsfaktoren von systemischem Risiko sind ähnlich aus nationaler und europäischer Perspektive, während es quantitative Unterschiede geben kann. Zum Beispiel reduziert ein höherer Kreditanteil das systemische Risiko, wobei die Wirkung auf nationaler Ebene größer ist als auf europäischer Ebene.

Bundesbank Discussion Paper No 09/2017

Drivers of Systemic Risk: Do National and European Perspectives Differ?*

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Abstract

In Europe, the financial stability mandate generally rests at the national level. But there is an important exception. Since the establishment of the Banking Union in 2014, the European Central Bank (ECB) can impose stricter regulations than the national regulator. The precondition is that the ECB identifies systemic risks which are not adequately addressed by the macroprudential regulator at the national level. In this paper, we ask whether the drivers of systemic risk differ when applying a national versus a European perspective. We use market data for 80 listed euro-area banks to measure each bank's contribution to systemic risk (SRISK) at the national and the euro-area level. Our research delivers three main findings. First, on average, systemic risk increased during the financial crisis. The difference between systemic risk at the national and the euro-area level is not very large, but there is considerable heterogeneity across countries and banks. Second, an exploration of the drivers of systemic risk shows that a bank's contribution to systemic risk is positively related to its size and profitability. It decreases in a bank's share of loans to total assets. Third, the qualitative determinants of systemic risk are similar at the national and euro-area level, whereas the quantitative importance of some determinants differs.

Keywords: Systemic risk, bank regulation, Banking Union

JEL codes: G01, G21, G28

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1 Motivation

Systemic risk can create negative externalities for the financial system which individual banks do not internalize.[1] If banks experience a negative shock to capital, they curb their lending or sell assets. In responding to such an individual capital shortage, banks may fail to anticipate that other banks may have capital shortages, too. This may aggravate the response to the initial shock. Systemic risk thus leads to an aggregate shortage of capital in the financial sector (Acharya and Steffen 2012, Acharya et al. 2017). The externality that generates systemic risk is the propensity of a financial institution to be undercapitalized when the whole system is undercapitalized. It is the task of macroprudential supervision to internalize systemic risk by supervising financial institutions and, if needed, by imposing appropriate capital buffers on banks.

In this paper, we address two issues. First, what is a bank's contribution to systemic risk at the national as opposed to the euro-area level? Second, do the drivers of systemic risk differ at the national and the euro-area level? Understanding whether the assessment of systemic risk by national supervisors may differ from that by supranational supervisors and analyzing the factors driving systemic risk at different regional levels is important in Europe. Here, national supervisors are responsible for macroprudential oversight and for imposing macroprudential regulations. But under the supranational Single Supervisory Mechanism (SSM), the ECB can impose stricter regulations than the national regulator if the ECB identifies systemic risks that are not adequately addressed by the macroprudential regulator at the national level.

Despite a large and growing literature on systemic risk in banking, most previous studies do not take into account potential differences in contributions to systemic risk at the national and euro-area level. Prima facie, banks which are important and thus "systemic" for the national financial system may be less "systemic" for the European financial system simply because the relevant market is larger. But market share is not the only driver of systemic risk. The correlation of risks across banks, the exposure of banks to macroeconomic shocks, and the degree of interconnectedness of financial institutions are likewise drivers of systemic risk. If the impact of negative externalities caused by a bank at home differs from the contribution to systemic risk abroad, a national regulator might fail to take this cross-border externality into account. To the best of our knowledge, no comparative analysis of the drivers of systemic risk at the national level or at the supranational, euro-area level has been conducted before.

[1] "Systemic" risk is not synonymous with "systematic" risk (Hansen 2013). The latter is defined as macroeconomic or aggregate risks that cannot be diversified away. It is also known as market, non-diversifiable, or beta risk.

We combine stock market data for euro-area banks with balance sheet data. Overall, our dataset consists of 80 euro-area banks listed on the stock market and covers the years 2005-2013. To measure the systemic risk emerging from a specific bank and the underlying drivers, we proceed in two steps. In a first step, we follow Brownlees and Engle (2017) and calculate a systemic risk measure – SRISK – which captures a bank's contribution to an aggregate capital shortfall. SRISK is calculated based on stock market data. We differentiate between a bank's contribution to an undercapitalization of the financial system at the national versus the euro-area level. This reveals whether supervisors assess banks' systemic risk differently, depending on their regional perspective, while using the same systemic risk measure.

In a second step, we analyze the determinants of systemic risk. Given that not all explanatory variables of interest are available for all banks, we analyze the determinants of systemic risk for 75 out of 80 banks. Finding that the drivers of systemic risk at the national level differ from those at the euro-area level might have implications for the incentive of regulators to impose macroprudential rules and for the level at which banks should be supervised. Both of these are beyond the scope of the present analysis, however. Hence, our analysis reveals whether levels and drivers of measures of systemic risk derived from stock market data depend on the regional perspective taken.[2]

Our analysis is linked to three strands of literature. A first set of studies measures systemic risk empirically. The SRISK measure comes up in several previous studies. The study closest to ours is Benoit (2014), who extends the SRISK measure to distinguish the contribution to systemic risk at different levels – supranational or national. While the absolute values of SRISK can vary substantially across different regional levels, the ranking of banks according to SRISK is very similar for the different levels. We apply the SRISK measure to all euro-area banks that are listed on the stock market, including SSM-supervised banks. Similar to Benoit (2014), we compute the contributions of these banks to systemic risk at the national and the euro-area level. We find that, on average, the values obtained for SRISK for the banks included in this study are similar at the national level and at the euro-area level. However, at the level of the individual bank, we do find heterogeneity across banks and over time.

A measure of systemic risk which has been used as an alternative to SRISK is the ΔCoVaR by Adrian and Brunnermeier (2016).[3] Conditional value at risk (CoVaR) is defined as the financial system's Value-at-Risk conditional on the state of a particular financial institution. An institution's contribution to systemic risk is then the difference between the CoVaR with

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[2] We do not discuss whether national and supranational supervisors' objectives may differ. Also, our analysis does not extend to possible effects and resulting trade-offs of allocating supervision from the national to the supranational level.

[3] Benoit et al. (2016) and Bisias et al. (2012) provide a detailed survey of measures for systemic risk; Brownlees and Engle (2017) discuss how SRISK is related to other measures of systemic risk discussed in the literature.

the financial institution being in distress, and the CoVaR with the financial institution being at its median state.[4] The reason we prefer SRISK over ΔCoVaR is that the former has frequently been used in related studies (Benoit 2014, Bierth et al. 2015, Bostandzic and Weiß 2013, Laeven et al. 2016). This ensures comparability to our results. Another advantage is that SRISK can be easily calculated at the regional level. While this also holds true for the ΔCoVaR, the derived values are more difficult to compare across regions (Benoit 2014).

A second strand of literature analyzes why some banks are more systemically important than others. We contribute to this literature by analyzing the drivers behind banks' contribution to systemic risk at different regional levels. Previous evidence on the determinants of banks' contributions to regional systemic risk is scarce. Closest to our paper is the work by Weiß et al. (2014), who analyze the determinants of banks' contributions to global and local systemic risk during several historical financial crises using an event study approach. They find that bank-specific determinants of systemic risk are neither persistent across time nor across different regional levels. Our paper departs from their study in two dimensions. First, we rely on SRISK as a multidimensional measure of systemic risk, whereas Weiß et al. (2014) use tail measures of interconnectedness such as the marginal expected shortfall and lower tail dependence. Second, our focus is on a sample of publicly listed banks in the euro area, which allows analyzing whether determinants of systemic risk differ depending on whether we take a national or a European perspective.

De Jonghe (2010) also studies the effect of bank-specific characteristics on systemic risk using tail betas, which is the probability of a sizeable decline in a bank's stock price if the stock market crashes. His main focus is on the effect of "revenue diversity", resulting from a diversified portfolio, on systemic stability. The effect of the share of non-interest income on systemic risk is assessed in De Jonghe et al. (2015). They find that non-interest income increases systemic risk measured by the marginal expected shortfall, but that the effect is weaker for larger banks. Our results show that higher non-interest income relates positively to systemic risk for the smaller banks, with the effect reversing itself for the larger banks in the sample.

Laeven et al. (2016) regress measures of idiosyncratic risk (stock returns) and of systemic risk (SRISK) of banks during the crisis on pre-crisis bank characteristics. They find that larger banks contribute more to systemic risk if they have low capital and liquidity ratios and if they have complex and more market-based business models. We add to this literature by distinguishing between different regional levels when analyzing systemic risk and by placing a specific focus on the euro area. For the sample of euro-area banks, we confirm their finding

[4] Benoit et al. (2016) show that the time pattern of a bank's ΔCoVaR tends to be proportional to the bank's Value-at-Risk. Hence, this finding implies that, based on ΔCoVaR, a bank can lower its systemic risk by reducing its idiosyncratic risk component.

that larger banks are more systemically important. We also document that banks with a more traditional business model captured by a higher loan share contribute less to systemic risk.

A third set of previous studies analyzes the costs and benefits of allocating regulatory or supervisory powers to the supranational level from a theoretical point of view (Calzolari et al. 2016, Carletti et al. 2016, Dell'Ariccia and Marquez 2006, Kahn and Santos 2005, Morrison and White 2009, Vives 2001). Regulation at the supranational level is more likely to internalize cross-country interdependencies (Beck and Wagner 2013). Dell'Ariccia and Marquez (2006), for instance, show that a supranational regulator is more likely to take into account beneficial effects of higher capital requirements on the stability of banks in other countries. However, regulation becomes less flexible if uniform regulatory standards apply across countries. This might be costly if banking systems are heterogeneous across countries.[5]

Empirical studies show that a national approach to supervision and regulation might lead to distortions. Agarwal et al. (2014), for instance, exploit the fact that supervision of US commercial banks alternates between the state and federal regulator. They find that federal regulators tend to be less lenient.[6] Beck et al. (2013) analyze regulators' incentives to intervene in distressed banks depending on their type of cross-border activities. They show that the larger the share of foreign deposits and assets and the lower the share of foreign equity, the later national regulators step in. This supports the theoretical prediction that national regulators are less likely to internalize costs or benefits arising abroad.

In this paper, we are not only interested in possible differences in viewpoints between national and international supervisors arising from the measurement of banks' systemic risk, but also seek to assess whether drivers of systemic risk differ across regional levels. As regards the relevance of size, our study shows that larger banks contribute more to systemic risk than smaller banks, and this result holds irrespective of the regional level considered. "Size" is thus an important variable to identify global systemically important financial institutions (G-SIFIs). However, there are additional bank-level factors which are related to banks' contribution to systemic risk. More profitable banks, banks with a lower share of loans to total assets and thus a less "traditional" business model, contribute more to systemic risk. Given that one key criterion for a SSM-supervised bank is bank size, we analyze whether other drivers of risk differ between smaller and larger banks. Conditioning on bank size, we find that banks with higher profitability and a higher share of non-performing loans contribute

[5] Further theoretical studies include Colliard (2015), who compares the effects of local versus centralized supervision. Effects of supranational versus national bank resolution on contagion and market discipline are studied by Górnicka and Zoican (2016).

[6] Behn et al. (2015) use data for German banks to show that bailout decisions can be determined by the institutional design. Local supervisors are less likely to bail out banks before elections, and banks perform worse if local politicians intervene rather than the savings bank association, which is the head organization of the German savings banks. This suggests that increasing the distance between banks and supervisors can improve the decision-making process.

more to systemic risk the larger they are. Moreover, the effect of the share of non-interest income reverses: while smaller banks with a higher share of non-interest income contribute more to systemic risk, the effect turns negative for larger banks.

In qualitative terms, the determinants of systemic risk that we find are similar at the national and the euro-area level. This is likely to reduce discrepancies between national and supranational supervisors, align incentives, and contribute to financial stability. Carletti et al. (2016) study agency problems that can occur between local and centralized supervisors if decision-making power is shifted to the centralized supervisor while local supervisors remain responsible for collecting information on banks' soundness. Their model shows that local supervisors reduce their efforts to collect information if the discrepancy in the objective functions of different supervisors is large. However, in quantitative terms, we find that the relevance of some determinants of systemic risk differ across regional levels. A high share of loans in total assets, for example, tends to lower systemic risk, but this effect is stronger at the national than at the euro-area level.

The paper is structured as follows. In Section 2, we describe the institutional background for macroprudential supervision and regulation in the euro area. In Section 3, we explain the definition and measurement of systemic risk using the SRISK concept. In Section 4, we present our data, capturing possible determinants of systemic risk, and in Section 5, we show regression results relating systemic risk to these determinants. Section 6 concludes.

2 Institutional Background

Macroprudential supervision and regulation is a relatively new policy field. In Europe, the legislation establishing the European Systemic Risk Board (ESRB) came into force in 2010. It is based on a recommendation of the de Larosière report of the year 2009 to establish a European body with a mandate to oversee risks in the financial system as a whole.[7] The ESRB has no direct regulatory power, but it can issue warnings and recommendation to national regulators or to other authorities. An ESRB recommendation issued in the year 2011 requires EU member states to establish or designate an authority entrusted with the conduct of macroprudential policy. In addition, the new EU-wide prudential requirements for credit institutions (CRD IV/CRR) require member states to create an authority which can take measures to mitigate systemic risk posing a threat to financial stability *at the national level*.[8]

Upon the entry into force of the European Banking Union in November 2014, the Single Supervisory Mechanism (SSM) gave the ECB the right to impose stricter regulations than the

[7] See *ec.europa.eu/finance/general-policy/docs/de_larosiere_report_en.pdf*

[8] For details, see the ESRB recommendation of April 4, 2013, on intermediate objectives and instruments of macroprudential policy, ESRB/2013/1.

national authorities if the ECB identifies systemic risks which are not adequately addressed by the national regulator. Note that the ECB's ability to tighten national regulation is restricted to those instruments available under the Capital Requirements Regulation and Capital Requirements Directive (CRR/CRD IV). There is, hence, shared responsibility between the national and supranational supervisor as concerns macroprudential policies. This division of power between the national and the euro-area level may have implications for the stringency of macroprudential regulation. On the one hand, regulatory forbearance and "inaction bias" may be more pronounced at the national level if political considerations influence decision-making. On the other hand, European supervisors may fail to act if systemic risk is deemed to be contained to national financial markets. Our paper contributes to the discussion on whether the assessment of systemic risk can be expected to differ between the national and the European level.

Furthermore, with the establishment of the SSM, the ECB directly supervises the largest 120 euro-area banks, representing almost 82% of total banking assets in the euro area. Designation of financial institutions to be supervised by the SSM is based on a definition of systemic risk. The ECB uses the following criteria to define a systemically important financial institution:

(i) total assets (size),
(ii) importance of the bank for the (national) economy,
(iii) significance of cross-border activities, and
(iv) requested ESM/EFSF financial assistance.[9]

One goal of our empirical model is to analyze whether these factors are related to the systemic risk of individual banks. Other pieces of legislation likewise include assumptions on the drivers of systemic risk. The Basel Committee on Banking Supervision (BCBS 2013), for instance, proposes measuring the systemic importance of financial institutions based on five equally-weighted criteria:

- size,
- interconnectedness,
- substitutability,
- complexity, and
- cross-jurisdictional activity.

Each of these five criteria (excluding size) is composed of various sub-indicators which again receive equal weights. For example, the measure "cross-jurisdictional activity" considers cross-jurisdictional claims and cross-jurisdictional liabilities. This measure was adopted by the Financial Stability Board (FSB) to identify G-SIFIs.

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[9] For an online reference, see *http://www.ecb.europa.eu/ssm/html/index.en.html*

One advantage of the existing regulatory classification is that it is based on indicators which do not fluctuate widely over time. Basing the designation of systemically important financial institutions on market-based indicators like SRISK or ΔCoVaR which vary over time, would not be very practical. At the same time, it is important for regulators to know whether these indicators would yield assessments of the systemic importance of financial institutions that are similar to those provided by more structural indicators.

3 Defining and Measuring Systemic Risk

Defining and measuring systemic risk is a core component of our paper. In this section, we introduce our main measure – the expected shortfall of capital of a financial institution during a crisis situation – and we discuss why this measure might differ at the national and the euro-area level.

3.1 Marginal Expected Shortfall and Systemic Risk

We follow Brownlees and Engle (2017) and define systemic risk as a bank's expected capital shortfall if it only occurs whenever the rest of the financial sector is undercapitalized. The capital shortfall of an individual bank, given that the whole financial system experiences a capital shortfall, is a measure of the bank's contribution to systemic risk. The market-based systemic risk measure SRISK thus reflects a bank's contribution to systemic risk by describing the expected capital need, conditional on a systemic event:

$$SRISK_{it} = E_t\left(Capital\ Shortfall_{it+h} \middle| R_{mt+1:t+h} < C\right), \tag{1}$$

where $R_{mt+1:t+h}$ is a multi-period market return between period $t+1$ and $t+h$. C is an extreme threshold loss. Hence, $SRISK_{it}$, which gives the expected capital shortfall, depends on the systemic event $\{R_{mt+1:t+h} < C\}$. Applying this definition of systemic risk requires assumptions on the systemic event and on a bank's capital shortfall. To interpret SRISK in an meaningful way and to capture the capital shortfall of an institution conditional on a systemic event, the amount by which the market index falls has to be large enough and the period during which it falls has to be long enough (Brownlees and Engle 2017). Previous work assumes that a financial system is in a crisis whenever the market index falls by 40% over the next six months (Acharya et al. 2012). So the extreme threshold loss C is set to -40%. However, even if these parameters are modified, Brownlees and Engle (2017) show that SRISK provides similar rankings of banks at the top positions.

