

Bank Size and Systemic Risk

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EXECUTIVE SUMMARY

Large banks have grown significantly in size and become more involved in market-based activities (those outside traditional bank lending) since the late 1990s. The advance of information technology and deregulation, which has led to a proliferation of financial markets, may have been the key driver of this process.

Large banks tend to have lower capital, less-stable funding, more market-based activities, and be more organizationally complex than small banks. This suggests that large banks may have a distinct, possibly more fragile, business model.

Large banks are riskier, and create more systemic risk, when they have lower capital and less-stable funding. Large banks create more systemic risk (but are not individually riskier) when they engage more in market-based activities or are more organizationally complex.

Failures of large banks tend to be more disruptive to the financial system than failures of small banks. The failures of large banks generate liquidity stress in the banking system, their activities that rely on economies of scale and scope cannot easily be replaced by small banks, and the marginal cost of taxpayer support may increase in the volume required.

Traditional bank regulation, which focuses on individual bank risk, may be insufficient for large banks. Additional regulation, based on systemic risk considerations, is needed to deal with the externalities of distress of large banks. This may include capital surcharges on large banks and measures to reduce their involvement in market-based activities and their organizational complexity.

Banks may operate at a size that is too large from a social welfare perspective due to “too-big-to-fail” subsidies and corporate governance shortcomings. However, the potential for economies of scale in large banks cannot be dismissed. As a result, “optimal” bank size is uncertain.

I. INTRODUCTION

Large banks were at the center of the recent global financial crisis, and their distress caused damage to the real economy. This has triggered a heated debate on the optimal size, organizational complexity, and range of activities of banks (Viñals et al., 2013). This debate takes place against the backdrop of a financial landscape that has evolved markedly over the past two decades, spurred by financial innovation and deregulation. Large banks have increased in size, complexity, and involvement in market-based activities, as banking systems have grown in size and become increasingly global and interconnected.

Within this debate, the views on the optimal way forward differ. Some favor capital surcharges on large banks, as in Basel III. Others advocate restrictions on banks' market-based activities, as in the Volcker rule in the United States or the Vickers and Liikanen reports in Europe. (Table 1 summarizes the range of policy and legislative proposals.) Yet others emphasize the importance of reducing "too-big-to-fail" subsidies (Farhi and Tirole, 2012; Stein, 2013), or improving bank resolution (Claessens et al., 2011), including the role of contingent capital or bail-in capital.

While this variety of views is unavoidable given the different country circumstances, it is important ultimately to arrive at a globally coordinated policy. In a modern globalized financial system, only such a coordinated approach can prevent spillovers across jurisdictions and ensure global financial stability (Viñals et al., 2013).

This paper aims to provide an economic foundation for the debate on bank size, activities, and complexity. It starts with a descriptive analysis of how the size of large banks has increased over time, and along which dimensions large banks differ from small banks, using data for a large cross-section of banking firms in a broad set of 52 countries. Descriptive evidence suggests that large banks may have a more fragile business model (with higher leverage and more market-based activities) than small banks. Yet, since the literature is inconclusive about the economies of scale and scope in banks, it is difficult to determine optimal bank size.

Accordingly, this paper takes a narrower approach. It asks whether there is evidence that large banks are riskier or create more systemic risk than small banks. Once that question is analyzed, the paper discusses possible policy responses to systemic risk in banks.

The paper investigates the relation between measures of bank size, market-based activities, and organizational complexity and measures of bank risk using the same data set. It measures bank risk both at the individual firm level using bank stock returns during the recent financial crisis, and as a bank's contribution to systemic risk using a measure called SRISK based on Brownlees and Engle (2012) and Acharya, Engle, and Richardson (2012). The analysis places special emphasis on the influence of bank size, activities, and complexity on bank

risk, given the debate on the optimal size of banks, but also considers whether bank size interacts with bank capital and funding to influence bank risk.

The empirical analysis shows that large banks, on average, create more individual and systemic risk than smaller banks, especially when they have insufficient capital or unstable funding – both common features of large banks. Additionally, large banks create more systemic risk (but, interestingly, not more individual risk) when they engage more in market-based activities or are more organizationally complex.

These findings have an important bearing on the current policy debate on financial structure. They generally support the path taken by the Basel III regulatory framework, which focuses on strengthening bank capital and liquidity requirements. In particular, the results are consistent with the importance of capital surcharges on systemically important banks that reflect their size and complexity. The findings that market-based activities and the organizational complexity of banks increase systemic risk are consistent with proposals that limit risky trading activities of banks and with a call for living wills that would facilitate the orderly resolution of complex banks and provide ex ante incentives to reduce complexity.

The findings have two additional novel implications. First, the fact that market-based activities and organizational complexity of banks increase systemic risk, but not individual bank risk, implies that these dimensions may be insufficiently addressed by micro-prudential regulation, which focuses on individual bank risk. Measures targeting bank activities and complexity may need to be undertaken in the context of a wider macro-prudential framework. Second, the findings shed light on the debate over whether there may be “too much finance.” The paper finds that larger financial systems have more large banks. Accordingly, to reduce the systemic risk in large financial systems, policy needs to take into account the disproportional role of large banks. This financial stability argument goes beyond the literature’s traditional focus on whether large financial systems are optimal from an allocative efficiency point of view (Philippon, 2010; Arcand, Berkes, and Panizza, 2012).

Before we proceed to the analysis, it is important to place the subject of this paper – bank size, complexity, and activities – in the context of the broader debate on systemic risk. The financial crisis had many causes. Only some were related to the systemic risk from large banks. Inefficiencies in certain markets (such as those for securitized products or short-term bank funding) as well as the traditional credit/leverage cycle were other distinct problems.² Still, the focus on banks – and specifically large banks – is crucial. First, banks are central to the real economy. They provide most of the financing to firms and households (except for the largest corporates in advanced economies). Second, banks are central to the financial system.

² Also, the analysis does not explicitly consider the risks of cross-border bank activities. But our findings that banks that are larger and have more subsidiaries contribute disproportionately to systemic risk are consistent with the conjecture that risks in such activities may be higher. For more analysis of cross-border banking issues, see Goyal et al. (2013).

A large share of inefficiencies in financial markets, and a significant part of the excess cyclicality of credit, can be controlled through affecting incentives of banks.

The rest of the paper is structured as follows. Section II summarizes the recent evolution of bank size and activities. Section III studies the drivers of risk in large banks. Section IV discusses policy implications. Section V concludes. Annexes 1-2 summarize the literature on economies of scale and scope in banks and on corporate governance issues in large banks. Annexes 3-4 contain data and estimation details.

Table 1. Key International Policy Initiatives on Bank Size and Scope

Initiative	Description	Status
Basel Measures		
Additional loss absorbency requirement for global systemically important banks.	A capital surcharge of up to 2.5% imposed on banks deemed systemically important.	Finalized as part of Basel III; phase-in period 2016–19.
Basel Committee’s Fundamental Review of the Trading Book.	An increase of capital charges (and other measures to reduce regulatory arbitrage) on assets in the bank’s trading book.	In consultation.
Country and Regional Initiatives		
United States: Volcker Rule.	A prohibition of proprietary trading within the bank holding company.	Part of the U.S. Dodd-Frank Act, with implementation beginning in 2015 through 2018.
United Kingdom: Vickers Report (of the Independent Commission on Banking).	A separation of retail operations from most market-based and non-European activities. Retail operations to be “ring-fenced” in a separate entity with limited exposure to the rest of the bank.	Part of the Financial Services (Banking Reform) Act 2013, passed by Parliament on December 18, 2013. Final regulations are expected to be fully implemented by 2019.
European Union: Liikanen Report (of the European Commission’s High-level Expert Group on Bank Structural Reform).	A prohibition of proprietary trading in financial instruments and commodities, as well as supervisory powers to separate other high-risk trading activities (such as market-making) by placing them in a separate legal entity within the banking group (“subsidiarization”).	Legislative proposals by the European Commission on structural reforms of EU banks. The proprietary trading ban would apply as of January 1, 2017 and the effective separation of other trading activities would apply as of July 1, 2018.

