Research in International Business and Finance 38 (2016) 137–150

Contents lists available at ScienceDirect

Research in International Business and Finance

journal homepage: www.elsevier.com/locate/ribaf

Full length article

Bank earnings volatility in the UK: Does size matter? A comparison between commercial and investment banks

Konstantinos A. Moutsianas, Kyriaki Kosmidou*

Aristotle University of Thessaloniki, Department of Economics, Division of Business Administration, Greece

ARTICLE INFO

Article history:
Received 10 September 2014
Received in revised form
21 December 2015
Accepted 29 March 2016
Available online 8 April 2016

JEL classifications:
G21
G32
L25

Keywords:
Earnings volatility
Too-big-to fail
Financial crisis
Panel data

ABSTRACT

During the global financial crisis, the issue of banks' size and especially whether banks could be 'too big to fail' (TBTF) was raised. Our study focuses on the impact of size on bank earnings volatility in the UK, which is among the most open financial systems in the world. This study analyzes commercial and investment banks. For the model specification, we employ panel data to analyze the period from 2000 to 2012. Our analysis indicates a nonlinear relationship between the bank size and earnings volatility of commercial and investment banks.

1. Introduction

Whether banks can be 'too-big- to fail' (TBTF) has been an issue for decades in discussions of banking regulation. The term was used in 1984 when Continental Illinois, the 7th largest bank in the US, approached insolvency (Völz and Wedow, 2011). To protect Continental's creditors and prevent financial instability, US regulatory authorities provided the bank with a capital rescue package (Morrison, 2012). The term TBTF reflects how regulatory authorities manage financially troubled large banks (Kaufman, 2002), especially systemically important financial institutions (SIFIs). The Financial Stability Board (2010) describes TBTF banking institutions as those whose disorderly failure could cause significant disruption to the functioning of financial markets and the economy as a whole because of their size, importance, complexity and systemic interconnectedness (Abreu and Gulamhussen, 2013). Federal Reserve Chair Bernanke (2010) defined TBTF as follows: *"a too-big-to-fail firm is one whose size, complexity, interconnectedness, and critical functions are such that, should the firm go unexpectedly into liquidation, the rest of the financial system and the economy would face severe adverse consequences."*[1]

During the years preceding the 2007–2009 financial crisis, banks rapidly expanded their balance sheets to increase their profitability. In Iceland, the liabilities of banks reached approximately 9 times GDP by the end of 2007, and in the United Kingdom, these liabilities reached 5.5 times GDP (Demirgüç-Kunt and Huizinga, 2013). The size of banks has increased

* Corresponding author.
E-mail address: kosmid@econ.auth.gr (K. Kosmidou).

[1] Causes of the Recent Financial and Economic Crisis. Before the Financial Crisis Inquiry Commission, Washington, D.C. September 2, 2010.

http://dx.doi.org/10.1016/j.ribaf.2016.03.013
0275-5319/

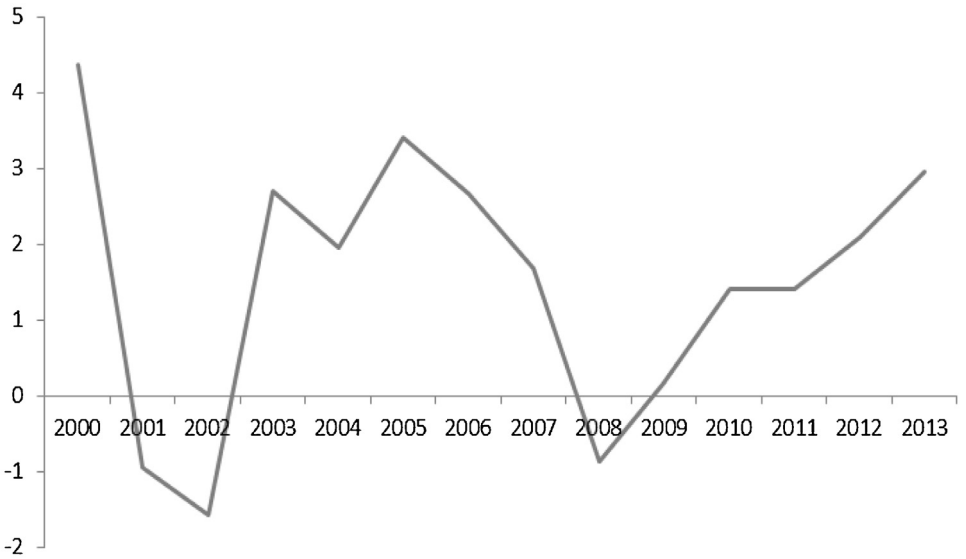

Fig. 1. Average ROAA of UK active banks.

