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Size of the banking sector: implications for financial stability

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Authors

Jan Kakes and Rob Nijskens

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De Nederlandsche Bank N.V.

P.O. Box 98

1000 AB Amsterdam

www.dnb.nl

Email: info@dnb.nl

Size of the banking sector: implications for financial stability

Jan Kakes and Rob Nijskens¹

¹ De Nederlandsche Bank, Financial Stability Division. We would like to thank Paul Cavelaars, Jakob de Haan, Willem Heeringa, Marco Hoeberichts, Iman van Lelyveld, Mark Mink and Job Swank for useful comments. The views expressed in this paper do not necessarily express those of De Nederlandsche Bank.

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1 Introduction

The recent global financial crisis has revived discussions about the optimal size of financial systems, particularly the banking sector. Indeed, several economies with a large banking sector relative to GDP, such as Iceland and Ireland, were hit hard during the crisis. At the same time, however, countries with small, domestically oriented banking sectors, such as those in Greece, Italy and Portugal, also turned out to be vulnerable. These recent experiences suggest that the relationship between banking sector size and financial stability is not clear-cut.

This study explores the nexus between banking sector size and financial stability for 38 advanced and emerging economies, by assessing the correlation between the size of the banking system and a number of systemic risk indicators. These indicators correspond to the intermediate objectives for financial stability policy, which have been developed by the European Systemic Risk Board (ESRB, 2013). In addition, we present case studies of Ireland and Greece, two economies with, respectively, a large and a small banking sector that were both hit hard after the global financial crisis.

We find that the size of the banking sector as a percentage of GDP is significantly correlated with most systemic risk measures. This correlation is positive for indicators such as credit volume, banks' non-deposit funding, bank leverage and the market share of the largest banks. Indeed, large banking sectors often go hand in hand with a high level of private credit, a strong reliance on wholesale funding and a concentration of highly leveraged banks. However, indicators like domestic orientation and sovereign exposures are negatively correlated with size: smaller banking sectors tend to be more focused on their home country and government, which may create concentration risks.

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We also find that banking sector size is related to economic damage in the recent crisis. Correlations are significantly positive for the increase in government debt, non-performing loans and banks' accumulated losses. This indicates that large banking sectors indeed experience larger direct financial crisis damage. However, the link with indirect economic damage is less clear: the correlation with GDP loss and risk premia is insignificant.

Finally, we find that rapid *growth* of the banking sector prior to the crisis, experienced by countries like Iceland, Ireland and Spain, is positively correlated with financial crisis damage. This growth is often accompanied by a strong credit expansion, facilitated by non-deposit funding, which may lead to vulnerabilities building up (Behn et al., 2017).

Overall, a positive relationship between banking sector size and financial stability risks can be established for *most*, but not for *all* indicators. Hence, policymakers should be cautious with measures to directly address banking sector size as such.

Rather than targeting the size of the banking sector directly, policies to promote financial stability should address underlying risk elements. For example, wrong incentives that artificially increase the size of banks and amplify credit growth, such as tax incentives or implicit guarantees, may be reduced. Recently developed macroprudential instruments, such as the countercyclical capital buffer and systemic capital surcharges, and new resolution frameworks (with additional requirements for loss absorbing capacity) can also help reduce banking sector vulnerabilities. In addition, instruments can be employed to target systemic risk in specific sectors, such as the housing market (Loan-to-Value restrictions, Loan-to-Income limits) and sovereign debt markets (large exposure constraints).

The next section provides a brief overview of the literature on the interaction of financial sector and the economy. Section 3 explains our approach, while Section 4 and 5 present empirical results on, respectively, vulnerability and damage indicators. Section 6 then goes on to show that the *growth* of the banking sector prior to the crisis, perhaps more than its size, is correlated with crisis damage. Section 7 concludes.

2 Related literature

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A long strand of literature has examined the relationship between financial development and economic performance (Levine, 2005). Finance can stimulate economic growth by pooling savings and making these available for investments, facilitating transactions and risk management. Following Goldsmith (1969), a number of empirical studies have established a positive relationship between finance – typically measured by money or credit aggregates as a percentage of GDP – and economic growth (King and Levine, 1993). Subsequent studies added financial market variables and other elements, such as legal system and the quality of institutions (Beck et al., 2010).

In the run-up to the recent crisis, however, there was growing concern among policymakers about the increasing size, interconnectedness and complexity of the financial system (Houben et al., 2004; Geithner, 2006). Rajan (2006) acknowledges the benefits of financial development, but also observes important side-effects as financial players may become more prone to misaligned incentives that could lead to systemic risk.

Several recent analyses have thus considered the possible negative impact of finance. Following Easterly et al. (2000), some studies have found that, beyond a certain size, the relationship between finance and economic performance becomes insignificant or even negative (Cecchetti and Kharroubi, 2012; Arcand et al., 2015; Bijlsma et al., 2018). One explanation is that financial activity has diminishing returns, for instance because excessive financial sector wages cause an outflow of human capital from the rest of the economy to the financial sector (Philippon and Reshef, 2012; Beck et al., 2014; Kneer, 2013). Another explanation is financial fragility, for instance because the financial sector is considered inherently unstable (Kindleberger, 1978; Minsky, 1992) or because a large banking sector may facilitate excessive credit supply (ESRB, 2014c). Gambacorta et al. (2014) consider the interaction between finance and growth in the context of

financial structure, distinguishing between bank-based and market-based financial systems. They conclude that, whereas banks in general may help to smooth the business cycle in a normal economic slowdown, a *large* banking sector may exacerbate recessions associated with a financial crisis. A related conclusion is drawn by Amoglobeli et al. (2015), who find that the costs of systemic banking crises are highest for countries with large banking sectors that rely on funding from abroad.

A related strand of literature focuses on the size of individual banks, rather than the financial sector as a whole. Economies of scale are often considered an important driver of bank size, but so are tax considerations and too-big-to-fail incentives (DNB, 2015). However, Davies and Tracey (2014) find that, after controlling for implicit too-big-to-fail subsidies, economies of scale are negligible. Laeven et al. (2014) analyze systemic risks of large banks and observe that these are most prominent in large financial systems. The latter is consistent with the ESRB (2014c) study on overbanking, which shows that the expansion of the EU banking system since the mid-1990s can be entirely attributed to the growth of the 20 largest banks.

3 Our approach

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We focus on the relationship between the size of national banking sectors and financial stability risks. Hence, we do not consider the implications of a large banking system for economic performance more broadly. Our assessment of financial stability risks follows the intermediate objectives of macroprudential policy recommended by the ESRB (2013) and set out in the accompanying Flagship Report and Handbook (ESRB, 2014a; 2014b). These intermediate objectives have been formulated to help operationalize the macroprudential policy framework and provide guidance for setting macroprudential instruments. For each intermediate objective, we define one or more risk measures or indicators, which aim to capture systemic risk at the country level. These are inspired by indicators suggested by, inter alia, the ESRB (2014a) and the IMF (2014). Table 1 presents these intermediate objectives and relates them to the risk measures we use in this paper.²

Table 1 Intermediate objectives and financial stability risks

Intermediate objective (ESRB, 2013)	Our risk measure*
1. Excessive credit and leverage	Credit to the private sector (% GDP) Sovereign debt (% GDP)
2. Maturity mismatch and illiquidity	Loan-to-deposit ratio
3. Misaligned incentives and moral hazard	Leverage of banks Total assets top 3 banks (% total assets)
4. Concentration risk	Domestic exposures (% total assets) Sovereign exposures (% total assets)

* See Annex A for more detailed definitions.

2 A fifth intermediate goal originally proposed by the ESRB – resilience of financial infrastructures – is not considered in this paper, as it is hard to find empirical proxies for this objective. In subsequent work, the ESRB has also dropped this intermediate objective and integrated it into the other four (see e.g. ESRB, 2016).