Source: IMF Staff Reports. See Gambacorta and van Rixtel (2012) for additional details. See also BCBS (2013), Vickers (2011), Liikanen (2012), and European Commission (2014). For details of the UK law, see http://www.legislation.gov.uk/ukpga/2013/33/pdfs/ukpga_20130033_en.pdf. For details of the EC proposals, see http://ec.europa.eu/internal_market/bank/structural-reform/index_en.htm#140129.

II. BASIC FACTS ABOUT LARGE BANKS

Since the 1980s, the global financial system has been transformed by a wave of financial innovation and deregulation. The origin of both can be traced to the information technology revolution, which increased the availability of information, made a variety of assets more tradable, and led to a proliferation of financial markets.³ Financial innovation and deregulation have expanded access to finance, bringing substantial welfare benefits.

At the same time, financial innovation and deregulation have affected the structure of the banking system. First, banks, especially the largest of them, have grown in size. Figure 1 shows how the balance sheet size of the world's largest banks at least doubled, and in some cases quadrupled, over the 10 years prior to the financial crisis. (The crisis was followed by some deleveraging, also in large banks, so their size has been relatively stable since the crisis.) Figure 2 illustrates the same trend from a market structure perspective: bank market concentration, measured as the fraction of banking assets held by the three largest banks in the country, increased markedly in most advanced economies. This process of consolidation was in part fostered by financial deregulation in a number of countries, notably the removal of interstate banking and branching restrictions in 1994 (the Riegle-Neal Act) and the removal of prohibitions on mergers between commercial banks, investment banks, securities firms, and insurance companies in 1999 (the Gramm-Leach-Bliley Act) in the United States; the 1986 "Big Bang" deregulation of financial markets in the United Kingdom; and the creation of a single financial market in the European Union, starting with the 1999 Financial Services Action Plan.

Figure 1: Increase in the Size of Selected Largest Banks

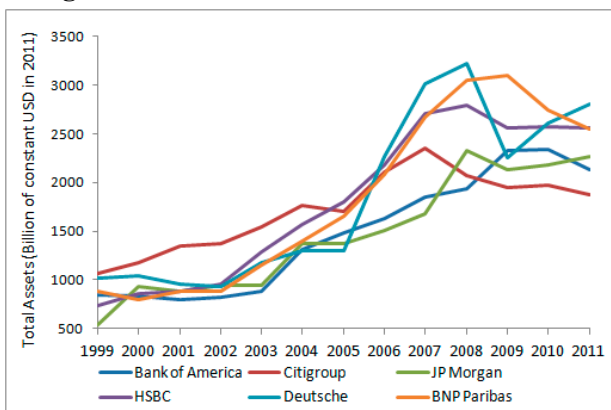
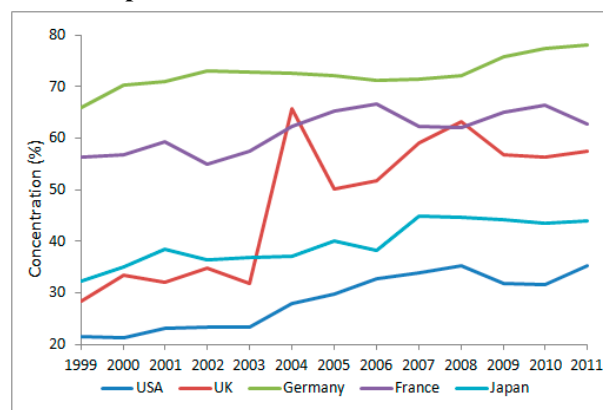


Figure 2: Increase in Bank Concentration Ratios, for Multiple Countries



Sources: Bankscope; World Bank, Financial Development and Structure Database; and IMF staff calculations.

³ For example, interest rate deregulation for banks in the United States (Regulation Q) was in part motivated by competition from financial markets (mutual funds) that could offer financial products with more attractive interest rates.

Second, banks have expanded the range of their activities. They added a wide range of market-based operations to the traditional business of making loans. These include proprietary trading, market-marking, origination and/or holding of securitized debt, security dealing and custodian services, and – more generally – a provision of various financial market services, from advisory to hedging, to customers. Figures 3 and 4 illustrate the shift of banks toward market-based activities using two alternative measures: a reduction of loans as a share of assets, and an increase in noninterest income as a share of income.

Figure 3: Decrease in Banks' Loans-to-Assets Ratio

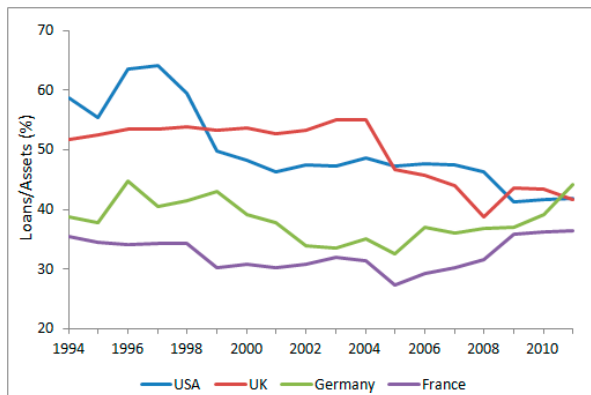
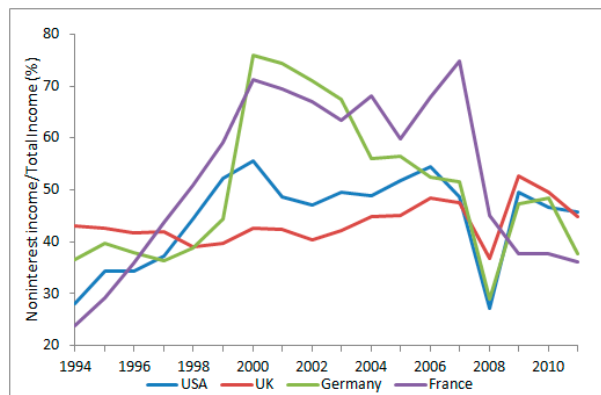


Figure 4: Increase in Banks' Share of Noninterest Income



Notes: The loan-to-asset and noninterest income ratios are computed as the average across the four largest banks in each country.

Sources: Bankscope; and IMF staff calculations.

While the changes in the financial system affected all banks, they had a particularly large impact on the largest banks. The business model of large banks became clearly distinct from that of small or medium-sized banks. First, large banks today engage disproportionately more in market-based activities (Figures 5 and 6). Second, large banks hold less capital than small banks, as measured either by risk-weighted capital ratios or a simple leverage ratio (Figures 7 and 8). Third, large banks have less stable funding than small banks, as measured by the share of deposits in total liabilities (Figure 9). Finally, large banks are more organizationally complex, as measured by the number of subsidiaries (Figure 10).

In fact, among large banks, the four dimensions – level of capital, stability of funding, the share of market-based activities, and organizational complexity – are correlated with each other (see the correlation matrix in Table 2). This suggests that there is a structural reason why some banks become large, with lower capital, fragile funding, more market-based activities, and more organizational complexity at the same time.