enormously relative to national economies, which produced large risks to public finance (Bertay et al., 2013) and prompted government interventions. The pre-crisis period was also characterized by waves of mergers, which provided opportunities for banks to increase their size and market share (Brewer and Jagtiani, 2013) During the financial crisis, the collapse of large, globally active financial institutions threatened the stability of the financial system (Basel Committee on Banking Supervision, 2011).

This study considers the impact of size on bank earnings volatility in the UK banking system over the period 2000–2012 and compares commercial and investment banking institutions. We focus on the impact of the size because it is related directly to the TBTF issue and because the Bank of England has participated in the debate over whether major UK banks should be split up to reduce financial threats to the British Treasury.[2] (Bertay et al., 2013). The UK banking system has received extraordinary government interventions to ensure financial stability (Rose and Wieladek, 2012). According to Morrison (2012), in the case of the Royal Bank of Scotland (RBS), the State acquired 83% of the rights to RBS cash flows and 68 percent of the voting rights after the bank's recapitalization. In the Lloyds Banking Group recapitalization, the State acquired 41% of the voting and cash flow rights. In the case of HBOS the government acquired an important amount of equity stakes (Tamakoshi and Hamori, 2016). The National Audit Office (2009) provided a total of £850 billion in liquidity support and capital injections support to the UK banking sector.[3] It should be noted that the link between earnings volatility and bank failure is an important element that motivates us to investigate this relationship for UK banking institutions. Figs. 1 and 2 that illustrate the behavior of Return on Average Assets (ROAA) for UK active and bankrupted (or dissolved) respectively show that the volatility of ROAA is more intense for banks which bankrupted.[4]

Our analysis focuses on the United Kingdom because it possesses among the most open global financial centers, substantial concentration of financial institutions and highly developed infrastructure. The United Kingdom operates as a financial market hub constituting a major home and host country for both bank and nonbank financial institutions. According to the Financial System Stability Assessment Update (2011) produced by the International Monetary Fund, *"the size and the role of the UK financial system in global intermediation means that its continuing stability is a global good necessitating effecting implementation of reforms."* The pre-tax profits of UK financial institutions declined from £29.719 million in 2004 to −£20.943 million in 2008, and profits equaled £4.293 million in 2012.[5]

During the recent financial crisis, the profitability of banking institutions declined dramatically. Because a profitable banking sector contributes to the stability of the financial system and its well-functioning promotes a country's economic growth (Moshirian and Wu, 2012),the assessment of bank earnings constitutes an integral part of supervision frameworks and urges the stakeholders to identify the factors that affect the profitability (Couto, 2002). Bank earnings volatility is an important predictor of financial crises (Demirgüç-Kunt and Huizinga, 1999) and an early indicator of financial disturbances

[2] See the speech by Mervyn King, Governor of the Bank of England, on 19th June, 2013, which states that *"It is not in our national interest to have banks that are too big to fail, too big to jail or simply too big."* The speech is available at http://www.bankofengland.co.uk/publications/Documents/speeches/2013/speech670.pdf.

[3] See National Audit Office Report (2010), "Maintaining financial stability across the United Kingdom's banking system" for details.

[4] The data Derived from Bankscope Bureau van Dijk Database for the period 2000–2010. The sample of active and bankrupted financial institutions consists of 470 and 96 financial institutions respectively.

[5] Bank of England, Explanatory Notes—Annual profit and loss of UK resident monetary financial institutions, Interactive database.