The first risk category – *excessive credit and leverage* – reflects the rapid credit expansion that can often be observed in the run-up to a financial crisis (Drehmann et al., 2010). Our empirical indicators for this risk category are credit to the non-financial sector and sovereign debt, both as a percentage of GDP.³

The second type of risk – *maturity mismatch and illiquidity* – can manifest itself through funding problems, as illustrated in the recent crisis. Our empirical measure is the loan-to-deposit ratio: bank loans to the private non-financial sector as a percentage of deposits from the same sector. This is an indicator of the sensitivity of bank funding to market sentiment: the higher this ratio, the higher banks' reliance on possibly flighty market-based funding (Demirgüç-Kunt and Huizinga, 2010; Huang and Ratnovski, 2011; López-Espinosa et al., 2012).

The third risk type – *misaligned incentives and moral hazard* – is measured by the importance of large, systemically important banks in the domestic banking sector, as a proxy for too-big-to-fail incentives. Large banks are often of vital importance for the economy, which is likely to increase bail-out expectations and thus moral hazard (Laeven et al, 2014). Our indicator for this risk type is total assets of the three largest banks by balance sheet size (G_3) as a share of total banking sector assets. In addition, we include bank leverage as a possible manifestation of such incentives, as banks may hold less capital if they can rely on state support. We use unweighted leverage (total assets divided by total equity) instead of the risk-weighted regulatory

³ An alternative indicator would be the Basel credit gap, i.e. the deviation of the credit-to-GDP ratio from its long-term trend, which is used as a guide for setting the countercyclical capital buffer for banks (BCBS, 2010). For our purposes, however, including the credit gap raises a conceptual problem, as it is a purely conjunctural measure of excessive credit whereas we focus on size of the banking sector as a structural phenomenon. The credit gap is not significantly correlated with our main size indicator (the level of bank assets as a proportion of GDP) but, not surprisingly, it is significantly correlated with banking sector growth, analyzed in Section 6.

capital ratio. Unweighted leverage is most widely available and comparable across countries in our sample as it is not affected by differences in (risk-weighted) capital regulation.

The fourth category – *concentration risk* – is captured by exposures to the domestic economy and domestic sovereign exposures as a proportion of bank assets. As noted by ESRB (2014c), geographical concentration of a banking sector on its own economy can lead to systemic risk when a crisis occurs at home.⁴ Exposures to domestic sovereign debt can lead to negative feedback loops in a crisis (Bekooij et al., 2016; BCBS, 2017).

Whereas this is not an exhaustive list, we believe it reflects the international consensus on financial stability risk categories and measures. Ideally, we would also like to include risk categories such as complexity, interconnectedness and the interaction with the non-bank financial sector. However, due to data gaps it is not feasible to find sufficient information on these risks for a large group of countries, on a consistent basis, over a longer time period.

In addition to the systemic risk measures related to the ESRB intermediate objectives, we also investigate the direct relationship between the size of the banking sector and the realization of risks. These are measured by indicators of financial crisis impact or damage: output loss, increase in sovereign debt, increasing risk premia, growth of non-performing loans and bank losses (Laeven and Valencia, 2013).⁵ We further analyze these indicators in Section 5.

4 There have also been cases in which internationally active banks ran into trouble due to insufficient knowledge of the economies they invested in (such as European banks that stepped into US mortgage markets, or Western European banks extending foreign currency loans in Eastern Europe). However, as long as banks are sufficiently diversified geographically, these problems should not endanger the whole banking system.

5 See Annex A for more detailed definitions of the damage indicators.

Our analysis focuses on the recent crisis episode and its aftermath (2007-2015), which can be considered a real-life stress-test on a global scale. We do not include earlier crises, mainly for practical reasons (such as a lack of data) but also because a longer sample would involve conceptual problems. As most banking sectors have grown over time as a result of financial deepening, it is not straightforward to compare the size of today's banking sector to its size decades ago. Of course, a similar problem may arise in a cross-section of economies that are in a different stage of economic and financial development. Therefore, we perform robustness checks by repeating the analysis for subsamples of higher and lower income countries, and relatively open versus more closed economies.

3.1 Data and methodology

Our dataset covers a broad, globally diversified set of 38 advanced and emerging economies, including nearly all OECD members and the BRICS countries (Brazil, Russia, India, China and South Africa).⁶ Table 2 provides descriptive statistics for our main indicators. More information on data sources, including a list of all countries, is presented in Annex A.

⁶ Two OECD members (Luxemburg and Latvia) are not included: Luxemburg has an enormous banking sector as a percentage of its GDP, but its financial system is very different from those of other countries, and is hardly related to Luxemburg's domestic economy. Latvia only joined the OECD in 2016.

Table 2 Summary statistics of main indicators

Variable	Average	Minimum	Maximum
Total bank assets (% GDP)	239.1	54.3	741.3
<i>Vulnerability indicators (2007)</i>			
Credit to the private sector (% GDP)	138.0	28.7	313.9
Sovereign debt (% GDP)	48.7	3.6	183.0
Loan-to-deposit ratio (%)	133.0	66.0	258.2
Bank leverage	15.7	6.6	27.8
Total assets top 3 banks (% all bank assets)	54.6	4.2	94.3
Domestic exposures (% total assets)	76.5	32.9	99.1
Sovereign exposures (% total assets)	7.1	0.3	41.0
<i>Damage indicators (2007-2015)</i>			
Maximum decline GDP (%)	5.2	0.0	26.4
Increase sovereign debt (% GDP)	26.8	-19.4	99.4
Increase CDS premium sovereign (bp)	506.2	31.1	8764.3
Maximum NPLs (% total loans)	7.8	0.6	42.0
Peak accumulated loss (RoE)	12.5	0.0	153.2

Most of our results are based on stylized facts and basic empirical relationships, such as correlations between variables. We are reluctant to go further than that with the data we have at our disposal. While 38 countries represent a broad geographical coverage, at the same time they make up only a small number of empirical observations, which reduces the scope for using more advanced empirical tools. Moreover, several of our variables are proxies of broad phenomena (“funding risk”, “misaligned incentives”) that are difficult to gauge with one single indicator. Hence, we stay away from presenting elasticities and are cautious in drawing conclusions about causal relationships between variables.

Our analysis focuses on the connection between the size of the banking sector and risk characteristics at the end of 2007 (i.e. the start of the financial crisis) and between size in 2007 and damage in subsequent years. We employ four different approaches:

1. We present correlations between the size of the banking sector in 2007, and indicators of financial stability risks and damage, respectively. These are both conventional correlations (Pearson) and, to check for outlier sensitivity, rank correlations (Spearman). To control for correlations among indicators, we also show semipartial correlations.
2. We present scatter plots to inspect the relationships between the variables visually, which can help to explain the observed patterns. Like the correlations, visual relationships do not imply causality.
3. We repeat the analysis for specific subgroups, by splitting our sample into high-income versus low-income countries as well as open versus closed economies. We also present case studies for Greece and Ireland, to provide a more in-depth picture of the relationship between size and stability.
4. Finally, as an alternative to size, we consider the growth of bank assets prior to the crisis.

4 The relationship between banking sector size and financial stability risks

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Table 3 presents correlations between the size of national banking sectors and financial stability risks, using the risk indicators discussed in the previous section. A quick glance at the table reveals that all conventional and rank correlations, except those with sovereign debt, are statistically significant. The two concentration risk measures – banks' domestic orientation and domestic sovereign exposures – are negatively related to size; the other significant correlations are all positive.

The vulnerability indicators are not fully independent from each other as they may partly reflect common trends, which is demonstrated by the semipartial correlations in the last column of Table 3. In most cases, the semipartial correlations are much lower than the pairwise correlations.

Table 3 Correlations between size and risk indicators

Size (bank assets, % GDP) and vulnerability indicators, 2007

	Conventional (Pearson)	Rank (Spearman)	Semipartial
Private credit	0.73 ^a	0.76 ^a	0.09
Sovereign debt	-0.02	0.11	-0.21 ^b
Loan-to-deposit	0.40 ^b	0.39 ^b	-0.02
Leverage	0.63 ^a	0.74 ^a	0.32 ^a
G3 banks	0.48 ^a	0.54 ^a	-0.06
Domestic exposure	-0.78 ^a	-0.75 ^a	-0.32 ^a
Sovereign exposure	-0.44 ^a	-0.54 ^a	0.08

Explanation: a, b and c indicate significance at, respectively, 99%, 95% and 90% confidence levels. Semipartial correlations control for the correlation among the vulnerability indicators.