Equation (1) shows that SRISK is based on the accuracy with which market participants anticipate the capital need of an individual bank in times of crisis. Any mechanism that might lead to an under- or overestimation of risk would affect the accuracy of this proxy for systemic risk. Similar problems apply to alternative measures of systemic risk based on market data such as ΔCoVaR models. Given that our focus is on differences in banks' contribution to systemic risk at the national and at the euro-area level, the possible mispricing of risk would be problematic if the degree of mispricing were to vary across regions. In robustness tests, we control for periods in which countries introduced short-sale bans as this might impact pricing in markets and thus SRISK. Yet our main conclusions remain robust.

A financial institution experiences a capital shortfall if the value of its equity capital drops below a given fraction k of its total (i.e. non-risk weighted), "stressed" assets: $Capital\,Shortfall_{it+h} = k(Assets_{it+h}) - Equity_{it+h}$. k is the microprudential minimum capital requirement for each institution to maintain a given percentage of its assets as equity capital. Substituting this into equation (1) gives:

$$\begin{aligned} SRISK_{it} &= E_t\left(Capital\ Shortfall_{it+h} \middle| R_{mt+1:t+h} < C\right) \\ &= E_t\left(k\left(Assets_{it+h}\right) - Equity_{it+h} \middle| R_{mt+1:t+h} < C\right) \\ &= E_t\left(k\left(Debt_{it+h} + Equity_{it+h}\right) - Equity_{it+h} \middle| R_{mt+1:t+h} < C\right) \\ &= kE_t\left(Debt_{it+h} \middle| R_{mt+1:t+h} < C\right) - (1-k)E_t\,(Equity_{it+h} | R_{mt+1:t+h} < C). \end{aligned} \tag{2}$$

Assuming that there is sufficient equity capital to cover potential losses (hence no bail-in of creditors is needed in case of distress), the book value of debt will be relatively constant. So $Debt_{it+h}$ cannot be renegotiated in the midst of a financial crisis, and the expression $E_t\left(Debt_{it+h} \middle| R_{mt+1:t+h} < C\right)$ simplifies to $E_t\left(Debt_{it+h} \middle| R_{mt+1:t+h} < C\right) = Debt_{it}$:

$$\begin{aligned} SRISK_{it} &= kDebt_{it} - (1-k)E_t\,(Equity_{it+h} | R_{mt+1:t+h} < C) \\ &= kD_{it} - (1-k)E_t\,(E_{it+h} | R_{mt+1:t+h} < C), \end{aligned} \tag{3}$$

where D_{it} is the book value of total liabilities and E_{it+h} is the expected market value of equity between the period $t+1$ and $t+h$ conditional on the multi-period market return.

However, in the event of a crisis, equity owners will have to absorb losses. The sensitivity of a bank's equity conditional upon a (future) crisis of the financial system is captured by the long-run marginal expected shortfall, $LRMES_{it}$, such that $LRMES_{it} = E_t\,(R_{it+1:t+h} | R_{mt+1:t+h} < C)$.[10] $LRMES_{it}$ can be interpreted as the bank's expected loss per euro conditional on a particular market index falling by more than the threshold loss, $C = -40\%$, at a time horizon of six-months.

[10] In line with Acharya et al. (2012), we proxy LRMES using the marginal expected shortfall (MES) measure, where $LRMES_{it} \cong 1 - \exp(18 * MES_{it})$. MES is defined as the one-day expected equity loss per dollar invested in a bank if the respective market index declines by more than its 5% VaR. To calculate MES, we follow Brownlees and Engle (2017) and opt for the GJR-GARCH volatility model and the standard DCC correlation model. The estimation period for MES is 2000-2015. Technical details of MES estimation are provided in the appendices of the two referenced papers.

Hence, $(1-LRMES_{it})$ represents the devaluation of the market value of equity after a shock has hit the system. Equation (3) can be written as:

$$\begin{aligned} SRISK_{it} &= kD_{it} - (1-k)(1-LRMES_{it})E_{it} \\ &= E_{it}[kL_{it} + (1-k)LRMES_{it} - 1], \end{aligned} \qquad (4)$$

where L_{it} is the leverage ratio $D_{it} + E_{it} / E_{it}$. Hence, the systemic risk of a financial institution is higher the higher its leverage, the higher its expected equity loss given a market downturn (higher tail dependence), and the larger the bank. Note that SRISK may become negative if a bank has a low degree of leverage and/or a low marginal expected shortfall.

SRISK delivers a clearly interpretable unit of measurement: the amount of capital needed to fulfill capital requirements after an adverse shock. The higher a bank's capital shortfall, the higher the probability that a bank will be distressed. If the entire sector is in distress and exhibits an aggregate capital shortage, banks find it hard to collectively improve their balance sheets. This generates negative externalities to the rest of the economy. Note also that a higher prudential capital ratio expressed by k implies that banks would need a larger amount of capital to maintain operations during crisis times, which, in turn, causes an increase in the capital shortfall.

In sum, SRISK is the difference between a bank's required capital and the available capital, conditional on a substantial decline in the overall market. Banks with the largest shortfall contribute most to the system's aggregate capital shortfall. Banks with a capital shortfall are vulnerable to runs, forcing them to liquidate long-term assets. This might fuel downward asset price spirals and destabilize the financial system. There is, thus, an important distinction between an institution's failure in normal times, without an aggregate capital shortage, and a bank's failure when the whole system is undercapitalized. Only the latter displays a key feature of systemic risk, which SRISK captures. In this sense, Acharya et al. (2017) provide a theoretical model in which negative externalities arise due to a capital shortfall at one firm conditional on situations in which the whole financial system is undercapitalized.

3.2 National Versus European Perspectives

Generally, a bank's contribution to systemic risk depends on its market share, the degree of diversification, and its exposure to market risk at home and abroad (Acharya et al. 2017). A priori, one might expect SRISK to be higher for the national market than for the euro-area market. In the extreme case of a monopolistic domestic bank without foreign operations, the capital of this bank would move one-to-one with the capital of the domestic banking system. The smaller the domestic market share of the bank is and the more the bank diversifies its activities away from the domestic market, the weaker the link will be between bank i and the national banking market. This suggests that it is not clear a priori that SRISK is necessarily higher if the national market rather than the euro-area market is taken as a benchmark.

As we are interested in comparing the contribution to systemic risk of a bank at the national (*N*) and at the euro-area level (*EA*), we follow Benoit (2014) and distinguish two measures of systemic risk:

$$SRISK_{it}^{EA} = kD_{it} - (1-k)(1-LRMES_{it}^{EA})E_{it} \tag{5}$$

$$SRISK_{it}^{N} = kD_{it} - (1-k)(1-LRMES_{it}^{N})E_{it} \tag{6}$$

Because there is nothing that a priori prevents *LRMES* with respect to the home market from being smaller or larger than *LRMES* with respect to the euro-area market, the difference between the two measures of systemic risk may be positive or negative:

$$\begin{aligned} \Delta SRISK_{it} &= SRISK_{it}^{EA} - SRISK_{it}^{N} \\ &= (1-k)(LRMES_{it}^{EA} - LRMES_{it}^{N})E_{it} \end{aligned} \tag{7}$$

This difference reveals in which market a downturn induces a higher capital shortfall, and it proxies at which level the bank is contributing more to systemic risk. If $\Delta SRISK_{it} < 0$ the bank exhibits a *national effect*, i.e., the bank's ability to absorb losses is smaller during a decline in the domestic market than during a decline in the euro-area market. If national SRISK is smaller than euro-area SRISK ($\Delta SRISK_{it} > 0$), a *euro-area effect* prevails: a bank contributes more to a decline in the capitalization of the European banking sector than to a decline in the capitalization of the national banking sector, given that there is a capital shortfall in the system. In this case, the national supervisor may have insufficient incentives to internalize the contribution of banks' to systemic risk at the euro-area level. This could be one reason for inaction bias at the national level when it comes to the activation of macroprudential policies aimed at strengthening the resilience of banks.[11]

3.3 Data Sources

SRISK is calculated based on daily stock market data which are publicly available. This facilitates comparability across studies but restricts our analysis to publicly listed banks. For many European banking systems, the number of banks for which we can calculate SRISK covers only a relatively small share of the market. The German banking market, for instance, is dominated by relatively small savings and cooperative banks as well as their central

[11] One potential caveat is that the national stock market index is driven by developments at the national but also at the euro-area level. This would imply that SRISK at the national level is also driven by euro-area factors. To check whether this affects our results, we conduct robustness tests, in which we extract euro-area factors from the national stock market index.

institutions. Nevertheless, in the context of recent regulatory changes, discussions have focused on the surveillance of large and systemically important banks. Also, publicly listed banks accounted for more than 80% of the total capital shortfall reported in the ECB's comprehensive assessment (Acharya and Steffen 2014).

To calculate SRISK, we consult data provided by *Datastream*. The SRISK of bank *i* consists of three data components: the book value of total liabilities, the market value of equity, and the long-run marginal expected shortfall (*LRMES*). While 110 banks were listed in the euro area as of January 2014, *Datastream* provides only yearly data on the book value of total liabilities and the daily market value of equity measured as shares outstanding times share price for 97 banks. 7 banks with poor trading frequency are dropped because the GJR-GARCH model, which underlies the estimation of *LRMES*, could not estimate time-varying volatilities due to insufficient fluctuation and/or zeros in the stock price data. Further, we drop 10 institutions with a market capitalization of less than 100 million euros as of 31 December 2007. For the remaining 80 banks, we calculate SRISK. To correct for outliers, we winsorize the series obtained for a bank's SRISK at the 1st and 99th percentile.

Finally, we match those banks for which we have calculated SRISK to balance sheet and income statement data from *Bankscope* by using te ISIN number. While we can match 80 banks, the regression analysis is based on 75 banks in 15 euro-area countries due to missing values in *Bankscope*. Given that *Bankscope* data are available at annual frequency, for most of our analysis, we use the annual average of a bank's SRISK.[12] The list of banks included in our sample can be found in the Appendix. Only a fraction of the 128 banks which participated in the ECB's comprehensive assessment (henceforth: "SSM banks") are publicly listed and remain in our sample. Hence, we can only compute SRISK for 44 SSM banks.

LRMES gives the sensitivity of a bank's equity return to a shock to the market. It is based on the bank's stock price and the euro-area or the national market index. To compute SRISK at the euro-area level, we make use of the EURO STOXX Total Market Index (TMI), which represents a broad coverage of euro-area companies. For the national level, we make use of STOXX Country Total Market Indices (TMI). These indices have two advantages. First, they are available for all euro-area countries. Second, they allow us to take into consideration financial and real sector developments. Our approach is similar to Acharya et al. (2012) and Laeven et al. (2016), who use the S&P 500 index and not an index specific to the banking sector for the market return.[13]

[12] In robustness tests, we also calculate the median of the daily values by bank to aggregate the SRISK series to the annual frequency.

[13] In robustness tests, we use an index related to the banking sector instead of a broad market index. SRISK tends to show higher values if this banking sector index is used. This arises due to a higher correlation of individual bank indices with the banking sector index at the country level.

Summary statistics of the daily stock market data used for the calculation of SRISK can be found in Table 1, which covers the national returns, the return of the EURO STOXX Total Market Index, and the average across the returns of all banks in the sample. We observe that mean values are, on average, close to zero. The standard deviation is smaller in relative terms for the euro-area stock return compared to most of the national stock returns, suggesting diversification opportunities.

3.4 Descriptive Statistics

Table 2 shows summary statistics for SRISK at the national and the euro-area level. Panel (a) uses daily data, while Panel (b) uses annual data. On average, SRISK at the euro-area level is close to SRISK at the national level. In order to check whether the averages cloud relevant patterns of heterogeneity across countries or across time, Table 3 shows the number of banks for which the difference between SRISK at the euro-area level and SRISK at the national level is positive. Based on daily data, we first calculate the difference of a bank's SRISK between the two levels. We then average this difference for each bank by year. Based on these averaged differences, we count the number of banks per country for which the difference is greater than zero, i.e. the average contribution to systemic risk measured by SRISK is higher at the euro-area level.

Table 3 reveals a considerable degree of cross-country heterogeneity. One the one hand, there are countries like Germany where the majority of banks have a positive difference, i.e. a higher level of SRISK at the euro-area level. One the other hand, the number of banks with a positive difference is small in countries such as Greece. Even within some countries, there is heterogeneity across time. In France, for example, the number of banks with a euro-area effect increases in the crisis period.

Figure 1 plots SRISK, averaged across all listed banks within each of the 15 euro-area countries. It shows that national and euro-area SRISK increased substantially in 2007. On average, the contribution of listed banks to systemic risk during times of systemic distress has thus increased. These patterns are very similar when considering the national and the euro-area level. However, as Table 3 has already indicated, the time series of $\Delta SRISK$ averaged across all banks per country shows heterogeneity across countries and with regard to time. According to this measure, the contribution of banks to systemic risk in countries like Greece or Portugal was higher at the national level than at the euro-area level. For countries like Germany or the Netherlands, the average of $\Delta SRISK$ is often positive, reflecting the fact that SRISK is higher at the euro-area level than at the national level.[14]

[14] Even if there is a co-movement among the two measures, they can differ in their levels. Given that we denote SRISK in billion Euros, differences in the level can correspond to significant amounts.

4 Measuring Drivers of Systemic Risk

The systemic importance of banks might increase in their size, their risk, their degree of interconnectedness, and their exposure to macroeconomic risks (Cai et al. 2016, Laeven et al. 2016). In addition, structural characteristics of banking systems may affect the systemic importance of banks across countries. Next, we describe how we measure potential bank-level drivers of systemic risk.

4.1 Bank-Level Determinants of Systemic Risk

Banks' balance sheet and income statement data are taken from *Bankscope*. Given that the market data from *Datastream* are based on consolidated balance sheets, we resort to consolidated statements from *Bankscope* if available. The data appendix provides more detailed information on the variables used, and summary statistics are provided in Table 4. To correct the data for implausible values, we exclude observations for which total assets are missing. We drop observations if assets, equity, or loans are negative. We do the same if the variables expressed as percentages such as the liquidity ratio are negative or exceed 100%. We keep only banks with at least three consecutive observations. To correct for outliers, we winsorize the explanatory bank-level variables at the 1st and 99th percentile.

One key driver of systemic risk is *bank size*, which we measure through (log) total assets. Shocks to large banks can affect aggregate outcomes simply because of granularity effects (Bremus et al. 2013). But large banks can also benefit from a "too-big-to-fail" subsidy which might affect their risk-taking behavior (IMF 2014). Furthermore, the business models of larger banks differ from those of smaller banks (Laeven et al. 2016). They tend to be more complex in their organizational structure and to be more involved in market-based activities. All these features imply that large banks are systemically more important; hence we expect a positive effect of bank size. To capture the relative importance of a bank for the domestic economy, in robustness tests, we include a bank's total assets in % of GDP.

To capture characteristics of banks' *business models*, we include the ratio of loans to total assets as well as the share of non-interest income in total income. Previous studies show that banks which are more involved in non-traditional activities have a higher exposure to (systemic) risk (Brunnermeier et al. 2012, Demirgüç-Kunt and Huizinga 2010). From a theoretical point of view, the impact of banks' business models on systemic risk is not obvious ex ante. Whereas a more diversified portfolio which combines loans and other securitized assets can reduce banks' idiosyncratic risk of failure, market-based activities are often more volatile and thus more risky. For example, De Jonghe (2010) shows that non-interest generating activities increase banks' systemic risk exposure. DeYoung and Torna (2013) find for a sample of US banks that fee-based non-traditional activities lowered the risk of failure during the recent crisis, whereas asset-based non-traditional activities increased it.

The choice of the business model also determines the *profitability* of a bank, which we capture through its return on assets (RoA). The effect of RoA on systemic risk is not clear cut a priori. RoA can serve as a crude proxy for the market power of banks. The link between market power and bank risk-taking, in turn, is ambiguous. Many cross-country studies report a negative relationship between banks' market power and risk (Ariss 2010, Beck 2008, Schaeck et al. 2009). This negative relationship is in line with Allen and Gale (2004) and Martinez-Miera and Repullo (2010), who argue theoretically that less intense competition increases banks' margins and buffers against loan losses. However, banks with a high degree of market power may also inflict excessively high funding costs on corporate customers, ultimately leading to higher credit risk and bank instability (Boyd and De Nicoló 2005).

As a proxy for the failure risk of banks, we include the share of *non-performing loans* (NPL) in total loans. If the whole financial system is in distress and liquidity is scarce, banks with a high share of non-performing loans are likely to become distressed. For instance, if banks are forced to write down non-performing assets held at market prices, these fire sales can cause a further decline in prices. This can affect other banks with common exposures in case they also have to write down their respective assets (Allen et al. 2012).[15]

We also include a measure of *liquidity risk.* To capture liquidity risk stemming from the liability side of banks' balance sheets, we include the ratio of short-term deposits to total deposits. A high share can fuel unsound expansions of banks' balance sheets and the buildup of systemic risks (Perotti and Suarez 2009, Shin 2010). In the run-up to the recent crisis, for instance, banks' reliance on short-term debt led to an increase in leverage. This mechanism broke down as soon as banks encountered difficulties rolling over short-term debt to finance long-term assets due to freezes of the interbank market (Gale and Yorulmazer 2013). In robustness tests, we control for liquidity risk related to the structure of banks' assets and maturity mismatch. The former is measured as the ratio of liquid assets to total assets.[16] Maturity mismatch is defined as short-term debt relative to liquid assets. A high ratio of short-term deposits to liquid assets can reduce flexibility and result in losses if banks are forced to liquidate assets prematurely to meet unexpected demand for liquidity on the part of depositors (Allen and Gale 2000, Cifuentes et al. 2005).