Figure 5: Large Banks Engage More in Nonlending Activities

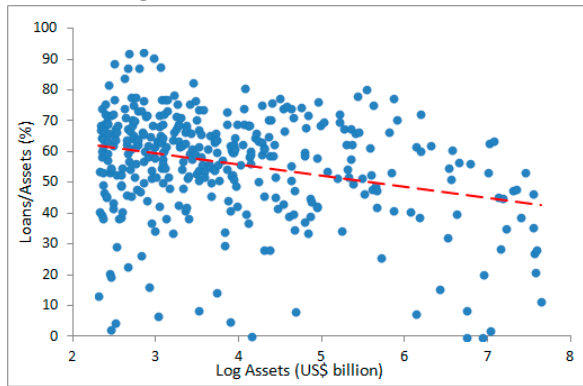


Figure 6: Large Banks Generate More Income from Noninterest Income

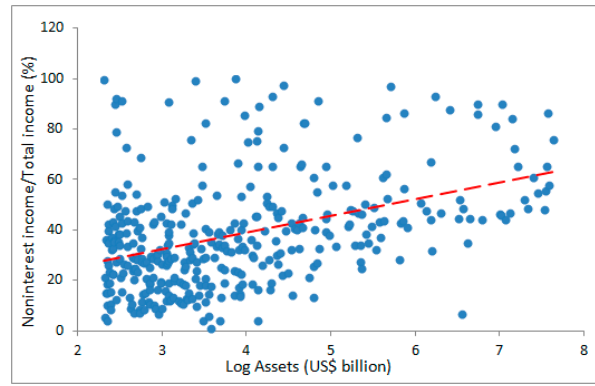


Figure 7: Large Banks Hold Less Risk-weighted Capital

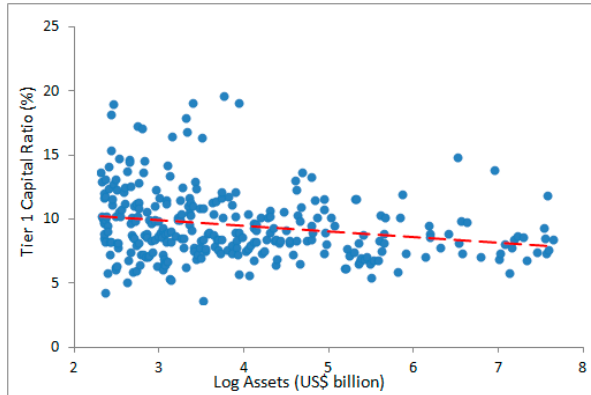


Figure 8: Large Banks Have Higher Leverage

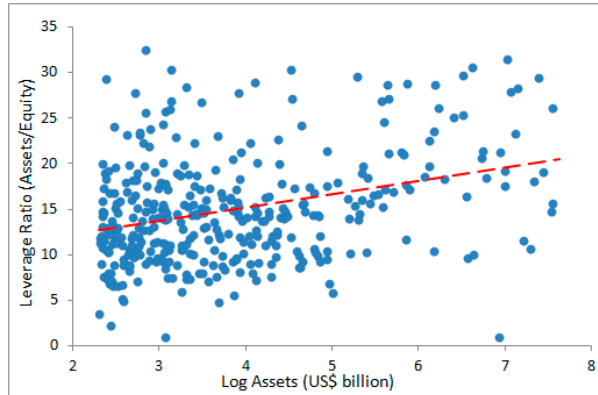


Figure 9: Large Banks Have Less Deposit Funding

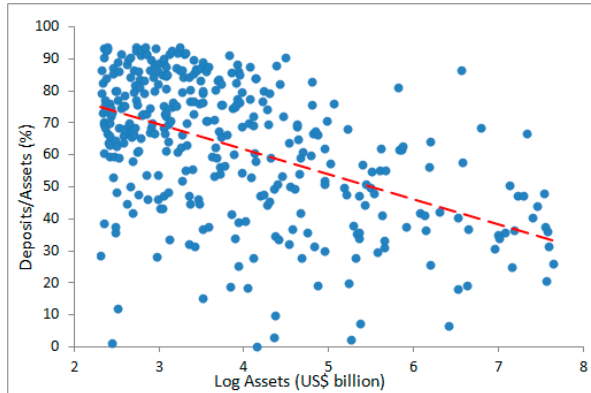
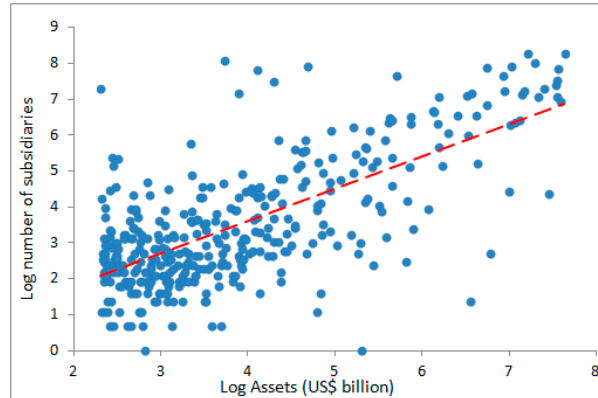


Figure 10: Large Banks Are More Organizationally Complex



Notes: Assets are in log billions of U.S. dollars (e.g., log assets = 2 corresponds to US\$7.4 billion, and log assets = 5 to US\$148 billion). Number of subsidiaries is expressed in log (1 + number of subsidiaries). Data are for the year 2011. The sample is limited to banks with assets over \$10 billion.

Sources: Bankscope; and IMF staff calculations.

Table 2. Correlation between Bank Size, Leverage, Activities, Funding, and Complexity

	Log(Assets)	Tier 1 ratio	Deposits/assets	Loans/assets	Noninterest income	Log(Subsidiaries)	Leverage
Tier 1 ratio	-0.21***						
Deposits/Assets	-0.49***	-0.06					
Loans/Assets	-0.29***	-0.47***	0.32***				
Noninterest income	0.39***	0.16***	-0.53***	-0.49***			
Log(Subsidiaries)	0.70***	-0.15***	-0.52***	-0.36***	0.53***		
Leverage	0.36***	-0.41***	-0.12**	0.00	-0.02	0.19***	
Funding fragility	0.38***	-0.03	-0.80***	-0.36***	0.55***	0.45***	0.17***

Note: The table reports pairwise correlations between various bank characteristics for the sample of banks with assets in excess of US\$10 billion; end-2011 values. Funding fragility is deposits from other banks, other deposits, and short-term borrowing as a fraction of total deposits plus money market and short-term funding. ***, and ** denote significance at the 1% and 5% levels, respectively.

Sources: Bankscope; and IMF staff calculations.

There are a number of possible explanations for why large banks are different:

- One explanation is that large banks benefit from economies of scale, and this affects their business model. There are two angles to this. The first is that size allows better diversification, which reduces risks and allows banks to operate with lower capital and less-stable funding. It may also facilitate market-based bank activities. The second angle is that large banks may operate in a different market segment than small banks. Large banks may have a comparative advantage in market-based activities, which require significant fixed costs and enjoy economies of scale. Market-based activities may invite more leverage and unstable funding, because securities can be used as collateral in repos. Small banks may stick to their comparative advantage in traditional, relationship-based lending.
- Another view is that large banks respond to (inefficient) too-big-to-fail subsidies. Due to a perception that the creditors of large banks will be bailed out in case of bank distress, the cost of debt for large banks is lower. This makes banks more willing to use leverage and unstable funding, and to engage in risky market-based activities.
- The third view is that excess bank size is a consequence of managerial empire-building, and that large banks suffer from bad corporate governance. Managers may reach for size to receive larger compensation (Murphy, 1985; Gabaix and Landier, 2008) or because they enjoy private benefits from the prestige of running a large firm (Jensen, 1986).

Managers can boost bank size by attracting additional funding and increasing bank leverage, or through mergers and acquisitions of other banks.⁴

All of the explanations above have some validity. Large banks may experience economies of scale, although their value, as well as the bank size threshold at which they disappear, is subject to much debate. Annex 1 summarizes the literature on the economies of scale in banks. Large banks benefit from too-big-to-fail subsidies, although their value is also uncertain and varies across countries and over time.⁵ And there is evidence that large banks face specific corporate governance challenges, although again it is hard to quantify their importance. Annex 2 reviews the literature on corporate governance issues for large banks.

Note that the explanation that large banks are so large and operate in the way in which they do because of economies of scale is benign. It suggests that bank size is economically beneficial. Explanations based on too-big-to-fail subsidies and bad corporate governance imply that distortions may be present. Banks may be too large compared to what is socially optimal, and have no incentives to shrink because of private interests of shareholders or managers. Taken together, this implies that there may be a trade-off with large banks reaping economies of scale and scope but contributing to systemic risk.

Since the literature on economies of scale is inconclusive, it is difficult to determine optimal bank size. Accordingly, this paper takes a narrower approach and asks whether large banks are riskier or create more systemic risk. Once that is analyzed, and acknowledging that we do not know what the optimal bank size or scope is, the paper turns to discussing desirable policy responses.

III. RISKS IN LARGE BANKS

This section asks empirically whether large banks are riskier than small banks. We also ask, more specifically, which characteristics of large banks (size per se, lower capital, less-stable funding, more market-based activities, or higher complexity) are associated with more risk. To answer this question, we use the 2007–08 financial crisis as a “natural experiment” and capture bank risk through bank performance during the financial crisis.⁶

⁴ The consolidation process in U.S. banking following deregulation in the 1970s has led to an increase in bank concentration, with large banks growing in size, range of activities, and geographical spread. But while this has improved access to finance for U.S. firms and households, it has destroyed corporate value for many banking firms in the process, especially those that combined traditional banking with investment banking activities (Laeven and Levine, 2007) and those that spread geographically (Goetz, Laeven, and Levine, 2013).