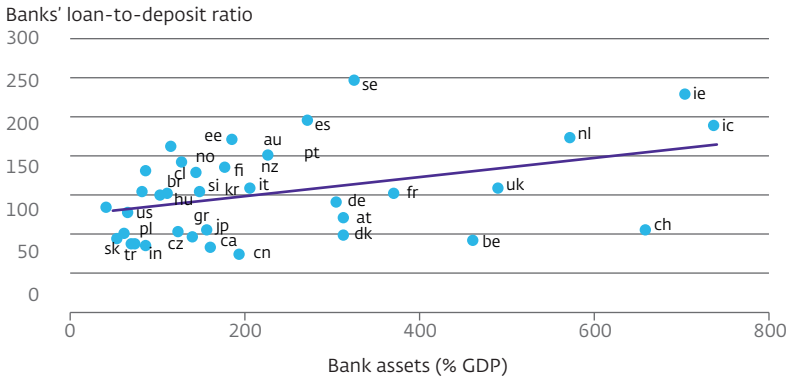
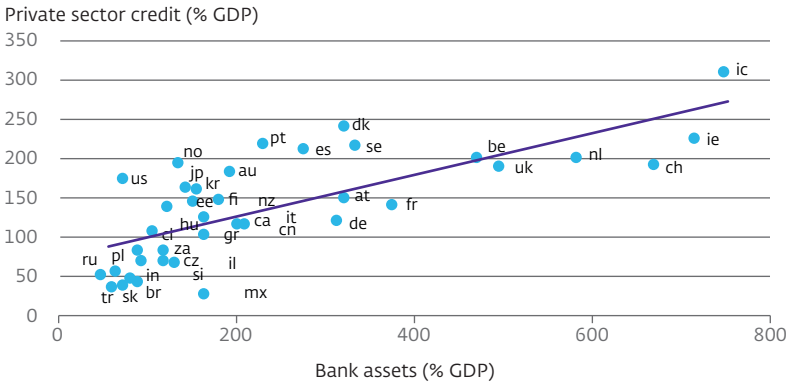
4.1 Excessive credit and leverage

Figure 1 (upper panel) corroborates the strong positive relationship between the size of the banking sector and the outstanding amount of domestic credit to the private sector. Several countries with the highest credit-to-GDP ratios – Iceland, Ireland, Spain and Portugal – experienced rapid credit growth in the run-up to the crisis. Other countries – Denmark, the Netherlands, and Switzerland – have a longer history of high private sector debt. To some extent, the observed correlation may just reflect a large share of credit being provided by banks, which would automatically expand their balance sheets. However, an alternative calculation, in which credit exposures are deducted from bank assets, still leads to significantly positive correlations.⁷ Hence, domestic credit extension by banks is unlikely to be the only driver of bank size. In that context, a relevant observation is that large banking sectors tend to have substantial exposures abroad, which is shown by the negative correlation between size and domestic exposures (further explored below).

⁷ We subtract banks' credit exposures to households and non-financial firms – a subset of total credit – from bank assets, thus excluding any direct contribution of credit to the size of banks' balance sheets. As a result, the conventional correlation becomes 58% (instead of 73%) and the rank correlation becomes 55% (instead of 76%). These correlations are lower but still statistically significant at a 99% confidence level. Our preferred indicator remains uncorrected bank assets, as presented in the main text, as this captures the size of the banking system more comprehensively than the adjusted measure.

Figure 1 Sector size positively related to credit and funding risk ...

Observations for 2007



Data source: see Annex A.

The positive correlation between size and credit may also reflect a difference in financial development across countries, with credit aggregates and bank assets both reflecting financial deepening. Indeed, all countries in the top-right corner of Figure 1 (upper panel) are advanced economies while countries in the lower-left corner are for the most part emerging economies. We further investigate the differences between subgroups of countries in Annex B, including a distinction between countries with above-medium and below-medium income per capita. The positive correlation is statistically significant for both subgroups: private sector debt and banking sector size going hand-in-hand is thus a broad-based phenomenon.

Altogether, we observe a clear positive relationship between the size of banking sectors and domestic credit, although our data allow several explanations for the underlying causes of this relationship.

4.2 Maturity mismatch and illiquidity risk

The positive correlation between size and banks' loan-to-deposit ratio is also statistically significant, albeit less pronounced than the correlation with credit. This is reflected by Figure 1 (lower panel). A possible explanation for this positive correlation is that banks' expansion prior to the crisis was facilitated by other sources than their traditional domestic deposit base. Indeed, in some countries bank lending increased significantly, which was financed by wholesale funding (Huang and Ratnovski, 2011; Boot and Ratnovski, 2016).⁸ We present further evidence for the role of non-deposit funding in Section 6, where we consider the relationship between risk indicators and banking sector *growth*, rather than size, prior to the crisis.

⁸ To some extent, this also holds for deposits on pure internet-based banks, which have proven to be less stable than traditional deposits. See Van Ewijk (2013) for a case study of ING Direct, one of the first large internet-based banks. Unfortunately, we cannot make a distinction between internet-based and more traditional deposits in our data. In the crisis, some banks that expanded using internet-based deposit funding were hit by bank runs, such as Icesave – a branch of the Icelandic bank Landsbanki – in October 2008.

4.3 Misaligned incentives and moral hazard

Both indicators of misaligned incentives – the importance of each country's three largest banks (G3) and bank leverage – show a clear positive relationship with total banking sector size. According to Figure 2 (upper panel), large banking sectors tend to be more dominated by the top three institutions than small banking sectors.⁹ The most extreme cases – Iceland, Switzerland, Belgium, the Netherlands – are all small, open economies with internationally oriented banking systems. This suggests that economies of scale and scope partly explain why these countries' banking sectors are dominated by large institutions: expansion abroad may be necessary because the domestic market is perceived too small for banks to grow further.¹⁰ However, the rank correlation in Table 3 shows that these outliers are not driving the results. The importance of large banks can also be measured by the top three banks' total assets as a percentage of GDP, rather than their proportion of the banking sector. The correlation of this alternative measure with banking sector size is even higher than the original G3 indicator, which provides further evidence of systemically important institutions in large banking systems.¹¹

The positive relationship between size and leverage (Figure 2, lower panel) has been established by previous studies, particularly in combination with the presence of large banks.¹² This may indicate that large banking sectors are more prone to moral hazard, providing an incentive to take more risk by increasing leverage. Moreover, high leverage enables banks to expand

9 This is in line with previous studies, such as Laeven et al. (2014).

10 Indeed, DNB (2015) concludes that one of the main reasons for Dutch banks' cross-border expansion in the 1980s and 1990s was that the domestic market was too small given banks' growth ambitions. This indicates that large banking systems may entail larger too-big-to-fail incentives than small banking sectors.

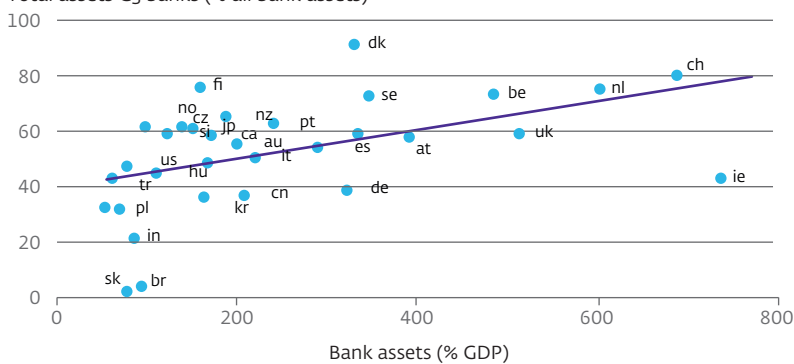
11 More specifically, the conventional correlation is 90.6 percent and the rank correlation is 93.3 percent. Whereas these high correlations may simply reflect that large banks by definition help to boost the size of the banking sector, they are nevertheless relevant observations in the context of this study.