Banks' capitalization can reflect their ability to withstand losses. However, given that capitalization is strongly related to our dependent variable that measures the capital shortfall during a systemic event, we only control for the *equity ratio* in robustness tests. Banks with a higher equity ratio have a larger buffer if negative shocks occur and shareholders have more

[15] Studies that analyze the relationship between asset commonality and systemic risk empirically include Blei and Ergashev (2014) and Lehar (2005).

[16] Liquid assets relative to total assets are included only in robustness tests given that they are highly correlated with the loan share.

incentives to monitor banks if a larger share of their capital is at stake. Thus, a higher equity ratio is expected to reduce banks' systemic risk.

Banks that have a larger contribution to systemic risk at the euro-area compared to the national level and vice versa might differ in their balance sheet characteristics. Thus, in Table 5, we show summary statistics for the bank-level variables from *Bankscope* for the subsample of observations for which $\Delta SRISK$ is smaller than zero (Columns 1-2), i.e. SRISK measured at the euro-area level is smaller than SRISK measured at the national level, and the subsample for which $\Delta SRISK$ is larger than zero (Columns 3-4). After testing whether the means between those subsamples are significantly different, we find that banks that have a higher SRISK at the euro-area level have, for example, a lower equity ratio, a lower loan share and a lower return on assets ratio. Interestingly, those banks that have a higher SRISK at the national level tend to have, on average, a greater relevance for the domestic economy in terms of the bank assets-to-GDP ratio, though the means are not significantly different between the two groups. In the following regression analysis, we will examine whether these determinants matter differently for systemic risk depending on the considered regional level.

We also relate SRISK to information about the *complexity* of banks' (international) activities. The more complex the international organization of a bank, the more difficult it will be to restructure and possibly resolve in times of distress. This, in turn, may create bailout expectations. In fact, the classification of banks as G-SIFIs by the FSB has increased the implicit state subsidies enjoyed by these banks (SVR 2014). Implicit subsidies may be particularly relevant for large banks, given that no effective regime for the resolution of large, internationally active banks was in place during the time period of our study. Even though the international reform agenda is moving in the right direction, bank resolution is still largely uncharted territory. We thus control for the assignment of the G-SIFI status by the FSB by creating a dummy which equals one for the years in which a bank was considered a G-SIFI and zero otherwise. Furthermore, we construct a dummy variable for SSM banks that equals one if a bank took part in the ECB's first comprehensive assessment as announced in 2013 and zero otherwise.

Also, we capture the degree of complexity of international banks by drawing on data provided by the *Bankscope Ownership Module.* This data source contains information on banks' subsidiaries and allows two measures of a bank's degree of internationalization to be calculated, whereas we consider only banks' subsidiaries for which the headquarters is the direct (level one) and ultimate (at least 50%) owner. First, we calculate the share of foreign subsidiaries in total subsidiaries. To differentiate between banks with a high share of foreign subsidiaries, we create a dummy that is one if this share is larger than the sample average. Banks with a higher share of foreign subsidiaries might be more difficult to resolve as different national authorities have to coordinate their actions and distribute the losses. Second, geographical complexity (or diversification) is measured as a normalized Herfindahl index (HHI) across the different regions in which a bank's domestic and foreign subsidiaries are located (Cetorelli and Goldberg 2014). It is defined such that higher values indicate a higher degree of complexity, i.e. the bank has subsidiaries equally distributed across many different countries. Banks with a higher degree of geographical complexity might have more diversification opportunities and be able to buffer country-specific shocks. We again determine an indicator variable that is one if a bank has a high geographical HHI (above the sample average) and zero otherwise.

Following the criteria chosen by the ECB to determine whether a bank should be supervised by the SSM, we also control for *financial assistance*. To do so, we draw on the *European Commission's* State Aid Register (European Commission 2015). We create a dummy which equals one if the bank has received state aid and zero otherwise. More specifically, whenever a bank in our sample appears as a case in the State Aid Register, we assign a value of one to the state aid dummy at the time when the decision about the state aid request was made.

In Table 6, we show the average values of SRISK for subsamples of banks. We differentiate between banks that have received state aid at time *t*, have been assigned the G-SIFI status at time *t*, and SSM banks. On average, SRISK is higher for banks classified as G-SIFIs compared to those banks which have not been assigned G-SIFI status. Average values are also larger for banks which have received state aid or are supervised by the SSM. This points toward the fact that ECB criteria such as financial assistance indeed matter for systemic risk, and also that established classifications for whether a bank is systemically important such as G-SIFI status correlate with our measure for systemic risk.

4.2 Country-Level Determinants of Systemic Risk

To control for the general macroeconomic environment, we include in our regression model a country's annual GDP growth and the inflation rate. In robustness tests, we add further macro controls. We include a country's government debt relative to GDP and the ratio of domestic credit to GDP. Higher public debt positions might reflect unsustainable fiscal policies, and higher private credit-to-GDP ratios might capture higher levels of financial development but can also be related to unsound expansion in the financial sector.

In line with the ECB's criteria for determining whether a bank falls under the SSM, we also look at banks' international activities. Unfortunately, bank-level data on banks' cross-border activities is not publicly available. We thus resort to aggregate data on banks' cross-border activities from the Consolidated Banking Statistics of the *Bank for International Settlements* to measure the importance of cross-border activities. Figure 2 plots cross-border exposures of a country's banking system against the average SRISK across all banks in the respective country. In countries in which banks maintain significant cross-border activities, average

SRISK seems to be higher than in financially less open countries. To obtain at least a proxy for banks' degree of internationalization, we use data from the *Bankscope Ownership Module* as described above. This allows us to control for a bank's ratio of foreign subsidiaries to total subsidiaries as well as the spread of subsidiaries across geographical regions.

Finally, we control for economic health and competitiveness by including a country's current account (in % of GDP). The sustainability of the banking system as a whole is captured by including the aggregate capital to assets ratio.

5 Regression Results

5.1 The Empirical Model

With measures of systemic risk and data on potential drivers of such risk at hand, we can now turn to our second research question: What are the determinants of banks' contribution to systemic risk at the national level compared to the euro-area level? And do the drivers of systemic risk differ at the national level and at the euro-area level?

We estimate an empirical model similar to Laeven et al. (2014, 2016), explaining SRISK derived from equations (5)-(6) by bank-level variables:

$$SRISK_{ijt}^{R} = \alpha_i + \gamma_t + \beta_1 \Delta GDP_{jt} + \beta_2 Inf_{jt} + \beta_3 X_{ijt-1} + \beta_4 G-SIFI_{ijt} + \beta_5 StateAid_{ijt} + \varepsilon_{ijt} \quad (8)$$

Our panel consists of $i = 1, \ldots, 75$ banks across $j = 1, \ldots, 15$ countries and $t = 2005, .., 2013$ years, where R denotes the level at which systemic risk is measured, that is euro-area (EA) or national (N). We account for bank-invariant characteristics by including bank fixed effects α_i. Common macroeconomic developments are captured through year fixed effects (γ_t). To account for time-varying developments at the country level, we include GDP growth and the inflation rate.[17]

Time-varying, bank-specific factors are captured by X_{ijt-1}. These include proxies for bank size (log of total assets), the business model (loan share, share of non-interest income), profitability (RoA), the quality of loans (share of non-performing loans), liquidity risk (share of short-term debt). In addition, we include a G-SIFI dummy ($G-SIFI_{ijt}$), which is equal to one if a bank is assigned G-SIFI status at time t and zero otherwise, and a dummy for $StateAid_{ijt}$, which equals one if a bank received state aid in a particular year and zero otherwise. Standard errors are clustered at the level of the individual bank.[18]

[17] We control for alternative country-level drivers of systemic risk in robustness tests.

[18] We have also conducted regressions with two-way clustering to control for serial correlation across time for one bank and serial correlation across banks for one year. Results can be obtained upon request.

To compare whether the impact of a given variable differs from a national or European viewpoint, we additionally run seemingly unrelated regressions based on our estimation sample with (i) $SRISK^{EA}$ and (ii) $SRISK^{N}$ as the dependent variables. We then conduct Chi-squared tests of equality of coefficients resulting from these regressions. In the regression tables, we report the difference in coefficients joint with the statistical significance of these tests.

5.2 Baseline Regression Results

In Table 7, we regress SRISK measured at different regional levels on bank-level variables capturing possible drivers of risk. Columns 1-3 show results for the full sample of banks over the period 2005-2013. Columns 4-6 focus on the crisis period (2007-2012). This takes into account that the outbreak of the financial crisis represents a structural break in financial markets and was accompanied by changes in the regulatory framework. This, in turn, might impact the relevance of some drivers of systemic risk.

For the full sample, we find a positive and significant relationship between bank size and systemic risk. This finding is not very surprising, given that large banks are typically considered to be more systemically important than smaller banks. It also confirms previous research (Laeven et al. 2014, 2016). The effect of bank size becomes more pronounced during crisis times (Columns 4-5). For both samples, we find that size matters significantly more for the national contribution to systemic risk (Columns 3 and 6). Our proxy for bank size – the log of total assets – does not answer the question as to through which channel large banks become systemically important. Large banks, for instance, are more active internationally than smaller banks, and they operate with more complex business models. In Section 5.3, we will thus include interactions between size and other bank-level explanatory variables to learn more about the specific links between size and systemic risk.

Two additional variables, the G-SIFI dummy and the dummy for state aid, capture the impact of bank size and show, at the same time, the role of regulatory policy. The correlation between the dummy indicating whether a bank has received state aid and systemic risk is positive and highly significant. Again, this is not very surprising because rescue measures were targeted at the larger banks in financial distress. However, given that the proxy for bank size does not lose significance when we include the dummy for state aid, this suggests that additional information is included in the later variable. The G-SIFI dummy becomes significant only for the crisis sample. This might go back to the fact that banks received G-SIFI status only from 2011 onwards, which, in this reduced sample, gives the variable higher explanatory power.

We measure the retail orientation of a bank using the loan share and the share of non-interest income in total income. The link between a bank's business model and its contribution to systemic risk is not clear-cut. On the one hand, banks with a high share of loans in total assets have a lower degree of systemic risk, and this effect is more pronounced for the crisis period. The point estimate (in absolute terms) is higher for SRISK at the national market. The difference in the point estimates is also statistically significant as shown by the result of the Chi-squared test for equality of coefficients in Column 3.[19] On the other hand, banks with a higher share of non-interest income contribute (weakly) less to systemic risk during crisis times. Overall, these findings caution against jumping to conclusions regarding the superiority of specific business models when it comes to the contribution to systemic risk.

Another variable which has a quite robust and significant correlation with systemic risk is bank profitability. More profitable banks have a higher level of systemic risk. This effect does not differ much across regional levels. One explanation for this positive correlation could be that banks' returns are used to calculate both, RoA and SRISK. However, we derive our explanatory variable for profitability from annual balance sheet data whereas SRISK is calculated from daily stock market data. This should weaken concerns that the correlation between SRISK and profitability is spurious. In robustness tests, we exclude profitability (Table 11) from the set of explanatory variables, and the main results are unchanged.

The non-performing loan ratio has a positive sign – banks with a higher share of bad loans in their balance sheet contribute more to systemic risk. While the coefficient is not significant itself, the result in Columns 3 and 6 implies that the effect is stronger at the euro-area level. Our proxy for banks' exposure to liquidity risk is insignificant in both samples. This holds for the short-term debt ratio as well as for the liquid assets to total assets ratio (Table 11). One channel through which an aggregate shortage of capital in the banking system could affect individual banks is their ability to liquidate assets prematurely. Therefore, one would expect liquidity risk to matter. Our results suggest, instead, that systemic risk is driven mostly by the profitability of a bank and the structure of its assets.

5.3 Interactions with Size Measures

Size is an important factor affecting banks' contribution to systemic risk (Laeven et al. 2016). Some reform proposals thus go so far as to impose outright restrictions on bank size (Johnson and Kwak 2010). However, bank size might be a proxy for other factors that affect banks' contribution to systemic risk, such as the degree of internationalization or the degree of interconnectedness. Also, size is an important criterion of whether a bank is supervised by the SSM. Hence, our sample of SSM banks includes mostly large banks, and a supervisor might need to know which criteria besides size matter for banks' contribution to systemic risk.

[19] E.g. an increase of the loan share by one standard deviation relates to a euro-area (national) SRISK reduced by 2.87 (2.98) billion Euros.

In order to analyze whether the determinants of systemic risk are different for large and small banks, Table 8 includes interactions of bank-level variables and bank size measured by the log of total assets (Columns 1-2)[20] as well as the dummy that indicates whether a bank is supervised by the SSM (Columns 4-5). Large banks may, for instance, rely more on short-term financing, which exposes them to rollover risk if liquidity shocks occur. Large banks might also find it easier to diversify and invest in non-traditional activities like trading. These, in turn, could affect banks' contribution to systemic risk (Gennaioli et al. 2013).

The first result is that, when including interaction terms with log of total assets, the remaining variables by and large retain their signs. Statistical significance increases. Also, we find that a higher share of non-performing loans is positively and significantly related to SRISK. The share of non-interest income gains in significance. Turning to the significance of the interaction terms, we find that the negative impact of non-interest income on systemic risk, the positive impact of profitability, and the positive effects of non-performing loans seem to be stronger for the larger banks.

To obtain a more comprehensive view on the relationship between size and bank-level determinants of systemic risk, we plot average marginal effects of the different explanatory variables conditional on bank size (Figures 3 and 4). These plots show how the economic importance of each of the drivers of systemic risk varies with bank size. The plots confirm the results of the point estimates: the share of loans in total assets is highly significant and negative for a bank of average size. The sign of the non-interest income even reverses itself: it is positive for smaller banks but turns negative when bank size increases. This illustrates the fact that determinants of systemic risk are not homogeneous across banks but can differ for small and large banks. The marginal effects of the return on assets ratio and the non-performing loans ratio are significantly positive for larger banks, and they increase with bank size.

Regarding the interaction of the SSM dummy with bank-level variables, our results suggest that bank size and the loan share are significantly related to SRISK for non-SSM banks (Table 8, Columns 4-5). Banks that are supervised by the SSM contribute differently to systemic risk: the interaction term is significantly negative for the share of non-interest income, and significantly positive for profitability and the share of non-performing loans.[21]

In sum, we find no qualitative differences in the drivers of systemic risk whether we take a national or European perspective. However, the quantitative magnitudes are significantly different for some variables like the loan share or profitability. For example, at the national

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[20] Note that we have standardized the bank-level variables. The sign and significance of the single terms represent the effect for the average bank, i.e. the other variable of the interaction term is at its mean.

[21] Note that a dummy for the establishment of the SSM is not included because it is captured by bank fixed effects.

level, systemic risk decreases by more compared to the euro-area level if banks have a higher loans share, and this effect is stronger for larger banks (Column 3). This suggests that a more traditional business model as captured by a higher loan share is likely to generate a buffer against systemic shocks. Yet, the economic magnitudes of the effects differ between the national and the European level. The reason for that might be that banks that operate more at the supranational level are more engaged in wholesale activities.

5.4 Interactions with Internationalization Measures

Another dimension of systemic risk is a bank's degree of internationalization. Figure 2 provides an initial indication that average SRISK is higher in countries in which the banking system has a higher volume of cross-border activity. A priori, the effect of financial integration on systemic risk is not obvious. One the one hand, more international links among banks can be a source of systemic risk if they facilitate the spillover of shocks. One the other hand, well-distributed international exposures can serve as buffers against domestic shocks and offer diversification opportunities. Also, Hale and Obstfeld (2016) show that greater financial integration in the euro area fostered the build-up of large current account imbalances in the peripheral countries. To obtain some insights into the effects at work, we interact the bank-level determinants of systemic risk with indicator variables for (i) banks' share of foreign subsidiaries and (ii) banks' degree of diversification regarding the distribution of subsidiaries across different regions.[22]

Results are shown in Table 9. For the average bank, we find that a higher share of foreign subsidiaries relates positively to banks' contribution to systemic risk (Columns 1-2). The relationship becomes stronger for banks with a higher share of non-interest income and more profitable banks. In contrast, a higher degree of geographical diversification shows a negative sign but does not have a significant effect for the average bank (Columns 4-5). The reduction of systemic risk due to diversification is more pronounced for banks with a higher share of non-interest income. This again points in the direction that the negative correlation of non-interest income with systemic risk is attributable to diversification opportunities.

5.5 Robustness Tests

We test the robustness of our results by changing the sample, including additional bank-level variables, controlling for short-sale bans and modifying the way in which SRISK has been calculated. These tests are conducted in six steps.

First, we restrict the sample to cover only banks that are supervised by the SSM (Table 10). In line with the results in Table 8 where we interacted bank-level variables with the SSM dummy, we find that bank size is to a minor extent associated with SRISK. This can go back

[22] See the data appendix or section 4.1 for a detailed description of these variables.

to the fact that the sample of SSM banks is a rather homogeneous sample in terms of bank size, i.e. only large banks are included, causing bank size to lose explanatory power. For this sample, size has a stronger qualitative effect for banks' contribution to systemic risk at the national level.