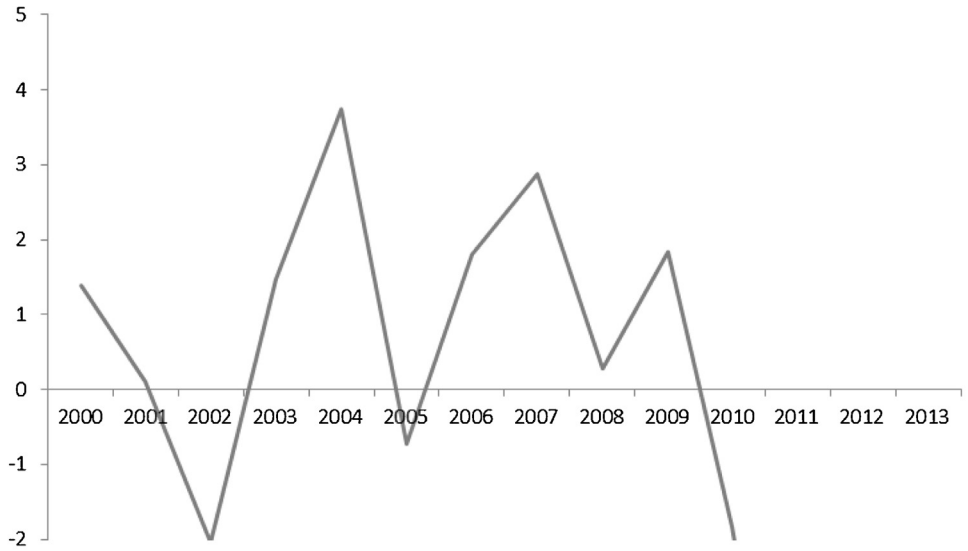

Fig. 2. Average ROAA of UK bankrupted (dissolved) banks.

in the financial system. Tsomocos (2003) argues that low banking profitability and increased defaults are the common attributes of financial crises. Likewise, Crockett (1997) and Gonzalez-Hermosillo (1999) suggest that the reduction of bank earnings is associated with financial instability. Golin (2001) argues that the solvency, survival and growth of banking institutions require adequate earnings. Therefore, the identification of the determinants of banking profitability provides useful information for the management of banks, supervisory authorities and central banks.

The objective of this comparative analysis between commercial and investment banks is to investigate the impact of size on earnings volatility for two different types of banking. The nature, scope of the operations and risk strategy that these banks adopt differ; commercial banks tend to be more conservative and risk averse, while investment banks undertake more risky activities and are more risk tolerant. Another difference relates to the time horizon (Haberman, 1987): investment banks operate according to very short time horizons and adjust their risk profiles quickly unlike commercial banks, which change their risk profiles more slowly. According to Iannotta (2010), commercial banks are financial intermediaries with high leverage that use customer deposits to make loans to firm and individuals. Commercial banks offer mainly wholesale and retail services (Hefferman, 2005). Investment banks are engaged in a heterogeneous and complex set of activities that can be divided into three main areas (Iannotta, 2010): (a) traditional investment banking (underwriting services and advisory services), (b) trading and brokerage and (c) asset management.

Additionally, the analysis focuses on the impact of size on investment banks' earnings volatility because investment banks were criticized for their role in financial instability during the crisis. The current crisis led to the collapse and financial instability of large investment banks that required government rescue packages. In the US, Lehman Brothers experienced bankruptcy, Bear Stearns and Merrill Lynch were bought by more robust financial institutions and Goldman Sachs and Morgan Stanley were converted into financial holding companies.

In this study, the distinction between commercial and investment banks is based on the definitions utilized by the Bankscope Bureau van Dijk Database. The activities of commercial banks include combinations of retail, wholesale and regular private banking (not belonging to savings or co-operative banks). Investment banks are mainly active in corporate finance, investment banking and private banking. The main activities of investment banks are related to debt/equity issues, mergers and acquisitions and securities trading.

The dependent variable of our analysis is bank earnings volatility, which is proxied by the variation in banks' return on average assets (ROAA). We examine whether earnings volatility is affected by bank size as measured by the logged total assets while controlling for bank efficiency, leverage, diversification, and market concentration. Bank earnings volatility rather than stock price volatility is examined (Demsetz and Strahan, 1997; Haan and Poghosyan, 2012) because earnings volatility could produce uncertainty about the level of equity, affect the financial health of the banking institutions (Couto, 2002) and lead to unstable capital structures (Albertazzi and Gambacorta, 2009).