12 For instance, Laeven et al. (2014) show that large banks tend to be more leveraged than small banks.

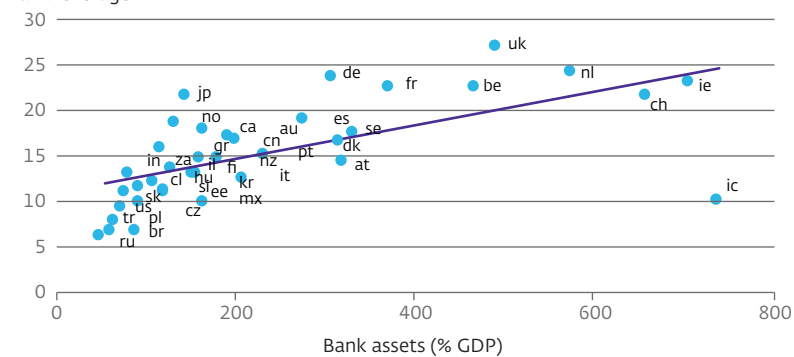
Figure 2 ... and to misaligned incentives ...

Observations for 2007

Total assets G3 banks (% all bank assets)



Bank leverage



Data source: see Annex A.

rapidly. Alternative explanations for high leverage may be that large banks tend to have more advanced risk management systems and are more diversified than small ones. More diversity could justify higher leverage from a bank's own perspective, although these bank-specific diversification benefits may be less relevant from a macroprudential point of view.¹³

4.4 Concentration risk

In contrast to the previous three risk categories, there is a clear *negative* relationship between banking sector size and the proportion of domestic exposures (Figure 3). Apparently, smaller banking sectors tend to have a strong home bias, while large banking sectors are more internationally diversified. Part of the negative correlation may be driven by the distinction between advanced and emerging economies. Separate calculations by subgroup (Annex B) show that this correlation is only significantly negative for countries with above-medium income per capita. It is insignificant for low-income countries, whose domestic exposures are between 80 and 100 percent in nearly all cases. Altogether, the correlation reflects differences between high-income and low-income countries as well as variation within the high-income group.

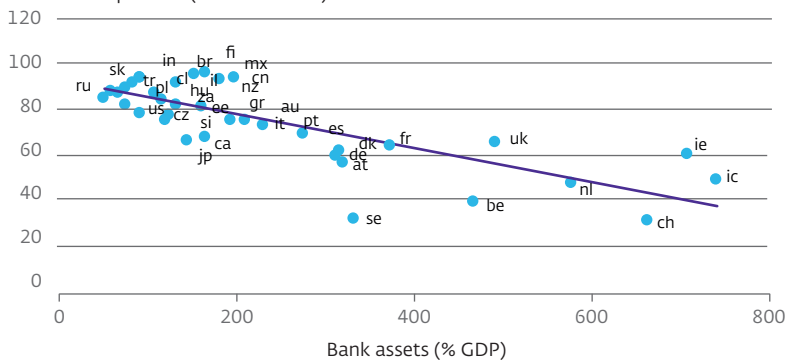
In line with the pattern of overall domestic exposures, smaller banking systems also tend to be relatively more exposed to their own sovereign. This holds in particular for a few emerging economies – Brazil, India and Turkey – where sovereign exposures comprise 20–40 percent of banks' assets, which is high compared to the sample average of 7 percent.

¹³ From a macroprudential perspective, the benefits of more diversification of individual banks may be counteracted by more homogeneity across banks. In other words: diversification by banks may come at the expense of diversity of the financial system. Evidence for such a trend in the Netherlands is presented by DNB (2015).

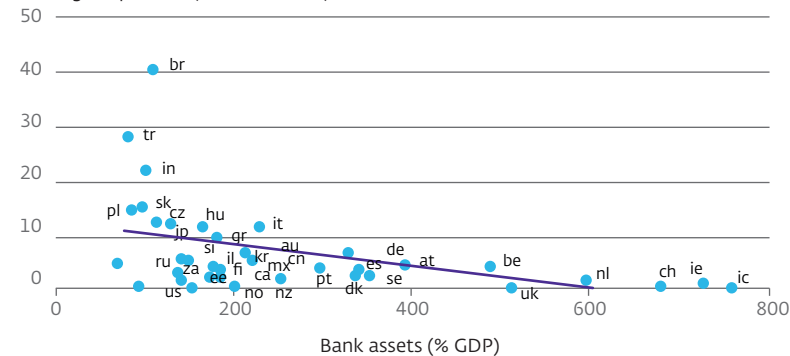
Figure 3 ... but negatively related to concentration risk

Observations for 2007

Domestic exposures (% bank assets)



Sovereign exposures (% bank assets)



Data source: see Annex A.

As Table 3 shows, however, these outlier countries do not drive the negative relationship between banking sector size and sovereign exposures. On the contrary: the rank correlation, which accounts for outliers, is even more pronounced than the conventional correlation.

5 Have large and small banking systems been affected differently by the recent crisis?

Table 4 presents correlations between banking sector size and five indicators of crisis damage over the 2007-2015 period. Size is significantly related to the increase in government debt after the crisis, banks' peak accumulated losses and maximum non-performing loans (NPLs), although the latter correlation becomes insignificant if the impact of outliers is taken into account. All significant correlations are positive, which suggests that large banking sectors have been more affected by the crisis than small sectors. This especially holds for direct measures of crisis damage: non-performing loan ratios and bank losses, as well as the increase in sovereign debt (as a consequence of assisting troubled banks), are larger for larger banking sectors.

At the same time, for two indicators (increase in CDS premium, GDP decline) the correlations are insignificant. This can be interpreted as a sign that banking sector size and indirect crisis damage are less strongly correlated. It also somewhat qualifies the positive connection between banking sector size and crisis damage, especially because GDP decline, which may be considered the most comprehensive damage indicator, is not statistically correlated with banking sector size.

Table 4 Correlations between size and crisis impact

Correlations between size (2007) and damage indicators (2007-2015)

	Conventional (Pearson)	Rank (Spearman)	Semipartial
GDP decline	0.03	0.14	0.11
Increase sovereign debt	0.41 ^b	0.38 ^b	0.17 ^c
Increase CDS premium	-0.03	-0.06	0.07
Maximum NPL	0.31 ^c	-0.15	0.20 ^b
Peak loss (RoE)	0.28 ^c	0.47 ^a	0.20 ^b

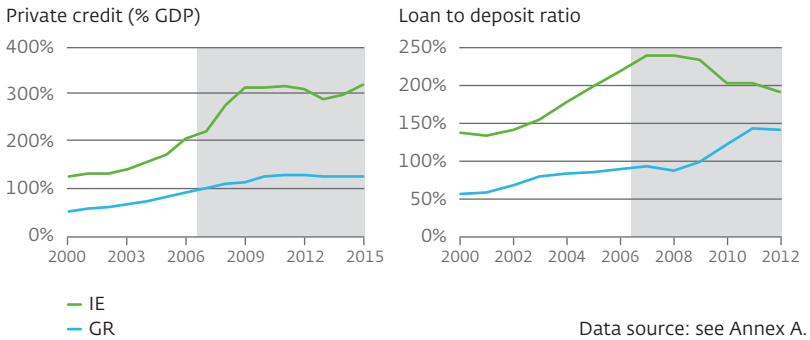
Explanation: a, b and c indicate significance at, respectively, 99%, 95% and 90% confidence levels. Semipartial correlations control for the correlation among the vulnerability indicators.

Overall, the relationships between banking sector size and damage indicators are weaker than those between size and vulnerabilities. One possible explanation is that, as we showed in the previous section, some risk indicators are *positively* related to size (credit, leverage, non-deposit funding and the importance of large banks) but for other vulnerabilities this relationship is *negative* (concentration on domestic exposures and sovereign debt). This discrepancy may blur the overall relationship between size and damage. Semipartial correlations can control for the correlation between damage and vulnerability indicators. The last column in Table 4 indeed shows that these semipartial correlations are lower than the conventional correlations, but they are still significantly positive.