Regarding the other bank-level variables, we confirm that systemic risk decreases in the share of loans on banks' balance sheets and increases in the degree of profitability. In this reduced sample, significance tends to be stronger. As already indicated by the significant results for the interaction terms of the bank-level variables and the SSM dummy (Table 8, Columns 4-5), for the sample of SSM banks, we find that the ratio of non-interest income to total income and the share of non-performing loans correlate significantly with banks' systemic risk. As observed in Table 7, the G-SIFI dummy only becomes significant during the crisis period.[23]

Second, we vary bank-level determinants of systemic risk (Table 11). We exclude the variable return on assets which might be correlated with a bank's stock market returns and thus SRISK (Columns 1-2) and include the equity ratio (Columns 3-4). We confirm the results for bank size, the loan share, and the state aid dummy if we exclude the return on assets. Including the equity ratio affects the significance of bank size, which might be due to multicollinearity. The other variables remain significant while the equity ratio itself is significant with a negative sign, suggesting that banks' contribution to systemic risk decreases as the capital buffer increases.

In Columns 5-6, we include the ratio of short-term debt to liquid assets to capture a bank's maturity mismatch. The higher the short-term debt is relative to liquid assets, the more difficult it is to meet unexpected withdrawals of short-term deposits. The ratio of short-term debt to total liabilities is excluded as the two variables are both composed of the short-term debt position. As expected, banks with a higher reliance on short-term funding but lower amounts of liquid assets, have a higher contribution to systemic risk.

In Columns 7-8, we include the market-to-book value of equity, whereas higher values indicate that the market has a positive assessment of the bank's performance. However, this variable has no significant coefficient. To test whether we also observe a positive effect if we control for a bank's relative importance for the economy, we include a bank's total assets to GDP (in %) instead of the log of total assets (Columns 9-10). The significant and positive coefficient reflects the fact that the relative importance of a bank for the economy, too, relates to banks' contribution to systemic risk. Our final control variable is the ratio of liquid assets to

[23] We have also conducted robustness tests restricting the sample to developed countries following the "MSCI Global Investable Market Indices Methodology" as of 2013. Excluding Cyprus, Malta, Slovakia and Slovenia, results remain robust for the crisis sample. Coefficients partially lose significance for the full sample period, most likely due to reduced sample size.

total assets which we include instead of the loan share (Columns 11-12). However, this dimension of liquidity does not seem to play a relevant role within our regression sample.

Third, we include other macro controls (Table 12). Our main result for the positive relationship of bank size, a lower loan share and higher profitability with systemic risk remain mostly robust. As regards the additional control variables, banks contribute more to systemic risk if the economy is highly leveraged, i.e. when public debt or domestic credit are high.

Fourth, we change the way the SRISK measure is calculated (Table 13). In Columns 1-2, we take the log of SRISK to account for skewness in the distribution. In Columns 3-4, we do not base the calculation of SRISK on the market index but exchange it by a stock price index related to the banking sector. In Columns 5-6, we do not take the mean across daily SRISK values to aggregate to the annual level, but we take the median to reduce the effect of outliers. In Columns 7-8, we set the prudential capital ratio to 5.5 (Acharya and Steffen 2014). In general, our results remain robust for bank size, the loan share, and the state aid dummy. The coefficient of return on assets partly loses in significance while keeping its positive sign.

Fifth, we account for the fact that, during the financial crisis, several countries introduced short-sale bans. This could result in mispricing and thus introduce distortions in the calculation of SRISK. According to Beber and Pagano (2013), there are ten countries in our sample which introduced such bans in the years 2008-2009.[24] This should reduce concerns about confounding factors in the pricing of financial stocks at different points in time for different countries. Also, we average the daily SRISK series to aggregate it to the yearly frequency. This helps further reduce confounding pricing factors that prevail only in the short run.

To verify whether the introduction of short-sale bans affects our regression results, we include a dummy variable that takes a value of one for the period 2008-2009 and the countries that introduced a short-sale ban. The results remain in general robust (Table 14). Only the coefficient of the non-interest income for the crisis sample loses significance. The short-sell ban variable itself has a positive and significant coefficient. This suggests that banks' systemic riskiness has been at higher levels during periods, in which a country maintained a short-sell ban.

Finally, we account for the fact that euro-area stock market indices can be driven by national developments, but more importantly, that national stock market indices can be driven by euro-area developments. Euro-area and national stock market indices are used to calculate SRISK at the euro-area and national level, respectively. Hence, this can imply that the systemic risk measure at the two regional levels are not completely separable and contain partly the same

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[24] Austria, Belgium, France Germany, Greece, Ireland, Italy, Netherlands, Portugal, and Spain introduced short-sale bans in September or October 2008 for around 234 to 277 days.

information. Thus, we conduct an additional set of robustness tests, which are shown in Table 15 and briefly summarized below. For more details on data and estimations regarding this part of the robustness tests, please see Appendix A.

For comparison, the first two columns of Table 15 show the result of our baseline model where the dependent variable is either SRISK at the euro-area level (Column 1) or SRISK at the national level (Column 2). In Column 3, we compute banks' SRISK at the euro-area level but use MSCI stock market indices for the euro area, which exclude the national index from the respective banks' country of location. This reduces national influences from the euro-area index. For comparison, we repeat the analysis using the MSCI national stock market index to compute banks' SRISK at the national level (Column 4).

To further address this concern, we extract euro-area developments from national stock returns to improve upon the measurement of banks' systemic risk at the national level. We make use of a principal component analysis to generate a euro-area factor that is common to all sample countries. This common factor is used to extract euro-area developments from national stock market returns by means of a regression analysis. The residuals of this regression analysis, which reflect developments that can not be explained by euro-area factors, are used for the calculation of banks' SRISK at the national level. Columns 5 and 6 show results derived from two different ways of generating the euro-area factor.

In sum, our results remain robust across the different specifications. This holds for sign and significance of the coefficients. The non-interest income variable now also turns significant, which has been previously observed only for the crisis sample. However, bank size captured by the log of total assets loses significance. Part of this result might be explained by the G-SIFI dummy becoming significant in Columns 3-6.[25]

6 Concluding Remarks

The establishment of the European Banking Union shifted the regulation and supervision of systemically important banks to the euro-area level. The ECB-based, centralized Single Supervisory Mechanism (SSM) is designed to apply uniform microprudential rules across countries. While national supervisors are mainly in charge of macroprudential policies, the SSM has the power to tighten certain national macroprudential policies. Whether or not it is in the interest of the European supervisor to overrule national macroprudential authorities depends, inter alia, on their assessment of systemic risk. In this paper, we analyze whether the drivers of systemic risk differ depending on whether regulators adopt a national or a European perspective.

[25] For brevity, we only report results for the full sample. Conclusions are qualitatively the same for the crisis sample and are available upon request.

We use a measure of systemic risk – SRISK – that was proposed by Brownlees and Engle (2017). SRISK measures the marginal contribution of a bank to an aggregate shortfall of capital in the banking system. We calculate this measure for about 80 publicly listed European banks. Our sample spans the years 2005-2013. We distinguish between the contribution of banks to a shortfall of capital at the national and at the euro-area level. The two measures of systemic risk can differ because banks have different market shares at home and abroad or because they have different degrees of diversification and thus different return correlations. We then analyze the determinants of systemic risk at the national and at the euro-area level. Our research delivers three main findings.

First, on average, banks' contribution to systemic risk at the national level is slightly higher than that at the euro-area level. This suggests that most banks have stronger links with national than euro-area stock markets. Based on this assessment, a national supervisor would be more likely than a supranational supervisor to consider a bank to be systemically relevant. However, this does not hold for all banks and countries in the sample. Especially large and internationally active banks with, presumably, a higher exposure to other euro-area countries are likely to contribute more to systemic risk at the euro-area level. As regards time trends, systemic risk increased during the recent financial crisis.

Second, we analyze the determinants of banks' contribution to systemic risk. Systemic risk increases in bank size and in bank profitability. There is no direct link between the reliance of banks on more traditional activities and the degree of systemic importance: banks with a high share of loans are less systemically important, yet the same holds for banks with a high share of non-interest income in total revenue. These results are stronger for the larger banks in the sample. We do not find a significant relationship between liquidity risk on the asset or the liability side of the balance sheet and systemic risk.

Third, the main qualitative results hold irrespective of the regional level considered. This might suggest that there is no trade-off in assigning macroprudential oversight to the national level versus the euro-area level as concerns the micro-level determinants of bank risk. But while the determinants do not change with the regional level, banks' contribution to systemic risk can still differ in magnitude. Our results show that there can be specific features which explain why banks' contribution to systemic risk at the national level is different from that at the euro-area level. The mitigating impact of the loan share on systemic risk, for instance, is stronger at the national level than at the euro-area level.

Our results have a couple of interesting implications for the regulatory debate. The fact that the qualitative determinants of systemic risk differ little between regulatory levels implies that incentives for information collection should be largely aligned. The reason is that national and supranational supervisors might want to gather information on the same variables driving banks' systemic riskiness. At the same time, this does not mean that incentives for regulatory intervention might be aligned as well. The political economy of interventions may well differ across regional levels, but an analysis of a potential "inaction bias" would require taking a look at actual supervisory action. However, analyzing actual regulatory action is beyond the scope of the present study. Also, our results suggest that some drivers of systemic risk, such as bank profitability, are not included in the standard classification schemes for significant institutions and should thus be subject to additional surveillance.

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Data Appendix

To measure a bank's contribution to systemic risk, we calculate the SRISK measure, which is derived from data obtained from *Datastream*. In order to analyze the determinants of banks' contribution to systemic risk, we rely on various data sources. Balance sheet data are taken from *Bankscope*. We complement the dataset by information on ownership obtained from the *Bankscope Ownership Module*, state aid data from the *European Commission*, and country-level controls provided by the *International Monetary Fund* (IMF), the *World Bank*, and the *Bank for International Settlements* (BIS).

List of Banks

The following list contains all banks included in our sample. While 110 banks were listed in the euro area as of January 2014, *Datastream* provides only yearly data on the book value of total liabilities and the daily market value of equity measured as shares outstanding times share price for 97 banks. 7 banks with poor trading frequency are dropped because the GJR-GARCH model could not estimate time-varying volatilities due to insufficient fluctuation in the stock market data. Further, we drop 10 institutions with a market capitalization of less than 100 million euros as of 31 December 2007. For the remaining 80 banks, we calculate SRISK and match *Bankscope* by using the ISIN number.

Name of Bank	Country
Bank für Tirol und Vorarlberg AG-BTV (3 Banken Gruppe)	AUSTRIA
BKS Bank AG	AUSTRIA
Erste Group Bank AG	AUSTRIA
Oberbank AG	AUSTRIA
Raiffeisen Bank International AG	AUSTRIA
Dexia SA	BELGIUM
KBC Groep NV/ KBC Groupe SA-KBC Group	BELGIUM
Bank of Cyprus Public Company Limited-Bank of Cyprus Group	CYPRUS
Hellenic Bank Public Company Limited	CYPRUS
Aktia Bank Plc	FINLAND
Alandsbanken Abp-Bank of Aland Plc	FINLAND
Pohjola Bank plc-Pohjola Pankki Oyj	FINLAND
Banque de la Réunion SA	FRANCE
BNP Paribas	FRANCE
C.R. de Crédit Agricole Mutuel Atlantique Vendée SC-Crédit Agricole Atlantique Vendée	FRANCE
C.R. de Crédit Agricole Mutuel Brie Picardie SC-Crédit Agricole Brie Picardie	FRANCE
C.R. de Crédit Agricole Mutuel de la Touraine et du Poitou SC-Crédit Agricole de la Touraine et du Poitou	FRANCE
C.R. de Crédit Agricole Mutuel de l'Ille-et-Vilaine SA-Crédit Agricole de l'Ille-et-Vilaine	FRANCE
C.R. de Crédit Agricole Mutuel de Normandie-Seine	FRANCE
C.R. de Crédit Agricole Mutuel de Paris et d'Ile-de-France SC-Crédit Agricole d'Ile-de-France	FRANCE
C.R. de Crédit Agricole Mutuel du Languedoc SC	FRANCE
C.R. de Crédit Agricole mutuel du Morbihan SC-Crédit Agricole du Morbihan	FRANCE
C.R. de Crédit Agricole Mutuel Nord de France SC-Crédit Agricole Nord de France	FRANCE
C.R. de Crédit Agricole Mutuel Sud Rhône-Alpes SC-Crédit Agricole Sud Rhône Alpes	FRANCE
C.R. de Crédit Agricole Mutuel Toulouse 31 SC-Crédit Agricole Mutuel Toulouse 31 CCI	FRANCE
Crédit Agricole S.A.	FRANCE
Crédit Industriel et Commercial SA - CIC	FRANCE
Natixis SA	FRANCE
Société Générale SA	FRANCE
Commerzbank AG	GERMANY
Deutsche Bank AG	GERMANY
Deutsche Postbank AG	GERMANY
IKB Deutsche Industriebank AG	GERMANY
Oldenburgische Landesbank - OLB	GERMANY

Quirin Bank AG	GERMANY
Alpha Bank AE	GREECE
Attica Bank SA-Bank of Attica SA	GREECE
Eurobank Ergasias SA	GREECE
General Bank of Greece SA	GREECE
National Bank of Greece SA	GREECE
Piraeus Bank SA	GREECE
Allied Irish Banks plc	IRELAND
Bank of Ireland-Governor and Company of the Bank of Ireland	IRELAND
Banca Carige SpA	ITALY
Banca Finnat Euramerica SpA	ITALY
Banca Monte dei Paschi di Siena SpA-Gruppo Monte dei Paschi di Siena	ITALY
Banca Piccolo Credito Valtellinese-Credito Valtellinese Soc Coop	ITALY
Banca Popolare dell'Emilia Romagna	ITALY
Banca Popolare dell'Etruria e del Lazio Soc. coop.	ITALY
Banca Popolare di Milano SCaRL	ITALY
Banca Popolare di Sondrio Societa Cooperativa per Azioni	ITALY
Banca Popolare di Spoleto SpA	ITALY
Banca Profilo SpA	ITALY
Banco di Desio e della Brianza SpA-Banco Desio	ITALY
Banco di Sardegna SpA	ITALY
Banco Popolare - Società Cooperativa-Banco Popolare	ITALY
Credito Emiliano SpA-CREDEM	ITALY
Intesa Sanpaolo	ITALY
Mediobanca SpA-MEDIOBANCA - Banca di Credito Finanziario Società per Azioni	ITALY
UniCredit SpA	ITALY
Unione di Banche Italiane Scpa-UBI Banca	ITALY
Bank of Valletta Plc	MALTA
HSBC Bank Malta Plc	MALTA
Lombard Bank (Malta) Plc	MALTA
ING Groep NV	NETHERLANDS
Van Lanschot NV	NETHERLANDS
Banco BPI SA	PORTUGAL
Banco Comercial Português, SA-Millennium bcp	PORTUGAL
Banco Espirito Santo SA	PORTUGAL
Vseobecna Uverova Banka a.s.	SLOVAKIA
Abanka Vipa dd	SLOVENIA
Nova Kreditna Banka Maribor d.d.	SLOVENIA
Banco Bilbao Vizcaya Argentaria SA	SPAIN
Banco de Sabadell SA	SPAIN
Banco Popular Espanol SA	SPAIN
Banco Santander SA	SPAIN
Bankia, SA	SPAIN
Bankinter SA	SPAIN
Caixabank, S.A.	SPAIN
Liberbank SA	SPAIN

Bank-Level Data

Equity ratio: We use the equity to total assets ratio (in %), *Bankscope*.

Liquid assets: The liquidity ratio (in %) is defined as the ratio of banks' liquid assets to total assets, *Bankscope*.

Loan share: The variable loan share is defined as the ratio of total loans to total assets (in %), *Bankscope*.

Market to book value: The market to book value of equity is calculated from *Datastream/ Worldscope* and defined as the market value of the ordinary (common) equity divided by the balance sheet value of the ordinary (common) equity in the company.

Maturity mismatch: Maturity mismatch is defined as the ratio of short-term deposits to liquid assets (in %), *Bankscope.*

Non-interest income: We use non-interest income relative to total income (gross interest income and non-interest income) (in %), *Bankscope*.

Non-performing loans (NPL): The NPL ratio is defined as impaired loans over gross loans (in %), *Bankscope*.

Return on assets (RoA): RoA is the ratio of operating profits to total assets (in %), *Bankscope*.

Short-term debt: To measure banks' reliance on short-term funding, we use the sum of deposits from banks, repos and cash collateral, plus other deposits and short-term borrowing over total liabilities (in %), *Bankscope*.

Total assets: We use the logarithm of banks' total assets (in thousands of USD, %), *Bankscope*.

Total assets to GDP: To capture a bank's relative importance for the domestic economy, we calculate the ratio of a bank's total assets to a country's gross domestic product (in %), *Bankscope, IMF*.

Internationalization: We use the *Bankscope Ownership Module* to obtain information on a bank's degree of internationalization. The ownership data give information about banks' subsidiaries, their type, and the country in which they are located. We only keep level one subsidiaries that are owned by more than 50% by the parent bank because we have this information for all years. These data are used to calculate two measures:

First, we derive a normalized Herfindahl index (HHI) capturing geographical complexity (or diversification) following Cetorelli and Goldberg (2014). The HHI is defined as follows: $HHI_i = \frac{R}{R-1}(1-\sum_{i=1}^{R}(\frac{count^i}{totalcount^i})^2)$ where R is the number of geographical regions in which banks' subsidiaries are located. The regions encompass the euro area, the UK, Japan, South Korea, China, Canada, the USA, Taiwan, Middle East, other Americas, other Europe, Eastern Europe, other Asia, other. The HHI is defined between zero, lowest complexity, and one, highest complexity. Based on this HHI, we create a dummy which equals one if the bank's geographical complexity exceeds the sample average, and zero otherwise.

Second, we calculate a bank's share of foreign subsidiaries to total subsidiaries (in %). We then define a foreign subsidiaries dummy variable that equals one if a bank has a share of foreign subsidiaries that is larger than the sample average, and zero otherwise.