⁵ See Chapter 3 of the IMF’s April 2014 *Global Financial Stability Report* for a review of the current thinking on the too-big-to-fail subsidies (IMF, 2014).

⁶ This way, we treat the financial crisis as a stress test for the banking business models that arose as a result of financial innovation and deregulation. This approach is based on the assumption that the recent crisis is a “representative” shock to the banking sector. Risks may of course be different if the nature of future crises differs from that of the recent crisis, although Fahlenbrach, Prilmeier, and Stulz (2012) show that the same types of banks tend to repeatedly underperform during crises.

We focus on two dimensions of bank risk:

- Individual bank risk, which we measure through the bank's stock performance during the crisis; and
- The bank's systemic risk contribution. This captures how much the bank contributes to system-wide distress. Systemic risk contributions differ from individual bank risk, because they are driven also by correlations in returns between the bank and the financial system, and by bank size. It is the measure of bank risk most relevant to systemic risk (macro-prudential) concerns.

We address these two dimensions of risk in turn, based on a comprehensive global sample of publicly traded banks with assets of at least US\$10 billion.⁷

A. Individual Risk of Large Banks

To study individual risk, we regress bank stock returns during the period from July 2007 to December 2008 on pre-crisis bank characteristics in 2006.⁸ We associate bank stock returns during the crisis with individual bank risk. While the crisis continued into 2009, focusing on the period until the end of 2008 allows us to abstract from the impact of policy interventions on stock returns.⁹

We consider how the following pre-crisis (2006) bank characteristics affected bank risk during the crisis:

- Bank size, measured as the total value of bank assets, taken in logs;
- Bank capitalization, with two alternative measures: the Tier 1 capital ratio and a simple leverage ratio;
- Bank funding structure, with two alternative measures: the share of depository funding, and an index of funding fragility, defined as deposits from other banks, other deposits, and short-term borrowing as a fraction of total deposits plus money market and short-term funding;

⁷ This gives a sample of 370 banks from 52 countries. The sample effectively covers the whole universe of publicly traded banks for which data are available from Bankscope. The sample excludes nonlisted banks, which tend to be smaller than listed banks. For the detailed description of data and method, as well as for an extended review of results, see an accompanying working paper (Laeven, Ratnovski, and Tong, 2014).

⁸ We build on the framework in Beltratti and Stulz (2012). In addition to stock returns, they also analyze differences across banks in distance to default, and do not find a difference between large and small banks. This suggests that the unconditional probability of default does vary with bank size.

⁹ The conclusions we draw from the analysis do not materially change when we limit the sample to the period from July 2007 to July 2008, which predates the collapse of Lehman Brothers and the government interventions that followed.

- Bank activities, with two alternative measures: the share of loans in total assets and the share of noninterest income in total income. A lower share of loans and a high share of noninterest income reflect more bank involvement in market-based activities;¹⁰
- Bank organizational complexity, measured as the number of subsidiaries, in logs.

Results are presented in Table 3. Columns 1 and 2 show results for all banks in the sample. Column 3 reports results for large banks (defined as banks with assets in excess of US\$50 billion) only. Column 4 reports results using alternative measures of capital and funding, and includes nonbanks (investment banks) that do not have deposits and do not report Tier 1 capital. Country-specific factors, such as differences in bank regulations, market structure, or interbank markets, are absorbed by country fixed effects.

Table 3. Determinants of Banks' Stock Returns

Dependent Variable:				
Returns July 2007 – Dec 2008	(1)	(2)	(3)	(4)
Return in 2006	0.0208 (0.0901)	0.0207 (0.0894)	-0.165 (0.212)	0.00256 (0.0977)
Log Assets(\$)	-2.698* (1.500)	-4.160*** (1.515)	-1.495 (1.966)	-5.238*** (1.812)
Tier 1 Ratio	1.055 (0.973)	1.234 (0.982)	5.400** (2.494)	
Deposits/Assets	58.64** (22.01)	57.15*** (20.22)	49.17* (28.21)	
Loans/Assets	-50.40*** (9.459)	-47.20*** (9.640)	-21.63 (23.93)	-41.39** (16.63)
Noninterest Income	2.501 (20.72)	-2.061 (21.23)	-19.84 (25.12)	-13.52 (11.51)
Log Subsidiaries		2.176* (1.115)		0.760 (0.767)
Leverage				-0.622** (0.262)
Funding Fragility				-20.60** (7.911)
Observations	302	302	115	359
R-squared	0.421	0.425	0.531	0.362

Notes: Dependent variable is the bank's stock return computed over the period from July 2007 to December 2008. Global sample of stock exchange listed banks, excluding banks with assets below US\$10 billion. Column 3 is large banks only (with assets in excess of US\$50 billion). Column 4 includes nonbanks (investment banks). All regressions are estimated using ordinary least squares and include country fixed effects. Standard errors in parentheses. ***, **, and * denote significance at the 1%, 5%, and 10% levels, respectively.

Sources: Bankscope; Datastream; and IMF staff calculations.

¹⁰ It is useful to keep in mind that both proxies are imperfect. For example, lending fees may contribute to noninterest income, while securitized loans may enter balance sheets as securities (not as loans).

We find that:

- Size per se is an independent factor that drives individual bank risk. Large banks are riskier than smaller ones (Columns 1 and 2).
- However, among large banks only (over US\$50 billion in assets), size per se ceases to be an independent risk factor. Instead, risk is driven by insufficient capital (Column 3). Insufficient capital is also a risk factor for investment banks (Column 4).
- Nondepository (or unstable) funding is associated with more bank risk (Columns 1-3). As large banks have less depository funding, this can be seen as a compounding risk factor for large banks.
- In contrast, market-based activities do not add to individual bank risk. In fact, there is evidence, based on the loans-to-assets ratio, that more market-based activities may have improved bank performance during the crisis (Columns 1 and 2). A closer look reveals that this result is driven by the subset of U.S. banks with large exposure to mortgage loans that were hit hard by the U.S. mortgage crisis of 2007–08. When restricting the sample to large banks, the result is no longer significant (Column 3).
- Organizational complexity also does not appear to be an important driver of individual bank risk (it is borderline significant in Column 2 and not significant in Column 4).

The economic effects of size, capital, and funding on bank risk are substantial. During the crisis, the average bank stock return was –45 percent. However, for every fivefold increase in assets, stock returns would have been 7 percentage points lower, and for every 20 percentage point increase in the fraction of funding from deposits, stocks returns would have been 12 percentage points higher.¹¹ Additionally, an increase in capital ratios for large banks by 2.5 percentage points would imply an increase in stock returns of 13 percentage points, which is large compared to the average stock return for large banks of –55 percent.¹²

B. Systemic Risk of Large Banks

We now turn to the systemic risk posed by large banks. In broad terms, systemic risk can be described as the externalities of bank distress onto the rest of the financial system or the real economy (Bernanke, 2009; De Nicoló, Favara, and Ratnovski, 2012).

To measure systemic risk, this definition needs to be narrowed down. The literature’s most widely accepted way to do so is to proxy systemic risk through an SRISK measure, defined

¹¹ Ceteris paribus, based on regression results in Column 1, and equivalent to a one standard deviation increase in total assets, or the ratio of deposits to assets, respectively. These economic effects are strictly comparable because they are equivalent to one standard deviation changes in the underlying variables.

¹² Idem, but based on regression results in Column 2.

as a bank's contribution to the deterioration of the capitalization of the financial system as a whole during a crisis (Brownlees and Engle, 2012; Acharya, Engle, and Richardson, 2012).¹³

The assumption behind this method is that the bank's distress poses the largest externalities when multiple banks are distressed at the same time, so that the bank's distress contributes to the joint distress in the financial system. Joint distress is costly because it reduces the ability of financial firms to effectively raise capital,¹⁴ generates stress in the interbank market (which may create funding liquidity problems in the banking system), creates the risk of asset sales by banks at fire sale prices, and can lead to a generalized banking panic. Moreover, other banks may not be in a position to perfectly substitute for the lending and other functions of distressed banks, and the marginal cost of taxpayer support may be increasing in the volume of support required.