Another explanation for the weaker relationship between crisis impact and size is that different *types* of crises affect countries diverging banking sector sizes in different ways. For instance, the first phase of the global financial crisis, from 2007 to 2009, particularly affected wholesale-oriented banks that were highly leveraged and exposed to short-term financial funding risk (Altunbas et al, 2017; Beltratti and Stulz, 2012; Ayadi and De Groen, 2014). In the run-up to the crisis, these banks largely operated in economies with high private debt levels and strong credit growth, which are factors that can exacerbate the impact of a financial crisis (Boissay et al., 2016; Amaglobeli et al., 2015; De Haan and Kakes, 2018). The subsequent European debt crisis mainly affected retail-oriented banking systems in countries that suffered from structural economic weaknesses, such as a lack of competitiveness (De Haan and Kakes, 2018). These relatively small banking sectors were characterized by a strong home bias and exposure to their own sovereign.

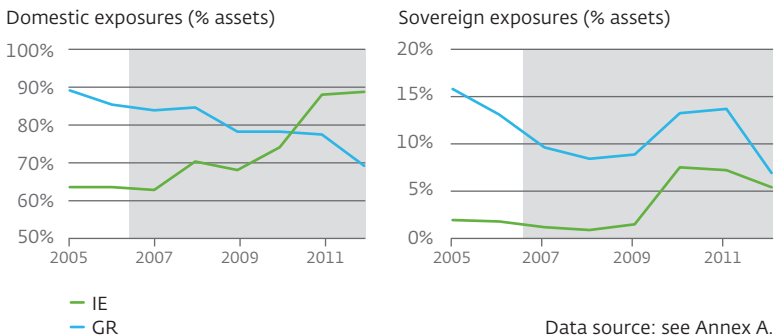
This difference in crisis impact is further illustrated by two case studies for Ireland and Greece, which are further elaborated upon in Annex C. These two countries were severely hit by the crisis and have relatively large (Ireland) and small (Greece) banking systems. Ireland was particularly sensitive to the 2008-2009 global financial crisis. As shown in Figure 4, the country had high private debt and a large, wholesale-funded banking sector, which both expanded rapidly in the run-up to the 2008 crisis. Presumably, the increase in bank lending was facilitated by a surge in non-deposit funding. These characteristics made the Irish banking system vulnerable to the collapse of property prices starting in 2007 and the international financial crisis in 2008.

Figure 4 Vulnerabilities related to credit and funding



Greece showed the typical vulnerabilities of a small banking sector at the start of the crisis in 2007: a strong domestic orientation and high sovereign exposure (Figure 5). The Greek banking sector weathered the global financial crisis relatively well, but was severely hit by the subsequent European debt crisis. A negative feedback loop developed, with a deteriorating domestic economy and public finances, increasing non-performing loans in the banking sector and a tightening of bank lending criteria, which exacerbated the downturn.

Figure 5 Vulnerabilities related to concentrated exposures



6 Correlations with banking sector growth

Apart from banking sector size, rapid *growth* in the run-up to a crisis may be a relevant factor in explaining vulnerabilities (ESRB, 2014c). The upper panel in Table 5 presents correlations between the growth in the bank-assets-to-GDP-ratio from 2002 to 2007 and our risk indicators in 2007 (i.e. growth vs. levels). These correlations tend to be lower than those with the levels in Table 3, although those that are statistically significant have the same sign.¹⁴

One vulnerability stands out: the loan-to-deposit ratio. Its correlation with banking sector growth is significant and relatively high, which squares with the notion that non-deposit funding may facilitate a rapid growth in banking activity (Boot and Ratnovski, 2016). In some countries, like Ireland, official evaluations have identified the role of wholesale funding as one of the key vulnerabilities in the run-up to the crisis (IEO, 2016; see also Annex C).

The middle panel of Table 5 presents correlations between growth rates of the vulnerabilities sector as well as the banking sector (growth vs. growth). It shows that banking sector growth between 2002 and 2007 was accompanied by strong credit growth in the same period. This is further illustrated in Figure 6: Ireland, but also Spain, Russia and Hungary saw a strong growth in credit to the private sector, together with significant banking sector growth. In Ireland and Spain, the loan-to-deposit ratio increased at a similar pace as bank assets, which suggests that the credit and banking expansion was largely financed by non-deposit funding. However, this does not hold for all countries: the overall correlation between banking sector growth and the change in the loan-to-deposit ratio in Table 5 is not significant (although it is positive). The relationship between banking sector growth, credit growth and – in some cases – wholesale funding points to the build-up of vulnerabilities, possibly through loose

¹⁴ Semipartial correlations (not shown) largely confirm this pattern.

Table 5 Correlations between growth of the banking sector, and risk and damage indicators

Growth of bank assets (% GDP) 2002-2007

	Conventional (Pearson)	Rank (Spearman)
<i>Vulnerability indicators, level 2007</i>		
Private credit	0.42 ^b	0.20
Sovereign debt	-0.21	-0.29
Loan-to-deposit	0.38 ^b	0.56 ^a
Leverage	-0.17	0.03
G3 banks	0.64 ^a	0.35 ^c
Domestic exposure	-0.18	-0.04
Sovereign exposure	-0.24	-0.32 ^c
<i>Vulnerability indicators, growth 2002-2007</i>		
Private credit	0.82 ^a	0.52 ^a
Sovereign debt	-0.17	-0.23
Loan-to-deposit	0.03	0.24
Leverage	-	-
G3 banks	-	-
Domestic exposure	-0.91 ^a	-0.15
Sovereign exposure	-0.62 ^b	-0.79 ^a
<i>Damage indicators, 2007-2015</i>		
GDP decline	0.18	0.51 ^a
Increase sovereign debt	0.30 ^c	0.28 ^c
Increase CDS premium	0.04	0.48 ^a
Maximum NPL	0.68 ^a	0.48 ^a
Peak loss (RoE)	0.17	0.27

Explanation: a, b and c indicate significance at, respectively, 99%, 95% and 90% confidence levels. Leverage and the total assets of G3 banks were not consistently available for a broad enough set of countries in the period 2002 to 2007.

lending standards (Mian and Sufi, 2009; Keys et al., 2010) and an excessive reliance on market funding.

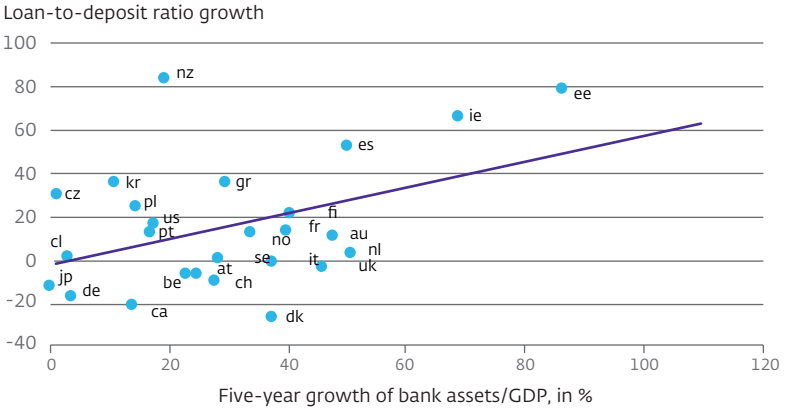
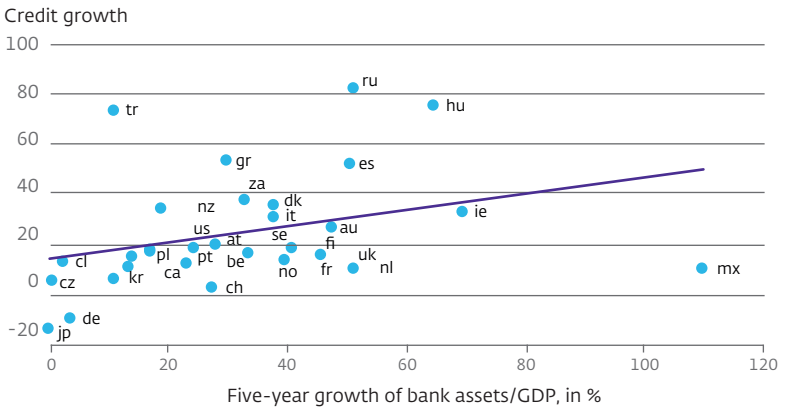
Like in Section 5, significant correlations with crisis damage are all positive (Table 5, lower panel). Notably, the rank correlation between banking sector growth and GDP decline, the most comprehensive damage indicator, is now also statistically significant. In addition, we see that both the increase in government bond CDS premium and maximum NPL are significantly positively related to banking sector growth, when correcting for outliers through rank correlation.¹⁵