SSM bank: We create a dummy which equals one throughout the sample period if a bank was required to participate in the comprehensive assessment conducted by the ECB together with national authorities in the context of the establishment of the Single Supervisory Mechanism (SSM), and zero otherwise. See ECB (2013). Note: Comprehensive Assessment. http://www.ecb.europa.eu/press/pr/date/2013/html/pr131023.en.html

G-SIFI: We create a dummy which equals one if a bank was assigned the status of global systemically important financial institution (G-SIFI) by the *Financial Stability Board* for a given year and zero otherwise.

State aid: We make use of the State Aid Register provided by the *European Commission*, which gives information on support measures like recapitalization or the provision of guarantees for individual banks. If a bank is listed as a case and received any kind of state aid, we assign a value of one at the decision date of the support measure, and zero otherwise.

Data Used to Calculate Systemic Risk (SRISK)

Book value of total liabilities: Total liabilities represent all short and long-term obligations expected to be satisfied by the company (*Datastream/Worldscope*). The book value of liabilities includes, but is not restricted to: Current Liabilities, Long Term Debt, Provision for Risk and Charges (non-U.S. corporations), Deferred taxes, Deferred income, Other liabilities, Deferred tax liability in untaxed reserves (non-U.S. corporations), Unrealized gain/loss on marketable securities (insurance companies), Pension/Post retirement benefits, Securities purchased under resale agreements (banks). The book value of liabilities excludes: Minority Interest, Preferred stock equity, Common stock equity, Non-equity reserves.

Market index: We use the EURO STOXX Total Market Index (TMI). This index is a regional subset of the STOXX Europe TMI Index which covers approximately 95% of the free float market capitalization of Europe = 552 constituents. With a variable number of components, the EURO STOXX TMI Index represents a broad coverage of euro-area companies. The index comprises Austria, Belgium, Cyprus, Finland, France, Germany, Greece, Ireland, Italy, Malta, the Netherlands, Portugal, Slovenia and Spain. The EURO STOXX TMI comprises large, mid and small-capitalization indices: the EURO STOXX TMI Large Index, the EURO STOXX TMI Mid Index and the EURO STOXX TMI Small Index (*www.STOXX.com*). Index returns are calculated as 1 day change with natural logs.

Bank index: We use the *Datastream* Bank Index (DS-Banks). Indices are calculated on a representative list of stocks for each market and bank indices are market value weighted. The sample covers a minimum of 75-80% of total bank market capitalization. The index is available for Austria, Belgium, Cyprus, Finland, France, Germany, Greece, Ireland, Italy, Malta, the Netherlands, Portugal, Slovenia, Spain, and the EMU market. Index returns are calculated as 1 day change with natural logs.

Market value of equity: Market value is the share price multiplied by the number of ordinary shares in issue. The amount in issue is updated whenever new tranches of stock are issued or after a capital change. For companies with more than one class of equity capital, the market value is expressed according to the individual issue (*Datastream/Worldscope*).

National market indices: For the national stock index, we use the STOXX Country Total Market Indices (TMI) representing the relevant country as a whole. It covers approximately 95% of the free float market capitalization of companies in the represented country, with a variable number of components (*www.STOXX.com*). Index returns are calculated as 1 day change with natural logs.

Stock prices: Stock prices of market listed banks (*Datastream/Worldscope*). Stock returns are calculated as 1 day change with natural logs.

Country-Level Variables

Bank capital: Aggregate bank capital to assets (in %) is obtained from the *World Bank*.

Cross-border exposures: To capture banks' foreign activities, we use cross-border assets of banking systems (in % of GDP) from the Consolidated Banking Statistics of the *BIS*. Cross-border assets of banking systems are provided by the *BIS* at the quarterly level and we use end-of-year values to aggregate them to the annual frequency. These data are only available at the country level.

Current account: The current account (CA) in % of GDP is taken from the *IMF*.

Domestic credit: Domestic credit by private sector banks (in % of GDP) is obtained from *The World Bank*.

GDP growth: We use the percentage change in a country's gross domestic product as obtained from the *IMF*.

Government debt: Central government debt (in % of GDP) is obtained from *The World Bank*.

Inflation: We use the percentage change in average consumer prices as obtained from the *IMF*.

Table 1: Summary Statistics for Stock Market Data

This table shows summary statistics for the daily stock market data (excluding weekend days). The national indices (STOXX and DS Bank index), the euro-area index (STOXX and DS Bank index) and individual banks' stock returns cover the period 1/1/2005-12/31/2013. The stock returns of the 80 banks are taken from consolidated accounts. Both the returns of the market indices and banks' stock returns are calculated as first log differences. Banks' market values and total liabilities are in billion euros. For more details on data sources, see the description in the Data Appendix.

		Obs.	Mean	Std. Dev.	Skewness	Kurtosis	Min	Max
Austria	DS Bank index	2,347	-0.00011	0.024	-0.13	7.89	-0.14	0.14
	STOXX index	2,301	0.00002	0.017	-0.15	21.66	-0.17	0.17
Belgium	DS Bank index	2,347	-0.00055	0.029	-0.42	11.30	-0.25	0.19
	STOXX index	2,301	-0.00001	0.013	-1.23	17.80	-0.16	0.09
Cyprus	DS Bank index	2,347	-0.00110	0.027	0.22	6.79	-0.12	0.16
	STOXX index	2,299	-0.00060	0.025	-0.28	10.23	-0.24	0.16
Finland	DS Bank index	2,347	0.00033	0.023	0.08	11.22	-0.18	0.20
	STOXX index	2,301	0.00006	0.018	0.10	23.81	-0.19	0.19
France	DS Bank index	2,347	-0.00015	0.025	0.31	9.61	-0.13	0.18
	STOXX index	2,301	0.00011	0.015	-0.03	16.68	-0.15	0.13
Germany	DS Bank index	2,347	-0.00028	0.022	-0.05	12.97	-0.16	0.16
	DS Bank index	2,301	0.00024	0.016	0.03	42.04	-0.20	0.19
Greece	STOXX index	2,347	-0.00142	0.034	0.35	8.66	-0.16	0.22
	DS Bank index	2,301	-0.00050	0.021	0.11	7.13	-0.10	0.15
Ireland	STOXX index	2,347	-0.00152	0.048	-1.44	35.80	-0.75	0.30
	DS Bank index	2,301	-0.00014	0.016	-0.40	8.13	-0.11	0.09
Italy	STOXX index	2,347	-0.00041	0.022	-0.10	7.54	-0.12	0.16
	DS Bank index	2,301	-0.00020	0.016	-0.04	10.62	-0.12	0.11
Malta	STOXX index	2,347	0.00010	0.011	0.17	16.25	-0.09	0.10
	DS Bank index	2,299	0.00008	0.013	0.17	21.92	-0.11	0.13
Netherlands	STOXX index	2,347	-0.00125	0.035	-22.79	845.05	-1.30	0.15
	DS Bank index	2,301	0.00014	0.014	-0.13	24.33	-0.14	0.14
Portugal	DS Bank index	2,347	-0.00066	0.021	0.09	8.21	-0.12	0.13
	STOXX index	2,301	-0.00017	0.013	-0.07	10.89	-0.10	0.10
Slovakia	DS Bank index	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
	STOXX index	2,299	-0.00002	0.025	-0.66	16.58	-0.29	0.15
Slovenia	DS Bank index	2,347	-0.00243	0.027	-2.88	37.88	-0.33	0.19
	STOXX index	2,299	-0.00015	0.012	-0.60	11.78	-0.10	0.09
Spain	DS Bank index	2,347	-0.00014	0.021	0.49	12.14	-0.14	0.19
	STOXX index	2,301	-0.00001	0.016	0.16	9.41	-0.10	0.14
Euro Area	DS Bank index	2,347	0.00011	0.013	-0.14	10.38	-0.08	0.09
	STOXX index	2,347	-0.00032	0.023	0.15	8.32	-0.11	0.18
Banks' Stock Returns		178,346	-0.00056	0.030	-1.25	131.11	-1.54	1.07
Banks' Market Values		175,422	8.13	15.18	2.79	10.94	0.02	98.58
Banks' Total Liabilities		179,676	192.02	385.78	2.84	11.02	0.06	2,162.04

Table 2: Summary Statistics for SRISK

This table shows summary statistics for the systemic risk measure SRISK. The sample comprises 80 banks listed on the stock market in the euro area and the period 1/1/2005-12/31/2013. SRISK is calculated from stock market data and expressed in billion euros. We proceed like Brownlees and Engle (2017) to calculate a bank's marginal contribution to systemic risk when there is an aggregate capital shortfall in the national, respectively euro-area market (Section 3). The calculation makes use of either the market index or the bank index. Panel (a) is based on daily data; Panel (b) provides summary statistics for SRISK averaged to yearly frequency.

a) Daily	Obs.	Mean	Std. Dev.	Skewness	Kurtosis	Min	Max
SRISK (Euro area, Market Index)	177,563	10.75	25.55	3.26	14.23	-36.96	171.03
SRISK (National, Market Index)	174,066	11.01	25.66	3.23	13.99	-39.93	170.48
SRISK (Difference, Market Index)	174,066	-0.25	0.88	-10.02	490.67	-49.80	18.81
SRISK (Euro area, Bank Index)	177,563	10.78	25.60	3.26	14.23	-36.66	170.93
SRISK (National, Bank Index)	175,216	11.25	25.87	3.24	14.10	-34.20	171.64
SRISK (Difference, Bank Index)	175,216	-0.33	1.22	4.89	80.01	-16.34	28.86

b) Yearly	Obs.	Mean	Std. Dev.	Skewness	Kurtosis	Min	Max
SRISK (Euro area, Market Index)	687	10.66	25.34	3.27	14.23	-17.48	158.21
SRISK (National, Market Index)	687	10.91	25.46	3.23	13.96	-20.15	157.77
SRISK (Difference, Market Index)	687	-0.25	0.62	-2.93	16.40	-4.50	2.76
SRISK (Euro area, Bank Index)	687	10.68	25.40	3.27	14.22	-17.61	157.87
SRISK (National, Bank Index)	678	11.15	25.67	3.24	14.11	-15.84	160.15
SRISK (Difference, Bank Index)	678	-0.33	1.08	3.63	44.03	-5.39	11.54

Table 3: Summary Statistics for the Difference Between Euro-Area and National SRISK

This table shows the number of banks for which the average difference between $SRISK_{it}^{EA}$ and $SRISK_{it}^{N}$ is greater than zero. The sample comprises 80 publicly listed banks in the euro area over the period 2005-2013. In a first step, we calculate the difference between SRISK (EA), measured at the euro-area level, and SRISK (N), measured at the national level, based on daily data for each bank. In a second step, we average this difference for each bank by year. Based on these average differences, we count the number of banks per country and year for which the difference is greater than zero, i.e. the average contribution to systemic risk measured by SRISK is higher at the euro-area level. The last column shows the total number of banks in our sample.

	Number of Banks Per Year with $\Delta SRISK_{it}>0$									Total Number of Banks at Time *t*
	2005	2006	2007	2008	2009	2010	2011	2012	2013	
Austria	1	0	0	0	0	0	2	2	1	5
Belgium	0	0	0	0	0	2	2	2	2	2
Cyprus	0	0	0	0	0	0	0	0	0	2
Finland	2	1	3	2	2	1	2	2	1	3
France	5	6	4	6	12	10	13	10	10	17
Germany	5	5	6	6	5	6	6	5	5	6
Greece	0	0	0	0	0	0	0	0	0	6
Ireland	2	0	0	0	0	0	2	2	1	2
Italy	3	1	1	0	0	2	2	0	1	18
Malta	0	0	0	0	0	0	0	0	0	3
Netherlands	2	2	1	1	1	2	2	1	1	2
Portugal	0	0	0	0	0	0	0	0	0	3
Slovakia	0	0	0	0	0	0	0	0	0	1
Slovenia	2	2	1	0	0	0	0	0	2	2
Spain	3	3	2	2	2	2	1	1	0	8
Total	25	20	18	17	22	25	32	25	24	80

Table 4: Summary Statistics for the Bank-Level Variables

This table shows summary statistics for the explanatory variables. The sample is based on all euro-area banks listed on the stock market which appear in our benchmark regression sample and covers the period 2005-2013. *Equity ratio* is the equity to total assets ratio (in %). *Liquid assets* is the share of liquid assets in total assets (in %). *Loan share* gives the ratio of total loans to total assets (in %). *Market to book value* denotes the market to book value of equity. *Maturity mismatch* reflects the ratio of short-term deposits to liquid assets (in %). *Non-interest income* is measured relative to total income (in %). *NPL* is defined as impaired loans over gross loans (in %). *RoA* is the ratio of operating profits to total assets (in %). *Short-term debt* indicates the ratio of short-term debt to total liabilities (in %). *Total assets* denote the logarithm of bank assets in thousands of USD. *Total assets to GDP* is the ratio of a bank's total assets to the country's GDP (in %). For more details, see the description in the Data Appendix.

	Obs.	Mean	Std. Dev.	Skewness	Kurtosis	Min	Max
Equity ratio (%)	430	6.55	3.11	2.17	12.70	1.45	24.60
Liquid assets (%)	430	17.11	10.23	1.31	5.25	2.51	61.56
Loan share (%)	430	62.21	17.13	-1.08	3.95	3.94	88.57
Market to book value (%)	415	1.19	0.78	0.99	3.51	0.06	3.84
Maturity mismatch (%)	430	0.01	0.05	8.14	68.62	0.00	0.48
Non-interest income (%)	430	21.14	8.87	2.06	13.45	3.73	78.44
Non-performing loans (NPL) (%)	430	5.24	4.26	1.56	5.96	0.41	25.45
RoA (%)	430	0.58	0.94	-2.63	17.12	-5.98	2.36
Short-term debt (%)	430	20.11	14.14	1.30	5.29	0.57	73.48
Total assets (log, k USD)	430	18.07	1.93	-0.09	2.38	13.39	21.66
Total assets to GDP (%)	430	34.28	45.95	2.02	7.28	0.03	231.58

Table 5: Difference in Means of Bank-Level Variables by ΔSRISK

This table shows mean values for the explanatory variables for the subsample of observations for which $\Delta SRISK_{it}<0$ and $\Delta SRISK_{it}>0$, respectively. The last three columns show the difference in means, as well as the t-value and p-value derived from testing whether the means differ significantly between those two subsamples. The sample is based on all publicly listed euro-area banks which appear in our benchmark regression sample and covers the period 2005-2013. *Equity ratio* is the equity to total assets ratio (in %). *Liquid assets* is the share of liquid assets in total assets (in %). *Loan share* gives the ratio of total loans to total assets (in %). *Market to book value* denotes the market to book value of equity. *Maturity mismatch* reflects the ratio of short-term deposits to liquid assets (in %). *Non-interest income* is measured relative to total income (in %). *NPL* is defined as the fraction of impaired loans relative to gross loans (in %). *RoA* is the ratio of operating profits to total assets (in %). *Short-term debt* indicates the ratio of short-term debt to total liabilities (in %). *Total assets* denote the logarithm of bank assets in thousands of USD. *Total assets to GDP* is the ratio of a bank's total assets to the country's GDP (in %). For more details, see the description in the Data Appendix.

	$\Delta SRISK_{it}<0$		$\Delta SRISK_{it}>0$		T-test of equal means		
	Obs.	Mean	Obs.	Mean	ΔMean	t-value	p-value
Equity ratio (%)	341	6.71	89	5.96	0.75	2.02	0.04
Liquid assets (%)	341	16.51	89	19.41	-2.90	-2.39	0.02
Loan share (%)	341	63.70	89	56.53	7.17	3.56	0.00
Market to book value (%)	329	1.28	86	0.88	0.40	4.30	0.00
Maturity mismatch (%)	341	0.01	89	0.00	0.01	1.20	0.23
Non-interest income (%)	341	20.92	89	21.98	-1.06	-1.00	0.32
Non-performing loans (NPL) (%)	341	5.44	89	4.49	0.95	1.87	0.06
RoA (%)	341	0.63	89	0.36	0.27	2.46	0.01
Short-term debt (%)	341	17.79	89	29.03	-11.24	-7.04	0.00
Total assets (log, k USD)	341	18.01	89	18.30	-0.29	-1.28	0.20
Total assets to GDP (%)	341	35.33	89	30.25	5.08	0.93	0.35

Table 6: Systemic Risk, State Aid, and Complexity

This table shows mean values for SRISK (yearly, bn euros) at the euro-area and national level for the period 2005-2013. The first two columns show results for the subsample of banks for which the state aid dummy equaled one at a specific date and for the observations for which the state aid dummy was zero. Column (3) shows results for the subsample of banks for which the G-SIFI dummy equaled one at a specific date and for the observations for which the G-SIFI dummy was zero (Column (4)). Columns (5) and (6) compare banks which were required to participate in the comprehensive assessment of the ECB, "SSM banks", with non-SSM banks. For more details, see the description in the Data Appendix.