These externalities are likely to be even greater if the bank joining the distress is large. Large banks often play dominant roles in the interbank market, providing liquidity to smaller banks, and they engage in activities that rely on economies of scale and scope and that cannot easily be replaced by small banks. Taxpayer support in case of distress of such banks may be constrained by their sheer size; and their failures are more likely to create a banking panic.

Consequently, a firm is systemically risky if it is likely to face a large capital shortfall when the financial sector itself is in distress. SRISK captures exactly this – the propensity to be undercapitalized when the system as a whole is undercapitalized. Following Brownlees and Engle (2012), we compute SRISK as the dollar value of capital shortfall that a bank is expected to suffer when the U.S. financial stock index falls by 40 percent over six months, expressed in billions of U.S. dollars.

SRISK is then determined by:

- Bank stock volatility during periods of distress;
- The covariance of bank stock with the market during periods of distress. This focus on covariance critically distinguishes systemic from individual bank risk measures;
- Bank leverage;
- Bank size.¹⁵

¹³ Other ways to estimate systemic risk are CoVaR (Adrian and Brunnermeier, 2012), defined as the difference between the value at risk of the financial system conditional on the firm being in distress and the value at risk of the system conditional on the firm being in its median state; and MES (Acharya, Engle, and Richardson, 2012), defined as the expectation of the firm's equity return conditional on a one-day market decline of 2 percent. See also Drehmann and Tarashev (2013) and Billio et al. (2013).

¹⁴ In good times, a distressed financial firm can raise new capital or be acquired. However, when multiple financial firms are in distress, such avenues to restore bank capital may no longer be available.

¹⁵ Indeed, during the sample period, all these components are important and independent drivers of SRISK, with covariance being responsible for only about 20 percent of the variation in SRISK, and the correlation of covariance with bank size is only 12 percent.

Thus, SRISK not only considers the sensitivity of the bank's capital shortfall to a generalized fall in the equity market, but also the degree of bank leverage and size.

Similar to the individual risk, we estimate SRISK over the period from July 2007 to December 2008 (but use stock market data over the period from January 2000 to December 2012 to estimate the underlying pricing model).¹⁶ Annex 4 describes the SRISK estimation method; for more details see the accompanying working paper (Laeven, Ratnovski, and Tong, 2013). Table 4 shows the top 10 banks according to their SRISK systemic risk contribution during the 2008 financial crisis. The list prominently features large banking firms from both the United States and Europe. The majority of institutions on the list received government support during the crisis, including in the form of capital injections and guarantees on assets or liabilities.¹⁷

Table 4. Banks with the Highest SRISK during the 2007–08 Financial Crisis

1	Royal Bank of Scotland	United Kingdom
2	Deutsche Bank	Germany
3	Barclays	United Kingdom
4	BNP Paribas	France
5	Credit Agricole	France
6	Citigroup	United States
7	JPMorgan Chase	United States
8	UBS	Switzerland
9	ING Groep	Netherlands
10	Bank of America	United States

Note: Global sample of stock exchange-listed banks.

Sources: Bankscope; Datastream; and IMF staff calculations.

Similar to the analysis of individual bank risk, we now consider how pre-crisis (2006) bank characteristics affected banks' SRISK during the financial crisis. We focus on the same variables, reflecting bank size, capitalization, funding structure, share of market-based activities, and organizational complexity.¹⁸

¹⁶ Results are robust to limiting the sample period to July 2007 to July 2008, allaying concerns that government interventions that followed the collapse of Lehman Brothers may distort the results. Moreover, to the extent that such government interventions focused primarily on large banks (because of too-big-to-fail considerations), this would introduce a bias against our results that large banks contribute more to systemic risk. That is, the true systemic risk of large banks might be even higher than what our results suggest.

¹⁷ This list excludes financial institutions that failed and de-listed, since these are not included in our sample.

¹⁸ We focus on publicly available indicators that can drive systemic risk. BCBS (2013) uses a more comprehensive set of indicators, which also includes measures of interconnectedness (intra-financial system assets and liabilities), substitutability (assets under custody and payments activity), and cross-border activities (cross-jurisdictional claims and liabilities).

Results are presented in Table 5. Column 1 shows results for all banks, Column 2 for large banks only, and Column 3 includes nonbanks. We find that bank size and organizational complexity are the only two variables that are significant in this simple analysis. The economic effect of the result on organizational complexity is substantial. An increase in the number of subsidiaries by 5 from its average of 30 implies an increase in SRISK – the dollar value of bank losses during a crisis – of US\$3 billion, or 50 percent of its average of US\$6 billion.

The results, however, change and become more informative once we include interactions of structural variables with bank size in Columns 4-6.¹⁹ Here, we find that:

- Large banks contribute more to systemic risk when they have less capital;
- Large banks contribute more to systemic risk when they have fewer deposits.
- Large banks contribute more to systemic risk when they engage more in market-based activities, as measured by the share of noninterest income in total income or the share of loans in assets; and

The economic effects are substantial, especially for bank capital. For a large bank with a size of US\$100 billion, increasing the Tier 1 capital ratio from 7 to 11 percent would decrease SRISK – the dollar value of bank losses in a crisis – by US\$14 billion. For a small bank with a size of US\$10 billion, a similar increase in bank capital would decrease SRISK by US\$7 billion. The difference of US\$7 billion is large compared to the average SRISK of US\$6 billion.²⁰ Similarly, an increase in the fraction of loans in total assets from 48 to 68 percent would decrease SRISK by US\$5 billion more for the large bank compared to the small bank, and an increase in the fraction of deposits in total assets from 48 to 80 percent would also decrease SRISK by US\$5 billion more for the large bank compared to the small bank.²¹

It is instructive to see how the drivers of systemic risk compare to the drivers of individual bank risk. The results on capital are similar: capital ratios matter, particularly for large banks. The results on funding are also similar: large banks that rely on less-stable funding contribute disproportionately to systemic risk.

But the results on the banks' market-based activities are starkly different. Banks that engage more in market-based activities did not have high individual risk during the crisis. If anything, there is evidence that they performed better. However, the systemic risk contributions were significantly higher for large banks that engaged in market-based

¹⁹ Including the same interaction variables in the return regressions in Table 3 does not yield significant results. The results, based on a large international sample of banks, are robust to focusing on OECD banks only.

²⁰ Based on regression coefficients in Column 6 of Table 5 and contrasting results for the 75th and 25th percentiles of the bank size and Tier 1 capital variables.

²¹ These economic effects are strictly comparable because they are evaluated for increases from the 25th to the 75th percentiles in the underlying variables.

activities. That is, large market-oriented banks may not be more volatile than traditional banks on a stand-alone basis, but they are more likely to fail together, and this creates risks for the financial system and the economy as a whole. A possible reason why large market-oriented banks are more likely to fail together is that they are jointly exposed to the boom-bust cycles in financial markets and more interconnected through asset and short-term funding markets.

Table 5. Determinants of Systemic Risk Contribution

Dependent Variable:						
SRISK in July 2007 to Dec 2008	(1)	(2)	(3)	(4)	(5)	(6)
SRISK in 2006	0.902*** (0.195)	0.449** (0.213)	0.966*** (0.162)	0.659*** (0.197)	0.598*** (0.171)	0.474** (0.201)
Log Assets(\$)	5.368*** (1.379)	14.54*** (2.562)	5.582*** (1.224)	8.054*** (1.822)	24.80*** (3.666)	28.76*** (4.541)
Tier 1 Ratio	-0.423 (0.341)	-2.303 (1.423)		2.653*** (0.602)	3.271*** (0.710)	3.320*** (0.745)
Deposits/Assets	3.115 (4.182)	-13.47 (8.428)		0.365 (5.377)	-1.586 (5.041)	27.32** (13.45)
Loans/Assets	-4.114 (3.493)	-12.49 (11.23)	0.993 (3.293)	4.678 (3.344)	62.28*** (12.13)	55.76*** (12.95)
Noninterest Income	-7.586* (4.518)	-10.52 (9.466)	-4.055 (3.329)	-54.84*** (10.59)	-10.90*** (3.582)	-9.551** (3.565)
Log Subsidiaries	1.917** (0.893)		1.249** (0.502)	1.981** (0.773)	1.862** (0.736)	1.786*** (0.660)
Leverage			0.114 (0.127)			
Funding Fragility			-4.037 (2.538)			
Log Assets * Tier 1 Ratio				-0.880*** (0.187)	-1.090*** (0.207)	-1.120*** (0.224)
Log Assets * Noninterest Income				13.28*** (2.839)		
Log Assets * Loans/Assets					-16.61*** (3.340)	-14.62*** (3.406)
Log Assets * Deposits/Assets						-8.042** (3.879)
Observations	285	110	338	285	285	285
R-squared	0.840	0.905	0.846	0.869	0.871	0.877

Notes: Dependent variable is SRISK computed over the period from July 2007 to December 2008. Global sample of stock exchange listed banks, excluding banks with assets below US\$10 billion. Column (2) includes only large banks (i.e., banks with assets in excess of US\$50 billion. Column (3) includes banks and nonbanks. Regressions are estimated using ordinary least squares and include country fixed effects. Standard errors in parentheses; * p<0.1; ** p<0.05; *** p<0.01.