These results indicates that, in addition to *size*, a rapid *expansion* of the banking sector is a signal of increasing financial fragility: excessive credit growth, overreliance on wholesale funding, and the emergence of Too-Big-to-Fail banks. This fragility may eventually result in damage to the financial sector and the real economy. Similar conclusions have been reached by e.g. the ESRB (2014c), the Bank of England (2014) and Behn et al. (2017) who point at the importance of growth – e.g. in credit variables – as leading indicators of crises.

¹⁵ Moreover, all semipartial correlations (controlling for the correlation between size and growth in the seven vulnerability indicators in Section 4) are positive; not shown here. However, their magnitude is smaller and, with the exception of credit growth, they are insignificant due to the small amount of observations: 27 instead of 38, due to data limitations.

Figure 6 Banking growth is positively correlated with wholesale-funded credit

Observations for 2002-2007



Data source: see Annex A.

7 Concluding remarks

We have examined the relationship between the size of banking sectors and systemic risk indicators for a large set of advanced and emerging economies. Overall, we find a positive relationship between banking sector size and vulnerability indicators related to excessive credit, funding maturity mismatch, leverage and misaligned incentives. Banking sector size also correlates positively with some indicators of financial crisis damage. At the same time, we find a negative relationship for domestic concentration and sovereign exposure. These conclusions are robust across subsamples of higher versus lower income and open versus closed economies.

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In addition to its size, fast *growth* of banking in the run-up to the recent crisis may have contributed to countries' vulnerabilities in the past years. We show that banking sector growth often goes hand in hand with a (wholesale-funded) credit boom, leading to the build-up of risks. These risks have materialized in the crisis: countries with rapid banking sector growth took a relatively large hit in terms of output loss, non-performing loans and bank losses.

Altogether, a large and rapidly growing banking sector should be a reason for caution. But size in itself is not necessarily an obvious policy target. After all, we find that two risk indicators are negatively related to size. To address risks related to the size of the banking system, policies should address the build-up of underlying vulnerabilities that often go hand in hand with strong banking sector growth: a large private debt ratio and excessive credit growth, banks' reliance on wholesale funding, too-big-to-fail institutions with high leverage leading to misaligned incentives, and excessive exposure on the domestic government.

There are several ways to reduce these vulnerabilities:

- Risks due to excessive credit growth can be addressed by imposing countercyclical capital buffers, loan-to-value and loan-to-income restrictions. As tax systems tend to favour debt over equity, measures to reduce this bias would also contribute to lower debt levels.
- Overreliance on wholesale funding can be mitigated by liquidity and funding requirements. These have already been tightened as part of the Basel 3 rules.
- To reduce misaligned incentives and excessive banking sector growth, systemic buffer surcharges can be imposed on (groups of) individual banks. Furthermore, the setup of resolution frameworks and related loss absorption requirements (MREL, TLAC)¹⁶ will help in this regard. Total assets as a percentage of GDP is one of the key indicators to establish systemic importance. Apart from systemic surcharges and loss absorption requirements, which are risk-weighted, an unweighted leverage ratio requirement can be used to mitigate unintended effects from risk modelling.¹⁷
- For smaller banking systems, a high level of concentration within the banking system combined with a strong home bias can lead to overreliance on the domestic banking system. This can justify imposing systemic surcharges, even though the banking sector's size in terms of GDP seems manageable.

¹⁶ Minimum Requirement for own funds and Eligible Liabilities (MREL), Total Loss Absorbing Capacity (TLAC).

¹⁷ The Bank of England (2014) finds that economies with relatively large banking sectors are more likely to be hit by the a systemic crisis, but also that this relationship breaks down once banks' resilience – measured by the leverage ratio – is taken into account. This finding supports the implementation of higher capital and other loss absorption requirements to mitigate systemic risk related to large banking sectors.

- Other tools to address misaligned incentives include remuneration systems, particularly if they include incentives to increase a bank's risk profile.
- Large sovereign exposures of banking systems can be directly addressed by imposing, for instance, large exposure limits or higher capital requirements (see e.g. BCBS, 2017).

Some of these tools – particularly macroprudential instruments – are relatively new and have been specifically designed to address vulnerabilities discussed in this paper. These instruments can be combined with other macroeconomic policies, such as monetary and fiscal policy, and structural policies, such as the design of tax incentives, to reduce vulnerabilities related to the size of the banking sector.

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Annex A Data sources

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The data set spans 38 emerging and advanced economies from Africa, Asia, Europe, Latin America, North America and Australia, although most countries are located in Europe. The full list is presented in Table A1.

Table A1 Countries included in our analysis

Country	Bank assets (% GDP)	Income group*	Openness**
1 Iceland	741	H	O
2 Ireland	709	H	O
3 Switzerland	664	H	O
4 Netherlands	580	H	O
5 UK	495	H	C
6 Belgium	470	H	O
7 France	377	H	C
8 Sweden	334	H	O
9 Austria	324	H	O
10 Denmark	321	H	O
11 Germany	314	H	O
12 Spain	280	H	C
13 Portugal	235	L	C
14 Italy	214	H	C
15 China	203	L	C
16 Australia	195	H	C
17 New Zealand	186	L	C
18 Canada	170	H	C
19 Mexico	169	L	C
20 Greece	166	L	C
21 Korea	160	L	O
22 Finland	156	H	O
23 Japan	149	H	C
24 Norway	137	H	C
25 Israel	134	L	O
26 Estonia	126	L	O

Country	Bank assets (% GDP)	Income group*	Openness**	
27	Slovenia	124	L	O
28	South Africa	121	L	C
29	Hungary	112	L	O
30	Czech Rep.	97	L	O
31	Chile	95	L	O
32	Brazil	94	L	C
33	India	87	L	C
34	Slovakia	80	L	O
35	US	78	H	C
36	Poland	71	L	O
37	Turkey	64	L	C
38	Russia	54	L	C

* Sample split into countries with USD income per capita in 2007 below (L), respectively, above (H) the 2007 sample median (USD 32,610).

** Sample split into countries with openness – exports plus imports as a percentage of GDP – below (C), respectively, above (O) the 2007 sample median (74.3 percent)

Most of our data come from central banks, which typically have the most comprehensive overview of the banking system due to their responsibilities for statistics, monetary policy, supervision and financial stability. If data from central banks are not available, we use information from (national) statistical agencies, regulators, the IMF, the World Bank and data providers such as Thomson Datastream and SNL Financial. Table A2 lists our main data sources.

Obviously, definitions of variables may differ across countries, reflecting differences in accounting systems and statistical and regulatory frameworks. For example, total assets tend to be higher under IFRS than under US GAAP, particularly due to a different treatment of derivatives reporting. Such heterogeneity is inevitable; we do not expect that it has a major impact on our results.