	State aid		G-SIFI		SSM	
	Yes	No	Yes	No	Yes	No
SRISK (Euro area)	35.76	11.96	79.43	9.32	17.19	3.84
SRISK (National)	35.79	12.30	80.44	9.60	17.64	3.88

Table 7: Determinants of Systemic Risk – Bank-Level Variables

This table reports fixed effects regressions for the full sample (2005-2013) and the crisis sample (2007-2012) that are based on yearly data of publicly listed banks in euro-area countries. The dependent variable is SRISK (bn euros). In Columns (1) and (4), the reference level is the euro area and in Columns (2) and (5), the national level. In Columns (3) and (6), the difference in coefficients joint with the significance level of Chi-squared tests for equality of coefficients resulting from seemingly unrelated regressions are reported. The explanatory variables include GDP growth and the inflation rate as well as bank-level variables: log of total assets, loans to total assets (in %), non-interest income to total income (in %), return on assets (in %), non-performing loans to total loans (in %), and short-term debt to total liabilities (in %). These bank-level variables are lagged by one period and standardized. G-SIFI denotes a dummy which equals one if the bank was classified as a global systemically important bank by the Financial Stability Board and zero otherwise. State aid denotes a dummy which equals one if the bank received state aid following the State Aid Register of the European Commission and zero otherwise. The regressions take into account bank and year fixed effects. Standard errors are clustered by individual bank and depicted in parentheses. The p-values are as follows: *** p<0.01, ** p<0.05, * p<0.1.

	(1)	(2)	(3)	(4)	(5)	(6)
	Full sample			Crisis sample		
	SRISK EA	*SRISK NAT*	*ΔCoefficient*	*SRISK EA*	*SRISK NAT*	*ΔCoefficient*
GDP growth$_t$	-0.146	-0.158	0.012	-0.235	-0.246	0.011
	(0.218)	(0.224)		(0.169)	(0.175)	
Inflation rate$_t$	-0.860	-0.880	0.020	-0.367	-0.378	0.011
	(0.531)	(0.541)		(0.352)	(0.355)	
Log assets$_{t-1}$	8.616**	9.165**	-0.548**	11.688***	12.406***	-0.718*
	(3.414)	(3.478)		(4.164)	(4.327)	
Loan share$_{t-1}$	-2.877*	-2.983*	0.106*	-3.373**	-3.451**	0.078
	(1.500)	(1.524)		(1.605)	(1.648)	
Non-interest income$_{t-1}$	-1.040	-1.032	-0.008	-0.991*	-0.996*	0.005
	(0.736)	(0.740)		(0.587)	(0.591)	
RoA$_{t-1}$	0.994*	1.041*	-0.046	0.896**	0.930**	-0.034
	(0.570)	(0.601)		(0.414)	(0.438)	
NPL$_{t-1}$	0.876	0.785	0.091**	0.264	0.120	0.144**
	(0.644)	(0.668)		(0.810)	(0.850)	
Short-term debt$_{t-1}$	-0.493	-0.553	0.060	-0.939	-1.009	0.070
	(0.776)	(0.796)		(0.976)	(1.004)	
G-SIFI$_t$	5.624	5.598	0.026	7.898***	7.733**	0.165
	(3.955)	(3.984)		(2.965)	(3.033)	
State aid$_t$	4.776***	4.789***	-0.012	5.002***	5.045**	-0.043
	(1.675)	(1.751)		(1.863)	(1.944)	
Observations	430	430	-	328	328	-
R^2	0.336	0.330	-	0.414	0.406	-
Number of banks	75	75	-	66	66	-

Table 8: Determinants of Systemic Risk - Interaction with Size Measures

	(1)	(2)	(3)	(4)	(5)	(6)
	Interactions with log assets			Interactions with SSM status		
	SRISK EA	*SRISK NAT*	*ΔCoefficient*	*SRISK EA*	*SRISK NAT*	*ΔCoefficient*
GDP growth$_t$	-0.188	-0.196	0.008	-0.082	-0.095	0.013
	(0.209)	(0.216)		(0.202)	(0.208)	
Inflation rate$_t$	-1.097*	-1.115*	0.018	-0.872	-0.903	0.031
	(0.553)	(0.562)		(0.547)	(0.553)	
Log assets$_{t-1}$	10.495***	10.932***	-0.437*	11.170***	11.766***	-0.596**
	(3.661)	(3.747)		(3.500)	(3.533)	
Loan share$_{t-1}$	-2.761**	-2.914**	0.153***	-2.966**	-2.947**	-0.019
	(1.330)	(1.351)		(1.186)	(1.195)	
Non-interest income$_{t-1}$	-1.866**	-1.879**	0.013	0.653	0.651	0.002
	(0.897)	(0.904)		(0.492)	(0.498)	
RoA$_{t-1}$	2.021**	2.124**	-0.103***	-0.333	-0.346	0.013
	(0.960)	(0.987)		(0.216)	(0.215)	
NPL$_{t-1}$	1.741**	1.678**	0.063*	-0.704	-0.766	0.062*
	(0.759)	(0.768)		(0.634)	(0.643)	
Short-term debt$_{t-1}$	0.731	0.698	0.033	0.328	0.287	0.041
	(0.989)	(1.012)		(0.663)	(0.667)	
G-SIFI$_t$	5.054	5.090	-0.035	4.946	4.928	0.018
	(3.561)	(3.568)		(3.838)	(3.862)	
State aid$_t$	4.909***	4.982***	-0.073	5.380***	5.431***	-0.051
	(1.321)	(1.398)		(1.499)	(1.580)	
<u>*Interactions between the explanatory variables and log assets/SSM status*</u>						
Interaction with Loan share$_{t-1}$	-0.851	-0.960	0.109***	-0.152	-0.344	0.192**
	(1.461)	(1.460)		(1.701)	(1.702)	
Interaction with Non-interest income$_{t-1}$	-2.693***	-2.707***	0.014	-3.237***	-3.236***	-0.000
	(0.715)	(0.714)		(1.150)	(1.152)	
Interaction with RoA$_{t-1}$	1.340**	1.393**	-0.052**	2.778**	2.908**	-0.130***
	(0.556)	(0.568)		(1.115)	(1.151)	
Interaction with NPL$_{t-1}$	1.443**	1.408**	0.035	2.663***	2.646***	0.017
	(0.602)	(0.618)		(0.902)	(0.906)	
Interaction with Short-term debt$_{t-1}$	-0.361	-0.363	0.002	-0.475	-0.477	0.002
	(0.983)	(1.010)		(1.319)	(1.348)	
Observations	430	430	-	430	430	-
R^2	0.407	0.401	-	0.360	0.354	-
Number of banks	75	75	-	75	75	-

Notes to Table 8: This table reports fixed effects regressions for the full sample (2005-2013) that is based on yearly data of publicly listed banks in euro-area countries. The dependent variable is SRISK (bn euros). In Columns (1) and (4), the reference level is the euro area and in Columns (2) and (5), the national level. In Columns (3) and (6), the difference in coefficients joint with the significance level of Chi-squared tests for equality of coefficients resulting from seemingly unrelated regressions are reported. The explanatory variables include GDP growth and the inflation rate as well as bank-level variables (lagged by one period and standardized): log of total assets, loans to total assets (in %), non-interest income to total income (in %), return on assets (in %), non-performing loans to total loans (in %), and short-term debt to total liabilities (in %), and their interactions with bank size measured by log of total assets (Columns 1-2) or a dummy that equals one if the bank is supervised by the SSM and zero otherwise (Columns 4-5). G-SIFI denotes a dummy which equals one if the bank was classified as a global systemically important bank by the Financial Stability Board and zero otherwise. State aid denotes a dummy which equals one if the bank received state aid following the State Aid Register of the European Commission and zero otherwise. The regressions take into account bank and year fixed effects. Standard errors are clustered by individual bank and depicted in parentheses. The p-values are as follows: *** $p<0.01$, ** $p<0.05$, * $p<0.1$.

Table 9: Determinants of Systemic Risk - Interaction with Internationalization Measures

	(1)	(2)	(3)	(4)	(5)	(6)
	Interaction with foreign subsidiaries			Interactions with HHI geo		
	SRISK EA	*SRISK NAT*	*ΔCoefficient*	*SRISK EA*	*SRISK NAT*	*ΔCoefficient*
GDP growth$_t$	-0.088	-0.099	0.011	-0.135	-0.147	0.012
	(0.208)	(0.215)		(0.217)	(0.225)	
Inflation rate$_t$	-0.816	-0.839	0.023	-0.865	-0.888	0.023
	(0.560)	(0.569)		(0.577)	(0.588)	
Log assets$_{t-1}$	6.418*	6.983**	-0.565**	9.312***	9.499***	-0.187
	(3.360)	(3.440)		(3.505)	(3.504)	
Loan share$_{t-1}$	-3.053*	-3.204*	0.151***	-2.776**	-2.870**	0.094*
	(1.625)	(1.650)		(1.306)	(1.332)	
Non-interest income$_{t-1}$	-2.215*	-2.189*	-0.025	-0.296	-0.293	-0.003
	(1.121)	(1.128)		(0.491)	(0.490)	
RoA$_{t-1}$	-0.286	-0.253	-0.033	1.109*	1.146*	-0.036
	(0.664)	(0.670)		(0.601)	(0.621)	
NPL$_{t-1}$	1.032	0.945	0.087***	1.161*	1.111*	0.050*
	(0.677)	(0.683)		(0.658)	(0.664)	
Short-term debt$_{t-1}$	-0.389	-0.472	0.083	-0.208	-0.257	0.049
	(1.244)	(1.275)		(0.693)	(0.698)	
Internationalization$_t$	1.945**	1.934**	0.011	-0.521	-0.262	-0.259***
	(0.940)	(0.930)		(1.338)	(1.305)	
G-SIFI$_t$	5.517	5.487	0.030	5.736	5.735	0.001
	(3.831)	(3.856)		(3.869)	(3.885)	
State aid$_t$	4.168**	4.197**	-0.028	4.747***	4.769***	-0.022
	(1.833)	(1.910)		(1.608)	(1.689)	
Interactions between the explanatory variables and foreign subsidiaries/HHI geo dummy						
Interaction with Log assets$_{t-1}$	1.039	1.036	0.003	-1.311	-1.163	-0.148**
	(1.068)	(1.058)		(1.378)	(1.336)	
Interaction with Loan share$_{t-1}$	-0.602	-0.497	-0.105***	-0.528	-0.700	0.172***
	(0.826)	(0.827)		(1.540)	(1.532)	
Interaction with Non-interest income$_{t-1}$	2.281**	2.252**	0.029	-1.778**	-1.762*	-0.016
	(0.899)	(0.904)		(0.888)	(0.892)	
Interaction with RoA$_{t-1}$	1.855*	1.920*	-0.064	-0.277	-0.237	-0.040
	(1.012)	(1.049)		(0.648)	(0.667)	
Interaction with NPL$_{t-1}$	0.059	0.072	-0.013	-0.747	-0.839	0.092**
	(0.738)	(0.742)		(0.716)	(0.740)	
Interaction with Short-term debt$_{t-1}$	0.084	0.149	-0.065	-0.257	-0.314	0.057
	(1.179)	(1.190)		(0.958)	(0.978)	
Observations	420	420	-	420	420	-
R^2	0.373	0.367	-	0.354	0.348	-
Number of banks	74	74	-	74	74	-

Notes to Table 9: This table reports fixed effects regressions for the full sample (2005-2013) that is based on yearly data of publicly listed banks in euro-area countries. The dependent variable is SRISK (bn euros). In Columns (1) and (4), the reference level is the euro area and in Columns (2) and (5), the national level. In Columns (3) and (6), the difference in coefficients joint with the significance level of Chi-squared tests for equality of coefficients resulting from seemingly unrelated regressions are reported. The explanatory variables include GDP growth and the inflation rate as well as bank-level variables (lagged by one period and standardized): log of total assets, loans to total assets (in %), non-interest income to total income (in %), return on assets (in %), non-performing loans to total loans (in %), and short-term debt to total liabilities (in %), and their interactions with the internationalization variable. In Columns (1)-(2), internationalization is captured by a foreign subsidiaries dummy that is one if a bank's share of foreign subsidiaries to total subsidiaries lies above the sample average and zero otherwise. In Columns (4)-(5), internationalization is captured by a dummy that is one if the HHI geographical is larger than the sample average and zero otherwise. G-SIFI denotes a dummy which equals one if the bank was classified as a global systemically important bank by the Financial Stability Board and zero otherwise. State aid denotes a dummy which equals one if the bank received state aid following the State Aid Register of the European Commission and zero otherwise. The regressions take into account bank and year fixed effects. Standard errors are clustered by individual bank and depicted in parentheses. The p-values are as follows: *** p<0.01, ** p<0.05, * p<0.1.

Table 10: Robustness – Sample of SSM Banks

This table reports fixed effects regressions for the sample of SSM banks and the period (2005-2013) as well as the crisis period (2007-2012) based on yearly data of publicly listed banks in euro-area countries. The dependent variable is SRISK (bn euros). In Columns (1) and (4), the reference level is the euro area and in Columns (2) and (5), the national level. In Columns (3) and (6), the difference in coefficients joint with the significance level of Chi-squared tests for equality of coefficients resulting from seemingly unrelated regressions are reported. The explanatory variables include GDP growth and the inflation rate as well as bank-level variables: log of total assets, loans to total assets (in %), non-interest income to total income (in %), return on assets (in %), non-performing loans to total loans (in %), and short-term debt to total liabilities (in %). These bank-level variables are lagged by one period and standardized. G-SIFI denotes a dummy which equals one if the bank was classified as a global systemically important bank by the Financial Stability Board and zero otherwise. State aid denotes a dummy which equals one if the bank received state aid following the State Aid Register of the European Commission and zero otherwise. The regressions take into account bank and year fixed effects. Standard errors are clustered by individual bank and depicted in parentheses. The p-values are as follows: *** p<0.01, ** p<0.05, * p<0.1.

	(1)	(2)	(3)	(4)	(5)	(6)
	SSM sample			SSM crisis sample		
	SRISK EA	*SRISK NAT*	*ΔCoefficient*	*SRISK EA*	*SRISK NAT*	*ΔCoefficient*
GDP growth$_t$	-0.116	-0.132	0.016	-0.259	-0.271	0.012
	(0.252)	(0.260)		(0.198)	(0.204)	
Inflation rate$_t$	-0.986	-1.028	0.042	-0.450	-0.484	0.034
	(0.669)	(0.676)		(0.460)	(0.460)	
Log assets$_{t-1}$	9.677	10.597*	-0.920***	11.543	12.767*	-1.224*
	(5.884)	(5.892)		(7.189)	(7.338)	
Loan share$_{t-1}$	-4.698**	-4.849**	0.151**	-4.948**	-5.091**	0.143
	(2.215)	(2.249)		(2.247)	(2.302)	
Non-interest income$_{t-1}$	-2.235*	-2.256*	0.021	-1.740*	-1.787*	0.047
	(1.312)	(1.319)		(0.976)	(0.985)	
RoA$_{t-1}$	2.711**	2.830**	-0.119***	2.219***	2.323***	-0.104***
	(1.124)	(1.155)		(0.790)	(0.810)	
NPL$_{t-1}$	2.105**	2.006**	0.099**	0.921	0.764	0.157**
	(0.890)	(0.900)		(1.042)	(1.071)	
Short-term debt$_{t-1}$	-0.252	-0.292	0.040	-0.712	-0.749	0.037
	(1.274)	(1.306)		(1.410)	(1.455)	
G-SIFI$_t$	4.814	4.778	0.036	6.851**	6.670**	0.181
	(3.783)	(3.817)		(2.891)	(2.965)	
State aid$_t$	5.059***	5.116***	-0.056	4.743**	4.829**	-0.085
	(1.664)	(1.739)		(1.840)	(1.924)	
Observations	292	292	-	226	226	-
R^2	0.398	0.392	-	0.468	0.461	-
Number of banks	44	44	-	41	41	-

Table 11: Robustness - Alternative Micro-Level Variables

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
	w/o RoA		Equity Ratio		Maturity Mismatch		Market to Book Value		Bank Size to GDP		Liquid Assets	
	SRISK EA	*SRISK NAT*	*SRISK EA*	*SRISK NAT*	*SRISK EA*	*SRISK NAT*	*SRISK EA*	*SRISK NAT*	*SRISK EA*	*SRISK NAT*	*SRISK EA*	*SRISK NAT*
GDP growth$_t$	-0.143	-0.156	-0.205	-0.216	-0.125	-0.136	-0.135	-0.155	-0.113	-0.126	-0.115	-0.126
	(0.221)	(0.227)	(0.220)	(0.227)	(0.209)	(0.215)	(0.268)	(0.280)	(0.201)	(0.205)	(0.219)	(0.225)
Inflation rate$_t$	-0.872	-0.892	-0.859	-0.879	-0.912	-0.938*	-0.929	-0.961	-0.811	-0.829	-0.875	-0.895
	(0.535)	(0.544)	(0.541)	(0.551)	(0.551)	(0.562)	(0.577)	(0.594)	(0.517)	(0.527)	(0.556)	(0.565)
Log assets$_{t-1}$	10.134**	10.755**	5.426	6.021*	8.408**	8.916**	8.531**	9.158**			12.730***	13.432***
	(3.952)	(4.077)	(3.572)	(3.601)	(3.457)	(3.517)	(3.762)	(3.832)			(3.459)	(3.563)
Loan share$_{t-1}$	-2.585*	-2.678*	-2.662*	-2.771*	-2.842*	-2.942**	-3.054*	-3.159*	-2.863**	-2.992**		
	(1.460)	(1.482)	(1.484)	(1.509)	(1.443)	(1.465)	(1.589)	(1.622)	(1.417)	(1.439)		
Non-interest income$_{t-1}$	-0.688	-0.663	-0.964	-0.957	-1.118	-1.118	-0.888	-0.894	-1.284*	-1.285*	-1.090	-1.085
	(0.751)	(0.760)	(0.756)	(0.760)	(0.720)	(0.724)	(0.694)	(0.697)	(0.734)	(0.737)	(0.725)	(0.728)
RoA$_{t-1}$			1.112*	1.158*	1.432*	1.513*	0.964*	1.017*	1.169*	1.226*	0.936*	0.982*
			(0.615)	(0.648)	(0.737)	(0.773)	(0.568)	(0.599)	(0.599)	(0.633)	(0.539)	(0.569)
NPL$_{t-1}$	0.159	0.034	0.874	0.784	1.090*	1.013*	0.823	0.743	1.095	1.010	1.027	0.942
	(0.926)	(0.977)	(0.594)	(0.618)	(0.560)	(0.572)	(0.673)	(0.702)	(0.662)	(0.689)	(0.694)	(0.720)
Short-term debt$_{t-1}$	-0.476	-0.535	-0.751	-0.808			-0.731	-0.806	-0.402	-0.454	-0.218	-0.267
	(0.760)	(0.778)	(0.840)	(0.861)			(0.850)	(0.875)	(0.751)	(0.770)	(0.679)	(0.695)
G-SIFI$_t$	5.811	5.794	6.044	6.012	5.520	5.488	5.586	5.560	5.155	5.109	5.729	5.706
	(4.002)	(4.033)	(3.920)	(3.952)	(3.950)	(3.987)	(3.915)	(3.943)	(3.733)	(3.738)	(4.119)	(4.150)
State aid$_t$	4.404**	4.399**	4.205**	4.226**	4.845***	4.856***	4.235**	4.281**	4.536**	4.525**	5.164***	5.191***
	(1.832)	(1.912)	(1.742)	(1.813)	(1.706)	(1.782)	(1.726)	(1.800)	(1.868)	(1.952)	(1.610)	(1.683)
Bank-level control$_{t-1}$			-1.726*	-1.701*	1.186*	1.278*	-1.130	-1.048	6.484*	6.708*	0.703	0.736
			(0.981)	(1.000)	(0.705)	(0.742)	(0.884)	(0.923)	(3.323)	(3.510)	(0.764)	(0.767)
Observations	430	430	430	430	430	430	415	415	430	430	430	430
R^2	0.328	0.321	0.342	0.336	0.339	0.333	0.347	0.341	0.350	0.344	0.329	0.322
Number of banks	75	75	75	75	75	75	72	72	75	75	75	75