Sources: Bankscope; Datastream; and IMF staff calculations.

IV. POLICY IMPLICATIONS

We started the analysis by observing that large banks have less capital, less stable funding, engage more in market-based activities, and are more organizationally complex than small banks. Moreover, these properties are highly correlated across banks, suggesting a distinct, potentially more fragile business model of large banks.

We have further shown that large banks create more individual and systemic risk, particularly when they are not well capitalized and have unstable funding. Large banks also create more systemic risk (but not necessarily more individual risk) when they have more subsidiaries and engage more in market-based activities.

We also noted that, while too-big-to-fail subsidies and corporate governance issues may suggest that some banks operate at a scale that is too large from a social welfare perspective, the fact that large banks may also experience economies of scale prevents us from drawing conclusions as to what the socially optimal banks size is.

Taken together, these observations and results offer a number of important implications for the optimal policy vis-à-vis large banks.

A. Traditional vs. Systemic Risk-Based Regulation of Large Banks

When banks' shareholders and managers do not internalize the downsides of individual risk realizations due to limited liability, they would choose on the margin to operate riskier banks. In our context, this means larger banks, with less capital, and less-stable funding. The traditional view is that this market failure can in principle be resolved by the usual micro-prudential regulation. Yet our results caution that a pure micro-prudential approach is insufficient.

The reason is that micro-prudential regulation, which focuses on individual bank risk, may not fully reflect the systemic ramifications of large banks' risk-taking. Our analysis shows that the same capital or funding deficiencies create more systemic risk when they occur in large banks. This calls for more stringent capital and liquidity standards for large banks (due to systemic risk, i.e., macro-prudential reasons) in line with the approach of imposing capital surcharges on systemically important banks taken by Basel III.

Moreover, our analysis suggests that the micro-prudential approach may altogether neglect some important dimensions of bank risk-taking. Large banks' involvement in market-based activities and banks' organizational complexity do not increase individual bank risk, but increase systemic risk. Traditional micro-prudential regulation, which focuses on individual bank risk, would simply not see these dimensions of bank operations as a market failure that needs to be corrected.

At present, regulation proposes to address banks' market-based activities through higher capital surcharges (in the Fundamental Review of the Trading Book) and the imposition of minimal haircuts (which increase the cost of funding for market-based exposures, in the Financial Stability Board's work stream on repo markets). Additional tools proposed in the academic literature include a small, fixed (not risk-based) capital surcharge on all trading assets to reduce bank incentives to engage in low-margin, high-scale "tail risk" strategies such as carry trade (Acharya et al., 2010; Boot and Ratnovski, 2012). Regulation also proposes to deal with the organizational complexity of banks through living wills that facilitate the orderly resolution of complex banks and provide ex ante incentives to reduce complexity. Our analysis validates the scope for all of the above approaches.

B. Policy Tools

Capital surcharges (i.e., raising banks' minimum capital requirements) on systemically important banks are a cornerstone of the new Basel III regulatory framework for banks. They have been advocated by policymakers (IMF, 2010) and academics alike. For example, French et al. (2010) argue that "the failure of a large national bank...is almost certain to have a bigger impact on the banking system and the wider economy than the failure of several small regional banks that together do the same amount of business as the large bank. Thus, if everything else is the same, large banks should face higher capital requirements than small banks."

Our results confirm, based on their statistical and economic significance, that requiring large banks to hold more capital is a powerful tool to reduce systemic risk. Higher capital reduces the likelihood of bank failure (lower individual risk) and the impact of the bank's failure on the rest of the financial system and the broader economy (lower systemic risk), by increasing the bank's loss absorption capacity. Larger banks are also more likely to use nondeposit funding or engage in risky market-based activities, and to create more systemic risk in doing so. Capital surcharges on large banks, to the extent that they reduce their size, can therefore also indirectly mitigate externalities arising from unstable funding and market-based activities.

Capital is a more costly form of financing for banks than debt finance. The benefits of capital surcharges – safer large banks and less systemic risk – therefore have to be traded off with their costs. There are three types of cost. One is the impact of higher capital on bank lending and the real economy. The general view is that the effect of higher capital on bank lending is modest in steady state (Kashyap, Stein, and Hanson, 2010; Admati and Hellwig, 2013). However, the costs of raising capital requirements may quickly become substantial should banks respond by cutting lending (Aiyar, Calomiris, and Wieladek, 2014). This suggests that tighter capital requirements should be phased in over a period of time, backloaded to the time when economic growth accelerates. Another cost is the loss of possible economies of scale

and scope should banks reduce their size in response to capital surcharges (although these costs are likely to be modest; see Annex 1).²²

Because requiring banks to hold higher capital during normal times for the benefit of having sufficient capital during crisis times is costly, some have advocated supplementing capital surcharges with regulatory requirements for the issuance of hybrid debt instruments that can convert into equity during distress (e.g., Kashyap, Rajan, and Stein, 2010; French et al., 2010; and Ötcher-Robe et al., 2011). Such contingent capital would facilitate the recapitalization of banks during crisis times when capital is scarce.

Another source of uncertainty is the extent to which capital surcharges on large banks may affect the distribution of risk in the financial system. A benign scenario is that large banks may shrink in size, adopting a safer business model of smaller banks (with more capital, more stable funding, and less engagement in risky market-based activities) as they lose too-big-to-fail subsidies and economies of scale present in market-based activities. But there is also a risk that capital surcharges may push risk to outside of large banks – that is, to unregulated parts of the financial system or to smaller banks. In this case additional measures to contain new systemic risks may become necessary.

Some recent initiatives, such as the Volcker rule in the United States or the Vickers and Liikanen proposals in Europe, suggest supplementing capital-based regulation with outright restrictions on bank activities. Yet the analysis of the literature suggests that these tools may be very difficult to calibrate. While we provide evidence that banks' market-based activities contribute to systemic risk, the possible presence of economies of scale and scope means that it is hard to determine the optimal scope of banks' activities. When there is significant uncertainty about the optimal outcome, the logic of Weitzman (1974) suggests that price-based tools – in this case, properly designed capital surcharges – may be preferred (see also Viñals et al., 2013). Outright restrictions on bank activities also pose a risk of overregulation when they supplement capital surcharges already implemented in Basel III. At the same time, while broad-brushed restrictions on bank activities are likely problematic, specific restrictions on well-identified risky trading activities with little economic value, such as proprietary carry trade in collateralized debt or sovereign bonds, might still be warranted.

Finally, it is important to supplement policies that correct market failures (such as capital surcharges) with policies that aim to eliminate market failures in the first place. Such policies include better resolution to reduce too-big-to-fail distortions (such as living wills and a resolution regime for global systemically important financial institutions, as set out in Financial Stability Board, 2011) and better corporate governance mechanisms for large banks (including measures to reduce organizational complexity and high-powered incentives that encourage excessive risk-taking).

²² There is a debate about what the optimal level of capital for large banks may be; see Macroeconomic Assessment Group (2011), Miles, Yang, and Marcheggiano (2013), and Ratnovski (2013).