Table A2 Main data sources

Variable	Source	Coverage
Total banking sector assets	Supervisory data	All countries (38)
Credit to the private sector	BIS (Total credit to the non-financial sector)	All countries (38)
Sovereign debt	National central banks	All countries (38)
Banks' loan-to-deposit ratio	Supervisory data, SNL Financial	36 countries
Banks' domestic exposures	National central banks	37 countries
Banks' sovereign exposures	National central banks	37 countries
Leverage ratio of banks	Supervisory data, SNL Financial	All countries (38)
Total assets top 3 banks	Supervisory data, SNL Financial	34 countries
GDP decline	Laeven and Valencia (2013)	All countries (38)
Increase in sovereign debt	Laeven and Valencia (2013)	All countries (38)
Non-performing loans	IMF	36 countries
CDS premia	Thomson Datastream	37 countries
Bank losses (RoE)	IMF	36 countries

The vulnerability indicators (based on end-2007 data) have been calculated as follows:

- **Banking sector size** is total assets of the banking system as a percentage of domestic GDP. We use the total consolidated banking system, i.e. including subsidiaries abroad.
- **Credit to the private sector** includes total indebtedness of non-financial firms and households as a percentage of GDP.
- **Sovereign debt** is total government debt as a percentage of GDP.
- **Loan-to-deposit ratio** is total bank loans to the non-financial private sector divided by total bank deposits from the non-financial private sector.

- **Leverage** is total assets of the banking sector divided by total equity of the banking sector.
- **G3 banks** is the sum of total assets of the three largest domestic banks as a percentage of the banking system's total assets.
- **Domestic exposure** is total exposures to domestic counterparties as a percentage of total assets.
- **Sovereign exposure** is total exposures to the domestic government as a percentage of total assets

Damage indicators (2007-2015) have been calculated as follows:

- **GDP decline** is the maximum decrease in real GDP over the 2007-2015 period. So if, for instance, GDP peaked in 2008 and declined in two subsequent years, and if this is the total decline over the period considered, we use this decline as our indicator. Seven countries have not experienced negative growth in any of the years considered; for these cases, the indicator variable is set at zero.¹⁸
- The **increase in sovereign debt** is vis-à-vis its 2007 level (% GDP). For countries where the debt ratio has not increased, this variable is set at zero.
- The **increase in the CDS premium** is based on 5-year sovereign bonds. It is the maximum level (in bp) vis-à-vis the 2007 level.
- The **maximum NPL** is the highest annual NPL as a percentage of gross loans in the period considered.
- **Peak loss** is the window of consecutive years over which accumulated losses – measured by the return on equity – are highest. For countries where banking sectors had positive profits in every single year, this variable is set at zero.

¹⁸ There are various alternative measures of output loss as an indicator of crisis severity; see e.g. Laeven and Valencia (2013) and Wilms et al. (2018).

Annex B Robustness checks for subsamples

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Higher versus lower income per capita

Table B1 presents correlations for the entire group, as presented in the main text (Total), as well as for subsamples of countries with GDP per capita lower (Low) and higher (High) than the sample median in 2007 (USD 32,610). Most of the correlations for the two subsamples are not very different from those of the entire sample. In nearly all cases, they all have the same sign or, if that is not the case, they are statistically insignificant.¹⁹

Table B1 Correlations: higher vs lower income countries

	Conventional correlation			Rank correlation		
	Total	Low	High	Total	Low	High
<i>Vulnerability indicators</i>						
Private credit	0.73 ^a	0.74 ^a	0.59 ^a	0.76 ^a	0.66 ^a	0.50 ^b
Sovereign debt	-0.02	0.21	-0.33	0.11	0.10	-0.30
Loan-to-deposit	0.40 ^b	0.33	0.30	0.39 ^b	0.35	0.26
Leverage	0.63 ^a	0.74 ^a	0.35	0.74 ^a	0.72 ^a	0.42 ^c
G3 banks	0.48 ^a	0.51 ^c	0.18	0.54 ^a	0.63 ^b	0.18
Domestic exposure	-0.78 ^a	-0.13	-0.68 ^a	-0.75 ^a	-0.07	-0.80 ^a
Sovereign exposure	-0.44 ^a	-0.56 ^b	-0.41 ^c	-0.54 ^a	-0.67 ^a	-0.24
<i>Damage indicators</i>						
GDP decline	0.03	0.15	0.18	0.14	0.06	0.14
Increase sovereign debt	0.41 ^b	0.47 ^b	0.35	0.38 ^b	0.38	0.13
Increase CDS premium	-0.03	0.23	0.56 ^b	-0.06	-0.01	0.41 ^c
Maximum NPL	0.31 ^c	0.11	0.55 ^b	-0.15	-0.07	0.31
Peak loss (RoE)	0.28 ^c	0.33	0.49 ^b	0.47 ^a	0.42 ^c	0.33

Explanation: a, b and c indicate significance at, respectively, 99%, 95% and 90% confidence levels.

¹⁹ It should be noted that reduced statistical significance is not just due lower correlations, but also because the number of observations is reduced from 38 to 19 countries in both subsamples. This increases the threshold above which correlations are statistically significant.

The negative relationship between banking sector size and domestic exposures is only significant for the high-income countries. This mainly reflects that for nearly all low-income countries, domestic exposures are between 80 and 100 percent of total assets. For higher-income countries, there is more variation, with most cases between 30 and 80 percent. Interestingly, this difference between both groups does not show up in the sovereign exposures, where correlations are similar or – in the case of rank correlations – more pronounced for the low-income countries.

For most of the damage indicators, conventional correlations are mostly significant for higher income economies. This is largely driven by outliers, however, as most rank correlations are much lower and insignificant. The only exception is the increase in CDS premia, for which both correlations are significant.

Open versus closed economies

Table B2 presents the outcomes for subsamples of relatively open versus closed economies. Our measure of openness is the sum of exports and imports as a percentage of GDP. Economies for which this measure is above the sample median (74.3 percent) are considered relatively open economies, countries that are below the median are considered relatively closed. In general, correlations for the vulnerabilities indicators for both subsamples are very similar to those of the full sample. For the damage indicators, conventional correlations suggest that open economies have been hit more, but this is not supported by the rank correlations.

Table B2 Correlations: open vs closed economies

	Conventional correlation			Rank correlation		
	Total	Closed	Open	Total	Closed	Open
<i>Vulnerability indicators</i>						
Private credit	0.73 ^a	0.54 ^b	0.59 ^a	0.76 ^a	0.56 ^b	0.89 ^a
Sovereign debt	-0.02	-0.02	-0.33	0.11	0.07	0.16
Loan-to-deposit	0.40 ^b	0.35	0.30	0.39 ^b	0.43 ^c	0.43 ^c
Leverage	0.63 ^a	0.79 ^a	0.35	0.74 ^a	0.69 ^a	0.68 ^a
G3 banks	0.48 ^a	0.48 ^b	0.18	0.54 ^a	0.51 ^b	0.52 ^b
Domestic exposure	-0.78 ^a	-0.62 ^a	-0.68 ^a	-0.75 ^a	-0.56 ^b	-0.78 ^a
Sovereign exposure	-0.44 ^a	-0.41 ^c	-0.41 ^c	-0.54 ^a	-0.32	-0.82 ^a
<i>Damage indicators</i>						
GDP decline	0.03	0.03	0.03	0.14	0.08	0.17
Increase sovereign debt	0.41 ^b	0.43 ^c	0.51 ^b	0.38 ^b	0.54 ^b	0.23
Increase CDS premium	-0.03	-0.04	0.34	-0.06	0.08	-0.05
Maximum NPL	0.31 ^c	-0.02	0.45 ^c	-0.15	-0.08	-0.13
Peak loss (RoE)	0.28 ^c	0.04	0.60 ^b	0.47 ^a	0.37	0.54 ^b

Explanation: a, b and c indicate significance at, respectively, 99%, 95% and 90% confidence levels.

Annex C Case studies: Greece and Ireland

A discussion of individual cases helps to illustrate how systemic risk factors are related to the size of the banking sector as well as broader vulnerabilities in the economy. We selected two economies that have been severely hit in the recent crisis: one (Greece) with a relatively small banking sector and one (Ireland) with a large banking sector (Table C1). Concerning risk indicators, we see that Greek domestic and sovereign exposures were relatively high at the end of the crisis, while the other risk indicators – except the sovereign debt ratio – were all less pronounced than the international average. The opposite holds for Ireland: low domestic and sovereign exposures, while the other indicators – except sovereign debt – were more pronounced than the average. This is in line with the overall differences in risk indicators between small and large banking sectors presented in the main text.