Notes to Table 11: This table reports fixed effects regressions for the full sample (2005-2013) that is based on yearly data of publicly listed banks in euro-area countries. The dependent variable is SRISK (bn euros) whereas the reference level is either the euro-area or the national level as indicated at the top of each column. The explanatory variables include GDP growth and the inflation rate as well as bank-level variables: log of total assets, loans to total assets (in %), non-interest income to total income (in %), return on assets (in %), non-performing loans to total loans (in %), short-term debt to total liabilities (in %), equity to total assets (in %), maturity mismatch (in %), ratio of market to book value, total assets to GDP (in %), liquid asset to total assets (in %). These bank-level variables are lagged by one period and standardized. G-SIFI denotes a dummy which equals one if the bank was classified as a global systemically important bank by the Financial Stability Board and zero otherwise. State aid denotes a dummy which equals one if the bank received state aid following the State Aid Register of the European Commission and zero otherwise. The regressions take into account bank and year fixed effects. Standard errors are clustered by individual bank and depicted in parentheses. The p-values are as follows: *** p<0.01, ** p<0.05, * p<0.1.

Table 12: Robustness - Alternative Macro-Level Variables

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
	Government Debt		Domestic Credit		Cross-Border Exposures		Current Account		Capitalization	
	SRISK EA	*SRISK NAT*	*SRISK EA*	*SRISK NAT*	*SRISK EA*	*SRISK NAT*	*SRISK EA*	*SRISK NAT*	*SRISK EA*	*SRISK NAT*
GDP growth$_t$	-0.240	-0.254	-0.052	-0.063	-0.204	-0.208	-0.086	-0.095	-0.303	-0.309
	(0.255)	(0.263)	(0.236)	(0.242)	(0.307)	(0.315)	(0.194)	(0.198)	(0.188)	(0.195)
Inflation rate$_t$	-0.462	-0.479	-0.793	-0.811	-1.058	-1.069	-0.735	-0.747	-1.044*	-1.054*
	(0.584)	(0.604)	(0.528)	(0.538)	(0.740)	(0.761)	(0.477)	(0.481)	(0.591)	(0.605)
Log assets$_{t-1}$	8.049*	8.458**	7.884**	8.425**	9.319*	9.601**	8.855**	9.419***	10.095***	10.581***
	(4.110)	(4.140)	(3.428)	(3.470)	(4.683)	(4.742)	(3.460)	(3.514)	(3.285)	(3.308)
Loan share$_{t-1}$	-2.616*	-2.764*	-3.168**	-3.277**	-2.650	-2.789	-2.662**	-2.755**	-1.929	-2.026
	(1.468)	(1.495)	(1.549)	(1.569)	(1.662)	(1.684)	(1.335)	(1.351)	(1.276)	(1.297)
Non-interest income$_{t-1}$	-1.212	-1.197	-1.026	-1.018	-1.074	-1.065	-1.072	-1.065	-0.768	-0.762
	(0.840)	(0.847)	(0.722)	(0.726)	(0.869)	(0.869)	(0.729)	(0.732)	(0.596)	(0.597)
RoA$_{t-1}$	1.180*	1.231*	0.910*	0.957*	0.946	0.991	1.064*	1.116*	0.910	0.961
	(0.591)	(0.623)	(0.512)	(0.542)	(0.582)	(0.609)	(0.609)	(0.642)	(0.569)	(0.600)
NPL$_{t-1}$	0.524	0.367	0.785	0.693	0.587	0.472	0.926	0.838	1.033	0.932
	(1.002)	(1.047)	(0.644)	(0.671)	(0.851)	(0.876)	(0.683)	(0.710)	(0.754)	(0.780)
Short-term debt$_{t-1}$	-0.998	-1.076	-0.614	-0.676	-0.572	-0.616	-0.477	-0.536	-0.856	-0.907
	(1.264)	(1.303)	(0.768)	(0.788)	(0.804)	(0.821)	(0.766)	(0.785)	(0.706)	(0.729)
G-SIFI$_t$	10.399***	10.279***	5.607	5.581	5.363	5.337	5.638	5.614	4.041	4.025
	(3.415)	(3.519)	(3.952)	(3.986)	(3.931)	(3.948)	(3.936)	(3.962)	(3.547)	(3.600)
State aid$_t$	6.387**	6.371**	4.855***	4.868***	4.527***	4.553**	4.800***	4.814***	4.949***	4.974***
	(2.709)	(2.801)	(1.658)	(1.733)	(1.659)	(1.740)	(1.673)	(1.749)	(1.772)	(1.849)
Country control$_t$	0.025*	0.026*	0.028*	0.028*	0.002	0.004	0.118	0.125	-0.568	-0.622
	(0.013)	(0.013)	(0.015)	(0.015)	(0.018)	(0.018)	(0.165)	(0.169)	(0.656)	(0.681)
Observations	357	357	430	430	378	378	430	430	413	413
R^2	0.443	0.433	0.340	0.334	0.355	0.350	0.338	0.332	0.329	0.324
Number of banks	64	64	75	75	67	67	75	75	75	75

Notes to Table 12: This table reports fixed effects regressions for the full sample (2005-2013) that is based on yearly data of publicly listed banks in euro-area countries. The dependent variable is SRISK (bn euros) whereas the reference level is either the euro-area or the national level as indicated at the top of each column. The explanatory variables include GDP growth and the inflation rate as well as bank-level variables: log of total assets, loans to total assets (in %), non-interest income to total income (in %), return on assets (in %), non-performing loans to total loans (in %), and short-term debt to total liabilities (in %). These bank-level variables are lagged by one period and standardized. Additional control variables at the country-level include government debt relative to GDP (in %), domestic credit to GDP (in %), cross-border exposures of the country's banking system to GDP (in %), current account to GDP (in %), the banking system's aggregate bank capital to assets ratio (in %). G-SIFI denotes a dummy which equals one if the bank was classified as a global systemically important bank by the Financial Stability Board and zero otherwise. State aid denotes a dummy which equals one if the bank received state aid following the State Aid Register of the European Commission and zero otherwise. The regressions take into account bank and year fixed effects. Standard errors are clustered by individual bank and depicted in parentheses. The p-values are as follows: *** p<0.01, ** p<0.05, * p<0.1.

Table 13: Robustness - Alternative SRISK Calculation

This table reports fixed effects regressions for the full sample (2005-2013) that is based on yearly data of publicly listed banks in euro-area countries. The dependent variable is log of SRISK (bn euros) whereas we add a constant to avoid negative values, Columns (1)-(2), a bank's SRISK based on the aggregate bank index, Columns (3)-(4), SRISK derived from taking the median across the daily data, Columns (5)-(6), and SRISK when setting the prudential capital ratio to 5.5, Columns (7)-(8). The reference level is either the euro-area or the national level as indicated at the top of each column. The explanatory variables include GDP growth and the inflation rate as well as bank-level variables: log of total assets, loans to total assets (in %), non-interest income to total income (in %), return on assets (in %), non-performing loans to total loans (in %), and short-term debt to total liabilities (in %). These bank-level variables are lagged by one period and standardized. G-SIFI denotes a dummy which equals one if the bank was classified as a global systemically important bank by the Financial Stability Board and zero otherwise. State aid denotes a dummy which equals one if the bank received state aid following the State Aid Register of the European Commission and zero otherwise. The regressions take into account bank and year fixed effects. Standard errors are clustered by individual bank and depicted in parentheses. The p-values are as follows: *** p<0.01, ** p<0.05, * p<0.1.

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	Ln(SRISK)		SRISK (Bank index)		SRISK (Median)		SRISK (k=5.5)	
	SRISK EA	*SRISK NAT*	*SRISK EA*	*SRISK NAT*	*SRISK EA*	*SRISK NAT*	*SRISK EA*	*SRISK NAT*
GDP growth$_t$	-0.018*	-0.018*	-0.170	-0.193	-0.139	-0.199	-0.120	-0.133
	(0.010)	(0.010)	(0.230)	(0.153)	(0.220)	(0.147)	(0.189)	(0.195)
Inflation rate$_t$	-0.045**	-0.048**	-0.881	0.328	-0.817	0.321	-0.661	-0.681
	(0.022)	(0.023)	(0.544)	(0.202)	(0.549)	(0.206)	(0.454)	(0.463)
Log assets$_{t-1}$	0.733***	0.801***	8.671**	19.560***	8.072**	19.214***	4.297	4.854
	(0.178)	(0.235)	(3.480)	(3.886)	(3.422)	(3.811)	(3.219)	(3.241)
Loan share$_{t-1}$	-0.097*	-0.117*	-2.966*	-0.391	-2.970*	-0.442	-2.342*	-2.453*
	(0.050)	(0.060)	(1.539)	(1.096)	(1.504)	(1.083)	(1.287)	(1.308)
Non-interest income$_{t-1}$	-0.009	-0.010	-1.057	-1.215	-1.112	-1.487*	-1.052*	-1.044
	(0.018)	(0.020)	(0.750)	(0.815)	(0.768)	(0.822)	(0.630)	(0.635)
RoA$_{t-1}$	0.041	0.057	1.030*	0.647	1.010*	0.673	0.955*	1.004*
	(0.032)	(0.044)	(0.590)	(0.416)	(0.535)	(0.409)	(0.523)	(0.554)
NPL$_{t-1}$	-0.024	-0.065	0.911	0.612	0.978	0.735	0.747	0.654
	(0.061)	(0.090)	(0.638)	(0.474)	(0.658)	(0.485)	(0.617)	(0.643)
Short-term debt$_{t-1}$	-0.037	-0.042	-0.507	-1.095	-0.600	-1.206	-0.309	-0.370
	(0.023)	(0.026)	(0.807)	(0.848)	(0.777)	(0.854)	(0.678)	(0.696)
G-SIFI$_t$	0.107*	0.089	6.245	4.946	5.545	5.479	5.863*	5.837*
	(0.060)	(0.059)	(4.073)	(4.072)	(4.054)	(4.109)	(3.087)	(3.103)
State aid$_t$	0.141*	0.184*	4.907***	5.575***	5.401***	7.040***	5.051***	5.062***
	(0.073)	(0.109)	(1.791)	(1.115)	(1.892)	(1.696)	(1.789)	(1.869)
Observations	430	430	430	423	430	430	430	430
R^2	0.421	0.374	0.342	0.247	0.342	0.265	0.375	0.368
Number of banks	75	75	75	74	75	75	75	75

Table 14: Robustness – Short-Sell Ban

This table reports fixed effects regressions for the full sample (2005-2013) and the crisis sample (2007-2012) that are based on yearly data of publicly listed banks in euro-area countries. The dependent variable is SRISK (bn euros). In Columns (1) and (3), the reference level is the euro area and in Columns (2) and (4), the national level. The explanatory variables include GDP growth and the inflation rate as well as bank-level variables: log of total assets, loans to total assets (in %), non-interest income to total income (in %), return on assets (in %), non-performing loans to total loans (in %), and short-term debt to total liabilities (in %). These bank-level variables are lagged by one period and standardized. G-SIFI denotes a dummy which equals one if the bank was classified as a global systemically important bank by the Financial Stability Board and zero otherwise. State aid denotes a dummy which equals one if the bank received state aid following the State Aid Register of the European Commission and zero otherwise. Short-sale ban is a dummy variable that takes a value of one for the years in which a country maintained a short-sell ban and zero otherwise. The regressions take into account bank and year fixed effects. Standard errors are clustered by individual bank and depicted in parentheses. The p-values are as follows: *** p<0.01, ** p<0.05, * p<0.1.

	(1)	(2)	(3)	(4)
	Full sample		Crisis sample	
	SRISK EA	*SRISK NAT*	*SRISK EA*	*SRISK NAT*
GDP growth$_t$	-0.150	-0.162	-0.240	-0.252
	(0.216)	(0.222)	(0.165)	(0.170)
Inflation rate$_t$	-0.712	-0.729	-0.210	-0.218
	(0.544)	(0.555)	(0.364)	(0.369)
Log assets$_{t-1}$	8.017**	8.553**	10.723**	11.425***
	(3.442)	(3.494)	(4.138)	(4.288)
Loan share$_{t-1}$	-3.052*	-3.162**	-3.579**	-3.661**
	(1.532)	(1.555)	(1.644)	(1.683)
Non-interest income$_{t-1}$	-0.967	-0.957	-0.919	-0.923
	(0.731)	(0.734)	(0.586)	(0.590)
RoA$_{t-1}$	1.018*	1.066*	0.933**	0.968**
	(0.567)	(0.597)	(0.418)	(0.442)
NPL$_{t-1}$	0.884	0.793	0.290	0.146
	(0.645)	(0.669)	(0.813)	(0.852)
Short-term debt$_{t-1}$	-0.462	-0.522	-0.924	-0.995
	(0.771)	(0.792)	(0.968)	(0.997)
G-SIFI$_t$	5.790	5.768	8.083***	7.921**
	(3.959)	(3.985)	(2.953)	(3.018)
State aid$_t$	4.818***	4.831***	5.045***	5.089***
	(1.632)	(1.707)	(1.826)	(1.905)
Short-sale ban$_t$	1.802*	1.841*	1.569*	1.594*
	(0.986)	(1.006)	(0.843)	(0.854)
Observations	430	430	328	328
R^2	0.338	0.332	0.417	0.408
Number of banks	75	75	66	66

Table 15: Robustness – Orthogonalized stock market indices

This table reports fixed effects regressions for the full sample (2005-2013) that are based on yearly data of publicly listed banks in euro-area countries. The dependent variable is SRISK (bn euros). Columns (1)-(2) refer to our baseline model whereas in Column (1) the reference level is the euro area and in Column (2) the national level. In Column (3), SRISK is calculated using the EMU MSCI index excluding the national index. In Column (4), SRISK is calculated using the MSCI national index. In Column (5), SRISK is calculated using the national stock return orthogonalized to the first factor derived from euro-area series by means of a principal component analysis. In Column (6), SRISK is calculated using the national stock return orthogonalized to the first factor derived from national stock returns of euro-area member states by means of a principal component analysis. For more details see Appendix A. The explanatory variables include GDP growth and the inflation rate as well as bank-level variables: log of total assets, loans to total assets (in %), non-interest income to total income (in %), return on assets (in %), non-performing loans to total loans (in %), and short-term debt to total liabilities (in %). These bank-level variables are lagged by one period and standardized. G-SIFI denotes a dummy which equals one if the bank was classified as a global systemically important bank by the Financial Stability Board and zero otherwise. State aid denotes a dummy which equals one if the bank received state aid following the State Aid Register of the European Commission and zero otherwise. Short-sale ban is a dummy variable that takes a value of one for the years in which a country maintained a short-sell ban and zero otherwise. The regressions take into account bank and year fixed effects. Standard errors are clustered by individual bank and depicted in parentheses. The p-values are as follows: *** p<0.01, ** p<0.05, * p<0.1.