C. Implications for the “Too Much Finance” Debate

This paper has focused on the question of whether individual banks may be too large, from the perspective of individual and systemic risk. There is also currently an active policy debate on a complementary question of whether the financial (or banking) system as a whole may be too large. Papers typically consider this question from an allocative efficiency point of view, asking whether a large financial system may be a sign of a misallocation of resources in the economy, leading to lower welfare and growth (Phillipon, 2010; Arcand, Berkes, and Paninza, 2012). While the literature offers some evidence that this may be the case, the results generally are too dependent on the estimation techniques to be conclusive, and thus useful for policy.

Our findings offer a different angle for thinking about large financial systems, based on systemic risk considerations. It appears that larger financial systems have more large banks. Figures 13 and 14 show a high (0.75 and 0.71) correlation between the ratio of domestic credit to GDP and the market share of large banks (over US\$50 billion in assets). This suggests that large financial systems may have more systemic risk due to the disproportional presence of large banks. Certainly more work is needed to further examine the role of large banks in large financial systems. But this preliminary evidence suggests that, to control systemic risk in large financial systems, regulatory policy needs to pay special attention to the role of large banks.²³

Figure 11: Large Financial Systems and Large Banks, 2006

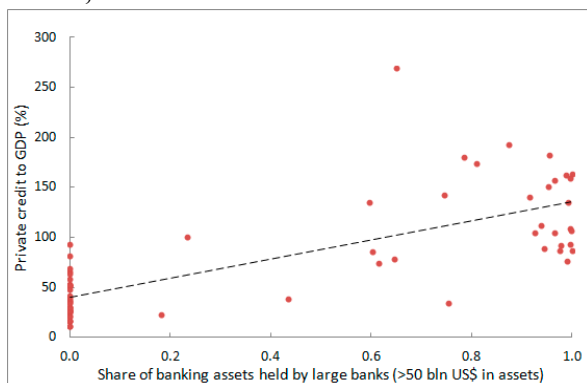
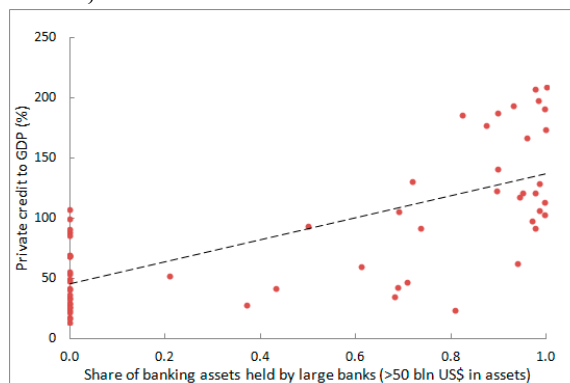


Figure 12: Large Financial Systems and Large Banks, 2011



Sources: Bankscope; and IMF staff calculations.

²³ The new minimum capital requirements for systemically important banks in Switzerland are an interesting case in point. These new capital regulations were motivated by the fact that the two largest Swiss banks, Credit Suisse and UBS, are both very large relative to the Swiss economy and therefore “too big” to be rescued by taxpayers.

V. CONCLUSIONS

This paper contributes to the debate on the optimal size and scope of banks. It shows that large banks, on average, create more individual and systemic risk than smaller banks. The risks of large banks are especially high when they have insufficient capital, unstable funding, engage more in market-based activities, or are organizationally complex. This, taken together with the evidence from the literature that the size of banks is at least in part driven by too-big-to-fail subsidies and empire-building incentives, suggests that today's large banks might be too large from a social welfare perspective.

However, the literature also does not dismiss the case for the economies of scale in large banks (even though, in our reading of the literature, these economies are likely to be modest). As a result, "optimal" bank size is highly uncertain, and regulations that restrict outright bank size may be imprecise and difficult to implement. Optimal regulation of large banks should combine micro- and macro-prudential perspectives, and its tools may include capital surcharges on large banks (as in Basel III) and measures to reduce banks' involvement in market-based activities and organizational complexity.

Annex 1. Economies of Scale and Scope in Banks

Evidence on the economies of scale in banks is inconclusive. Early studies have found economies of scale to be limited to relatively small banks, with no evidence of economies of scale in banks beyond US\$10 billion to US\$50 billion in assets (Benston, Hanweck, and Humphrey, 1982; Berger and Mester, 1997; Peristiani, 1997). More recent studies question these results and also find economies of scale also for large banks. There are valid economic reasons for why the evidence may have changed: with the advance of information technologies and the proliferation of scalable market-based operations, optimal bank size may have increased.

Most studies on economies of scale focus on cost economies – the ability of banks to efficiently use overhead. Kovner, Vickery, and Zhou (2013) estimate the total value of such economies in the U.S. banking system for banks over US\$50 billion in assets to range between US\$16 billion and US\$45 billion a year, corresponding to 0.1 to 0.25 percent of GDP (or 0.1 to 0.25 percent of total U.S. bank holding companies assets per year).

A more ambitious method is to take into account the diversification abilities of large banks. Studies that allow for possible changes in the input and product mix of banks find significant economies of scale. Wheelock and Wilson (2012) and Hughes and Mester (2013) find that an increase in bank size by 1 percent increases costs by only 0.95 percent for both small and large banks. This suggests that the cost of splitting the four largest U.S. banks (so that each of them manages not more than \$1 trillion in assets) would be over US\$70 billion a year. The cost of making banks even smaller would accordingly be higher than that.

However, these results should be treated with caution. Large banks diversify by moving from traditional deposit-taking and lending to more cost-effective but riskier wholesale funding and market-based activities. Thus, the estimates rely on two assumptions: that the large banks' higher risk tolerance is socially optimal, and that the social value of the market-based bank activities is the same as that of traditional lending. Either way, the results indicate that economies of scale may be higher than the cost-based studies suggest.

The literature on economies of scope points to negative returns to scope when banks move into market-based activities. Interestingly, the source of these negative returns is not technological. Indeed, a large literature points to the benefits of the efficient use of information from lending in the market-based activities of banks (Kroszner and Rajan, 1994; Puri, 1996; Drucker and Puri, 2005). Rather, the source of the negative returns to scope is the agency costs in banks that engage in market-based activities (Boot and Ratnovski, 2012).

The negative returns to scope for banks that engage in market-based activities is evident in lower market valuations (Laeven and Levine, 2007; Schmid and Walter, 2009), higher risk (De Jonghe, 2010; Demirgüç-Kunt and Huizinga, 2010; Brunnermeier, . Dong, and Palia, 2012; DeYoung and Torna, 2013), and lower risk-adjusted returns (Stiroh, 2004; Stiroh and

Rumble, 2006; Baele, De Jonghe, and Vander Vennet, 2007). This evidence points not only to the destruction of shareholder value but also to potential costs for other stakeholders in the bank, including taxpayers, from the risk of failure. Yet it may be that banks' involvement in market-based activities creates surplus to bank customers. In this case, from a social welfare perspective, the returns to scope in banking may still be positive.

Annex 2. Corporate Governance Challenges in Large Banks

In the Anglo-Saxon model of the corporation, the purpose of corporate governance is to ensure that firms operate in the interests of shareholders. Shareholders control firms through boards, and formulate incentive contracts for bank managers. Corporate governance is more efficient in the presence of concentrated ownership and active takeover markets (Shleifer and Vishny, 1997).

But effective corporate governance in banks faces multiple challenges. First, there are limits on the concentration of ownership and takeovers. For example, U.S. regulation effectively limits nonbank ownership of banks to no more than 10 percent of the voting stock. Similar limits exist in other countries (Caprio and Levine, 2002; Laeven, 2013). Limits on ownership also limit takeovers. Uncoordinated shareholders and an absence of the takeover threat reduce the influence that bank shareholders wield over bank managers.

Second, banks are highly leveraged institutions. This means that their shareholders may have aggressive risk preferences, which are not in the interest of other stakeholders – depositors, creditors, and the government (which is interested in a continued flow of credit to the economy and may have to support banks in distress). Indeed, there is evidence that banks where shareholders exercise more control tend to take more risk (Saunders, Strock, and Travlos, 1990; Laeven and Levine, 2009).

Third, the risks associated with the trading activities of banks may be genuinely difficult to control, either by shareholders or management (Mehran, Morrison, and Shapiro, 2011; Glode, Green, and Lowery, 2012; Ellul and Yerramilli, 2013). Banks have much scope to manufacture “tail risks” that are hard to quantify in normal times (Acharya et al., 2010), and, given the difficulty in assessing the riskiness of such positions, it is almost impossible to establish any neglect of management's fiduciary duty to shareholders.