In the run-up to the crisis, macro-financial imbalances were growing in both countries, which is reflected by rising debt-to-GDP ratios and house prices, and a deterioration in competitiveness (Figure C1). As Greece and Ireland are part of a currency union, monetary policy could not be used to counter these imbalances (Houben and Kakes, 2013). After the crisis started, both countries were substantially hit; the lower panel of Table C1 shows that all damage indicators performed significantly worse than the international average. Greece and Ireland both needed assistance from abroad (the European Commission, the European Central Bank, and the International Monetary Fund) to stabilize the crisis.

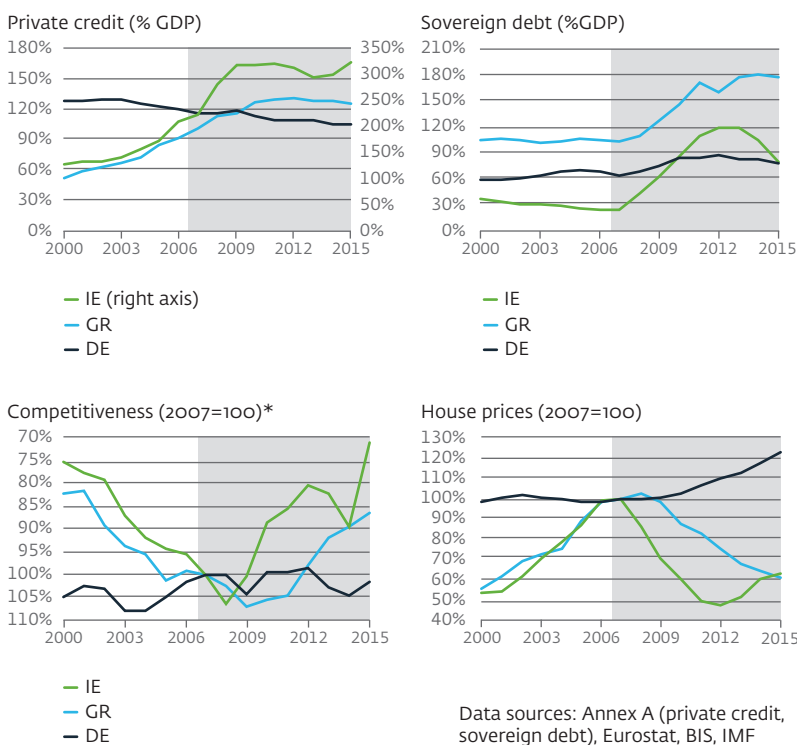
Table C1 Descriptive statistics: Greece and Ireland

Sample means

Variable	All countries	GR	IE
Total bank assets (% GDP)	239.1	166.1	709.1
<i>Vulnerability indicators (2007)</i>			
Credit to the private sector	138.0	104.8	227.4
Sovereign debt	48.7	102.8	24.0
Loan-to-deposit ratio	133.0	93.1	241.2
Bank leverage	15.7	15.4	23.8
Total assets top 3 banks	54.6	51.2	45.1
Domestic exposures	76.5	83.5	62.5
Sovereign exposures	7.1	9.7	1.2
<i>Damage indicators (2007-2015)</i>			
Maximum decline GDP	5.2	26.4	9.1
Increase sovereign debt	26.8	74.4	99.4
Increase CDS premium	506.2	8764.3	742.3
Maximum NPLs	7.8	36.6	25.7
Peak accumulated loss	12.5	153.2	102.3

Figure C1 Macro-financial developments: risks

Developments in Greece and Ireland; Germany is added as a benchmark.



* Real effective exchange rate (unit labour costs), reverse scale.

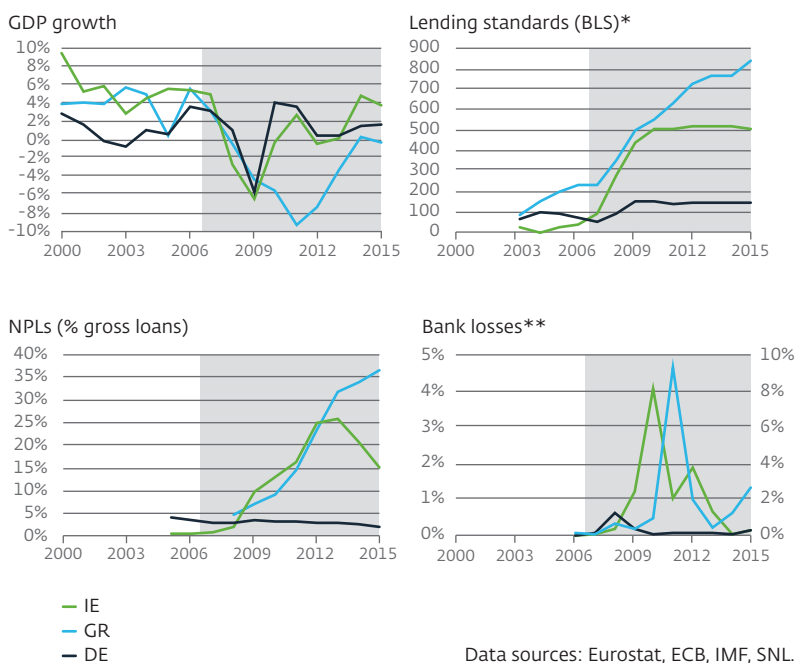
The patterns in Figure C2 show that Irish banks were particularly affected by the 2008-2009 global financial crisis. This coincided with a collapse in property prices, the impact of which was exacerbated by the high level of private debt. Banks tightened their lending standards, which probably contributed to the economic slowdown. Another vulnerability of Irish banks was their strong dependence on wholesale funding, which increased in the years before to the crisis.²⁰ The amount of losses as a percentage of total bank assets peaked at a very high level of around 8 percent in 2009. Irish government debt rose from 24% to over 100% of GDP. After a significant downward correction, the Irish economy recovered after 2009. Bank losses and NPLs decreased and banks did not tighten their lending standards further, which has probably contributed to ending the downward spiral of deteriorating economic conditions and problems in the banking system.

Interestingly, Greek banks weathered the 2008-2009 global financial crisis relatively well. Their small size and predominantly retail-oriented business models may have helped to contain negative market sentiment and losses in these years. When the European debt crisis developed in subsequent years, however, Greece was hit by a negative feedback loop of an economic slowdown, deteriorating state finances and rising problems in the banking system leading to a tightening of lending standards and a credit crunch. This started at the end of 2009, after the government announced that the public deficit was much larger than previous estimations (see, for instance, IEO, 2016).

²⁰ The report of the Commission of Investigation into the Banking Sector in Ireland (2011) has documented the build-up of vulnerabilities prior to the crisis. These include the rapid credit growth, exuberant property markets and banks' reliance on non-deposit funding.

Figure C2 Macro-financial developments: damage

Developments in Greece and Ireland; Germany is added as a benchmark.



* Accumulated quarterly scores of lending criteria for non-financial firms (positive means tightening).

** Sum of annual losses by loss-making banks (larger than EUR 30 bn), as a percentage of bank assets.

Overall, both cases illustrate how characteristics that are related to the size of the banking sector have played a different role during the recent episodes of financial crisis. They also show that these risks work in opposite directions. In countries like Ireland, with a large, wholesale-funded banking sector and high private debt levels, banks were particularly sensitive to the 2008–2009 global financial crisis. In countries like Greece, on the other hand, banks were vulnerable to the subsequent European debt crisis due to their home bias and their relatively large exposure to their own government.

DeNederlandscheBank

EUROSYSTEEM

De Nederlandsche Bank N.V.
PO Box 98, 1000 AB Amsterdam
+31 20 524 91 11
dnb.nl