The results indicate that size is negatively related to earnings volatility for both commercial and investment banks. Therefore, larger banks face less volatility in their profitability. Although, the effect is non-linear, when the size of a bank (either commercial or investment) exceeds an estimated threshold, the relationship between size and earnings volatility is positive. The finding of our research contributes significantly to the developing policies of the banking reform that began in the UK in the aftermath of the financial crisis to restore trust and financial environment stability. The sheer size and complexity of intermingled financial institutions constitute important aspects of structural reform. Also, the results reinforce

the opinion that large banks should be split up because, expect of the TBTF issue, they experience greater earnings volatility which undermine the financial stability.

Similarly, the report produced by the Parliamentary Commission on Banking Standards (2013) suggests that the size and the complexity of global financial institutions are principal causes of governance failures. The former Governor of the Bank of England has expressed the opinion that the banks should be broken up to protect taxpayers from future crises.[6] Additionally, there is political support for setting caps on the size of UK banks.[7]

The remainder of the paper is organized as follows. Section 2 reviews the related literature. Section 3 includes a description of the evolution of the UK banking system and its structure. Section 4 discusses the data and methodology. Section 5 describes the empirical results. Section 6 concludes and outlines potential future research.

2. Literature review

Too-big-to-fail (TBTF) banks have triggered an intense debate among regulatory authorities, central banks, governments and policy makers. TBTF is not determined by law or regulatory policy (Brewer and Jagtiani, 2013). The Financial Stability Board (2010) defines the too-big-to fail banks as those institutions whose disorderly failure, due to their size, complexity and systemic interconnectedness, can cause significant disruption to the wider financial system and economic activity. The TBTF category can also be applied to other financial intermediaries, such as clearing houses and mortgage securities company (Ennis and Malek, 2005). The Basel Committee on Banking Supervision (2011) argues that the failure of large, complex financial institutions shocked the financial system and subsequently caused problems in the real economy. If the activities of the banks represent a large share of global activity, the subsequent damage to the global economy is likely to be greater.

Previous research supports the view that the current financial crisis was mainly caused by governments' reluctance to allow large financial institutions to fail (Boyd et al., 2009). Boyd and Heitz (2012) argue that a TBTF policy produced the excessive risk-taking that shaped the financial crisis of 2008. According to Bernanke (2010),

> "Many of the vulnerabilities that amplified the crisis are linked with the problem of so-called too-big-to-fail firms. . ..Governments provide support to too-big-to-fail firms in a crisis not out of favoritism or particular concern for the management, owners, or creditors of the firm, but because they recognize that the consequences for the broader economy of allowing a disorderly failure greatly outweigh the costs of avoiding the failure...Too-big-to-fail financial institutions were both a source (though by no means the only source) of the crisis and among the primary impediments to policymakers' efforts to contain it."

Johnson and Kwak (2011) argue that for the US, "our biggest banks pose a real threat" and that "the only credible way to counter to this threat – and the only reasonable way to protect our democracy – is to break them up." The President of the Federal Reserve Bank of Dallas, Fisher (2011) states that "there is only one fail-safe way to deal with too big to fail. I believe that too-big-to-fail banks are too-dangerous-to-permit. . . . I favor an international accord that would break up these institutions into more manageable size."

Boyd and Heitz (2012) suggest that the costs to the economy exceed the potential benefits arising from the operation of TBTF banks based on the assumption that the current financial crisis was strictly caused by the dysfunction of these TBTF banks. Moreover, these large banks are inherently costly to society and the relationship between TBTF banks and financial crises can be broken by splitting large financial institutions into smaller units (Boyd and Jagannathan, 2009).

Boyd et al. (2009) describe a negative externality as the situation in which the dysfunctions of financial institutions affect everyone in an economic system. Larger financial institutions cause larger dysfunctions. Additionally, they present empirical evidence that the 20 largest banks in the US took substantial risks during the 2000s and experienced considerable losses in 2007. In addition, the operation of large financial firms is dangerous for the economy, and one way to address this problem is to limit bank size.