	(1)	(2)	(3)	(4)	(5)	(6)
	Baseline		**EA index excl. National**		**National index excl. EA**	
	SRISK EA	*SRISK NAT*	*SRISK EA (MSCI, excl. NAT)*	*SRISK NAT (MSCI)*	*SRISK NAT (Excl. EA)*	*SRISK NAT (Excl. EA)*
GDP growth$_t$	-0.146	-0.158	-0.133	-0.142	-0.122	-0.112
	(0.218)	(0.224)	(0.192)	(0.198)	(0.208)	(0.210)
Inflation rate$_t$	-0.860	-0.880	-0.667	-0.690	-0.569	-0.328
	(0.531)	(0.541)	(0.452)	(0.460)	(0.475)	(0.492)
Log assets$_{t-1}$	8.616**	9.165**	4.447	5.479	4.146	3.690
	(3.414)	(3.478)	(3.237)	(3.348)	(3.462)	(3.804)
Loan share$_{t-1}$	-2.877*	-2.983*	-2.369*	-2.503*	-2.737*	-2.712**
	(1.500)	(1.524)	(1.286)	(1.297)	(1.382)	(1.284)
Non-interest income$_{t-1}$	-1.040	-1.032	-1.048*	-1.023	-1.129*	-1.120*
	(0.736)	(0.740)	(0.625)	(0.630)	(0.629)	(0.617)
RoA$_{t-1}$	0.994*	1.041*	0.978*	1.085*	1.147*	1.257*
	(0.570)	(0.601)	(0.538)	(0.614)	(0.624)	(0.690)
NPL$_{t-1}$	0.876	0.785	0.718	0.524	0.583	0.664
	(0.644)	(0.668)	(0.631)	(0.738)	(0.715)	(0.795)
Short-term debt$_{t-1}$	-0.493	-0.553	-0.326	-0.398	-0.427	-0.601
	(0.776)	(0.796)	(0.681)	(0.696)	(0.733)	(0.683)
G-SIFI$_t$	5.624	5.598	6.043*	5.950*	7.685**	11.267***
	(3.955)	(3.984)	(3.104)	(3.098)	(3.241)	(3.265)
State aid$_t$	4.776***	4.789***	5.020***	5.014***	5.621***	6.313***
	(1.675)	(1.751)	(1.763)	(1.796)	(2.122)	(2.334)
Observations	430	430	430	430	430	430
R^2	0.336	0.330	0.378	0.366	0.388	0.423
Number of banks	75	75	75	75	75	75

Figure 1: Systemic Risk over Time per Euro-Area Country

This figure shows the evolution of the systemic risk measure SRISK per country at the national and euro-area level. The sample comprises 80 banks listed on the stock market in the euro area during the period 2005-2013. SRISK is derived from banks' stock market data and is averaged across all banks for each of the 15 euro-area countries. We depict the euro-area SRISK (blue, dotted line; left axis), the national SRISK (red, solid line; left axis) and the difference between the two (green, dashed line; right axis).

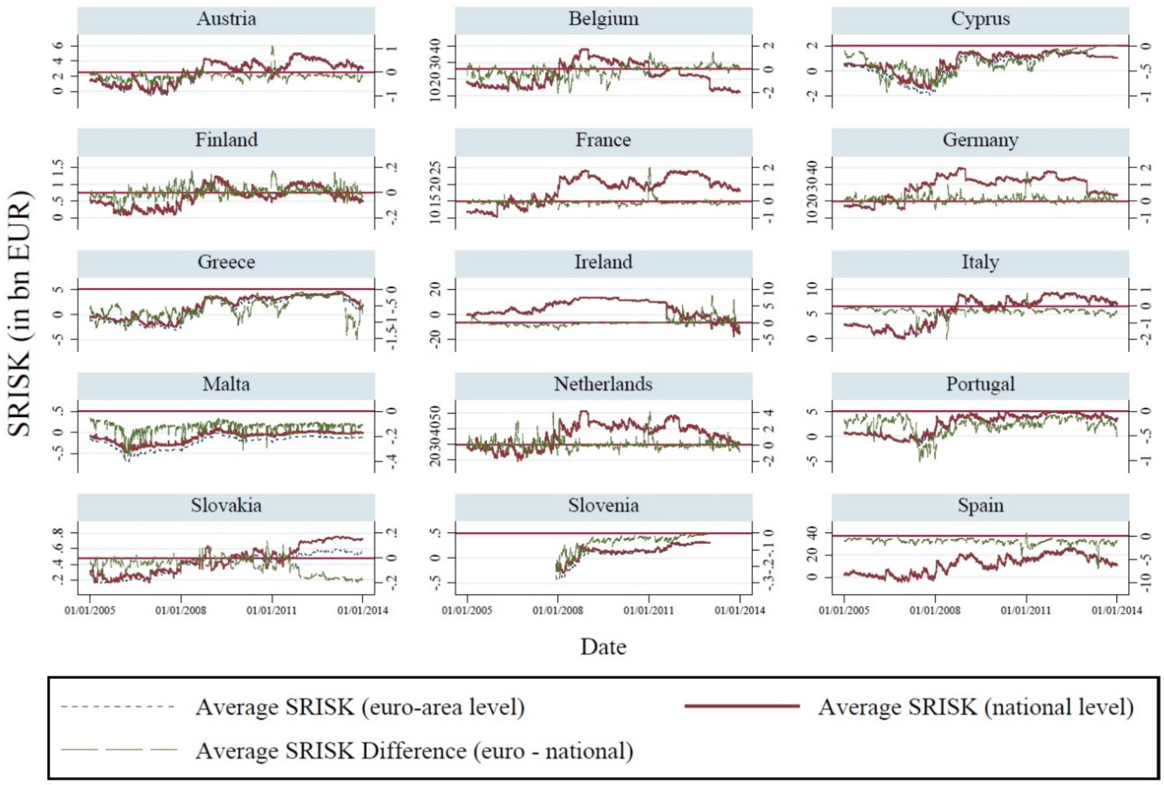


Figure 2: SRISK and Banks' Cross-Border Exposures

The graphs below show the average SRISK (bn euros) across all banks in one country and the period 2005-2013. SRISK is measured at the national (left panel) and euro-area (right panel) level and compared with the cross-border activities (% of GDP) of a country's banking system as obtained from the *Bank for International Settlements*.

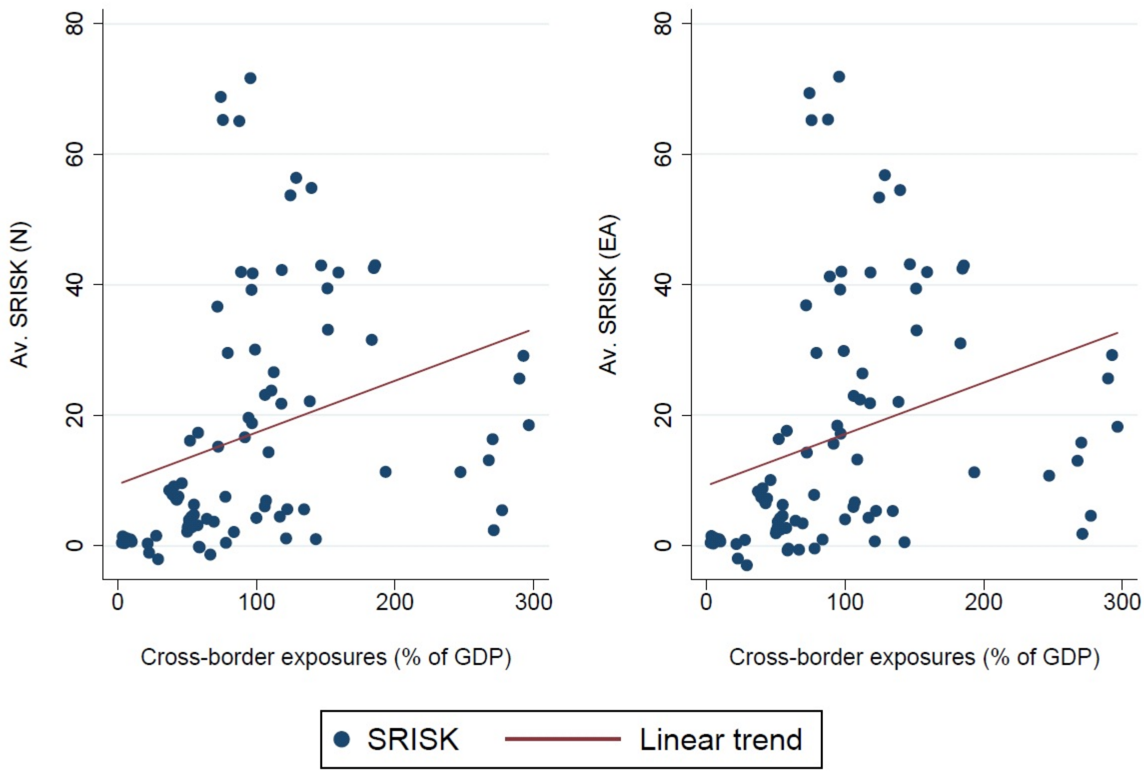


Figure 3: Average Marginal Effects Conditional on Bank Size – National SRISK

The graphs below show the average marginal effects of loans to total assets (in %), non-interest income to total income (in %), return on assets (in %), non-performing loans to total loans (in %) on SRISK (national) and conditional on bank size measured by the log of total assets. The estimated marginal effects are denoted by dots enclosed by 95% confidence bands.

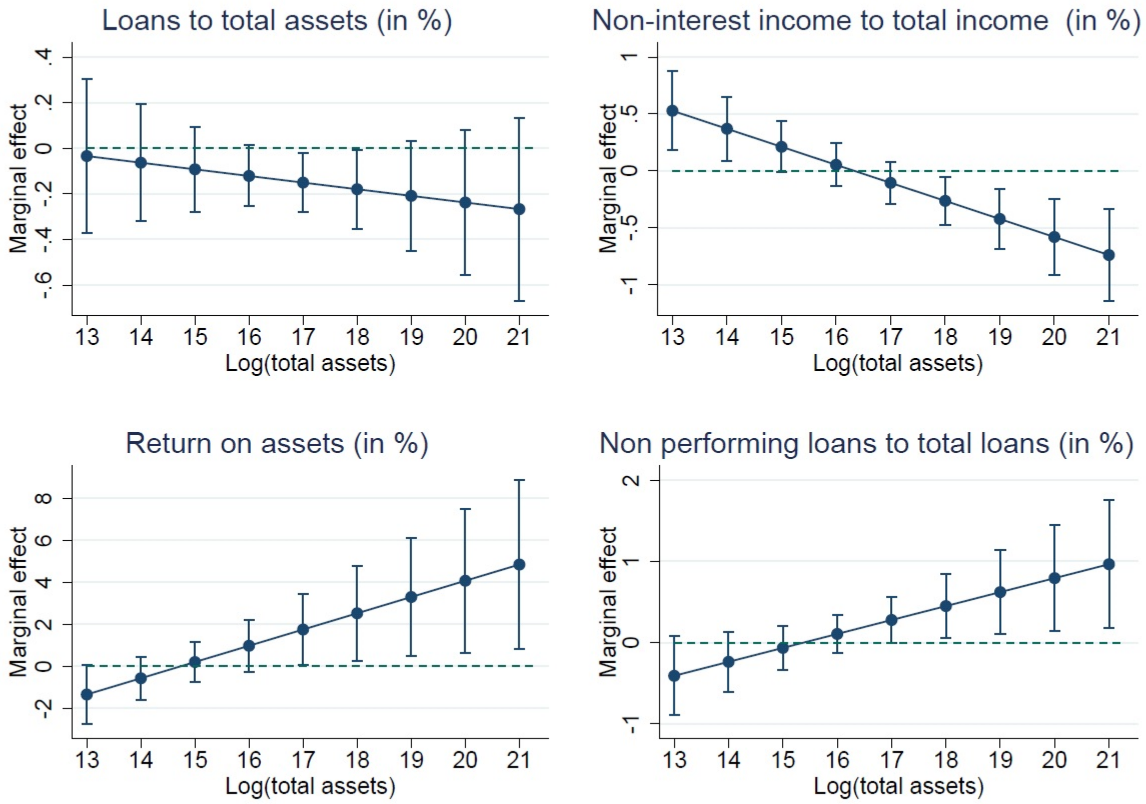
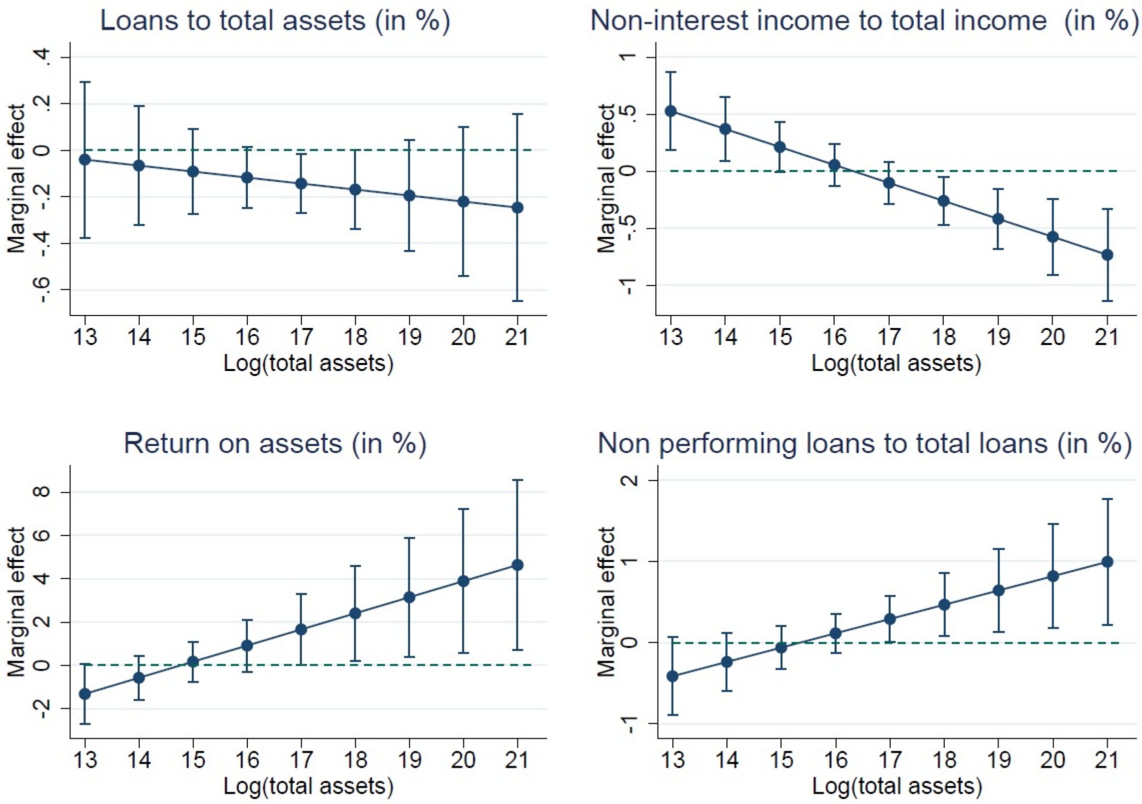


Figure 4: Average Marginal Effects Conditional on Bank Size – Euro-Area SRISK

The graphs below show the average marginal effects of loans to total assets (in %), non-interest income to total income (in %), return on assets (in %), non-performing loans to total loans (in %) on SRISK (euro area) and conditional on bank size measured by the log of total assets. The estimated marginal effects are denoted by dots enclosed by 95% confidence bands.



Appendix A: *Orthogonalization* – Data and Estimation Approach

This appendix contains additional information regarding the robustness tests presented in Table 15. Underlying data and pre-estimations conducted before calculating the SRISK measure are explained.

A.1 MSCI stock market data

For our main analysis, we make use of Eurostoxx data to obtain national and euro-area stock market indices. The reason is that, from this data source, we obtain stock market data defined in the same way for a large set of countries, which ensures comparability. In robustness tests (Table 15, Columns 3 and 4), we make instead use of MSCI stock market indices as provided by Datastream. This has the advantage that we obtain a national series for each country but also a euro-area series for each country excluding the respective country. We can hence calculate SRISK at the euro-area level based on the euro-area stock market index excluding national influences. The disadvantage is that data series are not available for all countries, such that we report these results in the robustness section.

A.2 Principal component analysis

Additionally, we want to extract euro-area factors from the national stock market data. To do so, we proceed as follows. First, we make use of a principal component analysis to generate a common "euro-area" factor. The euro-area factor is calculated in two ways:

In a first approach, we use standardized daily series of euro-area and global variables to generate a factor representing euro-area and global developments. The variables include changes in the (i) Thomson Reuters Euro Government Benchmark Bid Yield 10 Years (Euro), (ii) Standard and Poor's 500 Composite index, and (iii) STOXX Europe 600 Euro equity index. From these series, we extract the first principal component, which is assumed to reflect a common, euro-area factor. A scree plot of eigenvalues after factor confirms that there is one major factor as well as the Kaiser-Meyer-Olkin measure confirms that the sample is well-chosen.

In a second approach, we take the daily national stock market indices of the countries included in our sample being early members of the European monetary union. One reason for this choice of countries is data coverage. But more importantly, this choice increases homogeneity in the sample and, consequently, facilitates the extraction of a euro-area factor.[26] We use the standardized national stock market return series, and also for these series, we

[26] Hence, Cyprus, Malta, Slovenia and Slovakia are excluded from the calculation of the euro-area factor.

extract the first principal component, which is assumed to reflect a common, euro-area factor. Again the relevant tests confirm that there is a major common factor driving these series.

Second, having generated these euro-area factors, we orthogonalize national stock market returns with respect to euro-area developments. This is done by regressing them on one of these previously generated euro-area factors. Finally, the residuals of these regressions are used as a proxy for national stock returns *excluding* euro-area factors in the calculation of banks' SRISK at the national level. This should, as a result, give a cleaner measure to simulate shocks emerging in national market, which are then used for the calculation of banks' national SRISK.

Results of the regressions with SRISK at the national level, which is calculated based on national stock market returns being orthogonal to a euro-area factor, are shown in Table 15. In Column 5, the euro-area factor derived from aggregate euro-area and global series has been used. In Column 6, the euro-area factor derived from stock market returns of euro-area countries has been used.