Given the distorted incentives of bank shareholders, a natural proposition might have been to expand the control over banks to other stakeholders, such as creditors or government representatives (Macey and O'Hara, 2003). However, the literature points out that this is not a panacea, as creditor or government control may lead to directed or affiliated lending, compromising credit quality (Sapienza, 2004). Problems in many (regional) government-affiliated banks in Europe during the recent crisis illustrate this point.

The corporate governance challenges in large banks are especially significant given that large banks tend to be more highly leveraged, have more complex organizations, and engage in trading activities to a greater extent. One way to illustrate that corporate governance in large banks is especially complex is to look at the dispersion of analyst forecasts of bank earnings per share. A higher dispersion in such forecasts implies a higher complexity of the business, and/or lower transparency. Table A1 reports the analyst forecast dispersion in 2006 and 2011 for large vs. small banks. Dispersion is computed as the standard deviation across analysts' earnings per share (EPS) forecasts divided by the absolute value of the mean EPS forecast.²⁴ The dispersion in analyst forecasts is significantly larger for large banks and has grown since the crisis, suggesting that banks hold distressed assets that the market finds difficult to value.²⁵ These results suggest that large banks are indeed more complex and/or less transparent, indicating more challenges for effective corporate governance.

Table A1. Dispersion in Analyst Forecasts of Bank Earnings per Share
(In percent)

	2006		2011	
	Large Banks	Small Banks	Large Banks	Small Banks
Average forecast dispersion	5.8 [126]	4.1 [105]	7.6 [131]	6.0 [61]

Notes: Median values in forecast dispersion, computed as the standard deviation across analysts' earnings per share (EPS) forecasts divided by the absolute value of the mean EPS forecast. Sample is split between large and small banks. Large banks are banks with total assets in excess of US\$50 billion. Small banks are banks with total assets between US\$10 billion and US\$50 billion. Values reported separately for 2006 and 2011. The number of banks is reported in square brackets.

Source: I/B/E/S data on analyst forecasts.

Annex 3. The Sample of Banks and Summary Statistics

We use Bankscope data to examine a global sample of banks. To construct the sample, we start from the sample of publicly traded financial institutions in Bankscope with data on equity returns and total assets at the end of 2006. We exclude financial institutions that are not publicly traded because our measures of systemic risk are based on equity returns. We also exclude financial institutions that disappear before the end of our sample period in December 2008. This gives 1,721 financial institutions. For the most part, we exclude nonbank financial institutions and focus on deposit-taking institutions (i.e., commercial banks and bank holding companies), reducing the sample to 1,343 institutions. Table A2 reports the number of banks per country and the number of large banks (with assets in excess of US\$50 billion) in the sample, and Table A3 reports descriptive statistics for the main variables in the empirical analysis.

²⁴ We use forecasts made in December of the year from the Institutional Broker Estimate System dataset. We restrict our analysis to banks with at least three analysts so as to reduce the impact of small analyst numbers on forecast dispersion.

²⁵ Medians equality test suggests that the dispersion of analyst forecasts is significantly different in large versus small banks at the 5 percent level in both 2006 and 2011.

Table A2. Number of Banks in the Sample, by Country

Country	Number of Banks	Of which: Large Banks	Country	Number of Banks	Of which: Large Banks	Country	Number of Banks	Of which: Large Banks
Argentina	6	0	Indonesia	26	0	Poland	14	0
Australia	8	5	Israel	7	2	Portugal	5	2
Austria	6	3	Italy	20	6	Qatar	4	0
Bahrain	4	0	Japan	101	21	Russian	7	0
Belgium	4	3	Jordan	10	0	Saudi Arabia	8	0
Brazil	16	2	Kenya	8	0	Singapore	7	3
Canada	15	6	Korea, Rep. of	9	5	South Africa	10	4
China	9	5	Kuwait	6	0	Spain	13	5
Colombia	7	0	Malaysia	14	1	Sri Lanka	6	0
Croatia	9	0	Mexico	5	0	Sweden	4	3
Denmark	40	1	Morocco	5	0	Switzerland	15	2
Egypt	9	0	Netherlands	6	3	Thailand	11	0
France	11	4	Nigeria	14	0	Turkey	14	1
Germany	13	7	Oman	4	0	Ukraine	7	0
Greece	12	3	Pakistan	17	0	United Kingdom	13	8
Hong Kong SAR	11	2	Peru	4	0	United States	639	28
India	25	2	Philippines	12	0	Total	1,250	137

Table A3. Descriptive Statistics of Regression Variables

Variable	Observations	Standard			
		Mean	Deviation	Minimum	Maximum
Return	368	-45.42	27.76	-99.18	54.43
SRISK	346	5.70	17.26	-9.07	69.43
Log(Assets)	373	3.89	1.36	2.31	7.64
Tier 1 Ratio	310	10.14	4.34	3.68	48.47
Deposits/Assets	356	0.63	0.21	0.00	0.94
Loans/Assets	370	0.56	0.17	0.00	0.92
Noninterest	373	0.38	0.23	-0.55	1.10
Log(Subsidiaries)	373	3.51	1.75	0.00	8.30
Leverage	373	15.70	7.40	1.04	53.97
Funding Fragility	371	0.21	0.23	0.00	1.00

Annex 4. Estimating Systemic Risk

Our main measure of systemic risk is SRISK, based on Brownlees and Engle (2012) and Acharya, Engle, and Richardson (2012). Our focus is on systemic risk during the crisis period from the middle of 2007 to the end of 2008.²⁶ The SRISK index measures the expected capital shortage faced by a financial firm during a period of system distress when the market declines substantially. More precisely,

²⁶Our sample period coincides with the crisis period considered in Beltratti and Stulz (2012), which simplifies comparison between the two studies.

$$SRISK_{i,t} = kD_{i,t} - (1-k)E_{i,t}(1 - MES_{i,t+h|t}(C_{t+h|t})),$$

where k is the minimum fraction of capital (expressed as a ratio of total assets) each firm needs to hold, and $D_{i,t}$ and $E_{i,t}$ are the book value of its debt (total liabilities) and the market value of its equity, respectively. We set k equal to the prudential capital ratio of 8 percent. Note that we do not restrict SRISK at zero, allowing it to take on negative values.²⁷ A key component of SRISK is marginal expected shortfall (MES). MES is defined as the tail expectation of the firm's equity return conditional on a market decline:

$$MES_{i,t+h|t}(C) = -E_t(R_{i,t+h|t} | R_{m,t+h|t} < C),$$

where $R_{i,t+h|t}$ and $R_{m,t+h|t}$ denote the stock return for the firm and the market between period t and $t+h$, and C is the threshold of the decline in market index. We take the daily return on the S&P 500 index as a proxy for the market return. We set h equal to one day, with t measured in days, and C equal to -2 percent, so that MES is the one-day loss expected if market returns are less than -2 percent. We estimate the return model using daily data over the period from January 2000 to December 2012. Then we compute one-day MES for the crisis period as the average of the predicted values for MES over the period from July 1, 2007 to December 31, 2008. We set h in $C_{t+h|t}$ equal to 180 days and $C_{t+180|t}$ equal to -40 percent, and use the following approximation to compute long-run MES, where $C_{t+1|t}$ is -2 percent:

$$MES_{i,t+180|t}(C_{t+180|t}) = 1 - \exp(-18 \times MES_{i,t+1|t}(C_{t+1|t})).$$

As with MES, we construct SRISK by estimating the return model using daily data over the period from January 2000 to December 2012. Then we compute SRISK using the average of the predicted values for MES over the period from July 1, 2007 to December 31, 2008. In our analysis, we take the negative value of SRISK to translate it into an increasing measure of systemic risk. All stock returns are computed in local currency terms. SRISK is expressed in billions of U.S. dollars. For the purpose of our analysis, we winsorize each systemic risk measure at its 1st and 99th percentiles to remove the influence of outliers.

²⁷ Acharya, Engle, and Richardson (2012) restrict SRISK to zero because they are interested in estimating capital shortages that by definition cannot take on negative values. For our purposes, negative values of SRISK are meaningful because they provide information on the relative contribution of the institution to systemic risk.

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