Flannery (2010) argues that the advantages of TBTF financial institutions are related to lower borrowing rates because investors do not require extra compensation for potential losses. Therefore, these institutions maintain easier access to funding sources. Additionally, government insurance provided to TBTF institutions makes borrowing cost less sensitive to asset volatility. However, the main disadvantage of large banks is that they expand at the expense of smaller competitors.

Barth and Prabha (2012) argue that 'big is bad' and note that the financial problems of big banks can infect other banks and cause instability throughout the financial system. As a solution to the TBTF issue, they also recommend the break-up of big banks. Cumming and Eisenbeis (2010) argue in their research of systemically important cross-border financial institutions that complexity problems constitute an important dimension of the spillovers that affect financial markets.

However, another perspective supports large banks because they are characterized by scale of economies, and splitting these bank will likely result in a loss of efficiency. Proponents of this view suggest that economies of scales are worth preserving, and the TBTF financial institutions should be receiving special treatment because are systemically important.

[6] See a speech by Mervyn King, Governor of the Bank of England, on 20th October of 2009, at http://www.bankofengland.co.uk/archive/Documents/historicpubs/speeches/2009/speech406.pdf.

[7] See the plans of Ed Miliband (the Labour Leader) for the banking reform, at http://www.theguardian.com/politics/2014/jan/15/ed-miliband-plans-british-banks-competition.

Krugman (2009) notes the following: "One argument I don't buy . . . is that we should try to shrink financial institutions down to the point where nobody is too big to fail. Basically, it's just not possible." Additionally, Calomiris (2009) argues that limiting the size of complex, global financial institutions is associated with drawbacks for the international economy. Changes in the regulatory framework and the development of information technology have also contributed to bank mergers, which increased bank size (Wheelock and Wilson, 2011). In the same study, the results suggest that regulatory limits on the size of the banks can cause significant resource costs in the industry.

Hughes and Mester (2013) argue that banks enjoy scale economies as they increase in size because they can improve diversification that reduces credit and liquidity risks. In their investigation, they observe large-scale economies for small banks and larger scale economies for large banks. In addition, the advantages of larger banks include the spreading of overhead costs. However, they provide evidence that TBTF considerations are not related to scale economies.

Brewer and Jagtiani (2013) examine the merger boom during the period 1991–2004 in the US to test whether banking organizations perceive benefits from reaching a TBTF threshold size. Their results suggest that banks are willing to pay a premium to be TBTF financial institutions because they gain advantages over smaller institutions. Moreover, the impact of a TBTF merger agreement is considered positive by the stock and bond markets. Additionally, in according to Morgan and Stiroh (2005), the announcement of a bank as a TBTF institution by the Office of the Comptroller of the Currency in 1984 increased the bond rating of these banks approximately one point over non-TBTF institutions.

In an international sample of 152 ultimate parent companies of all commercial banks with total assets more than $50 billion in 37 countries, Davies and Tracey (2014) provide evidence that scale economies exist for large banks. They also argue that a bank that is considered TBTF may experience funding cost advantages.

Concerning bank earnings volatility, several studies have focused on the impact of bank size, market concentration, efficiency, leverage and diversification on the fluctuation of profitability. These studies investigate the determinants of bank profitability that contribute significantly to the assessment of bank earnings volatility.

Short (1979) suggests that there is a relationship between bank capital and size because large banking institutions have access to less expensive sources of capital. Pasiouras and Kosmidou (2007) examine the bank-specific variables that affect the profitability of commercial domestic and foreign banks in 15 European countries and find a positive relationship between size and profitability. Demirgüç-Kunt and Huizinga (2000) argue that size has an impact on profitability. However, Berger et al. (1987) find that size does not produce important cost benefits, and Micco et al. (2007), in research of developing and industrial countries, do not identify a relation between size and profitability.

De Haan and Poghosyan (2012a) provide a review of several empirical studies on the relationship between bank size and earnings volatility among US and European banking institutions. Demirgüç-Kunt and Huizinga (2011) find that large banks tend to be more profitable for an international sample of banks. Mercieca et al. (2007) consider 15 European countries and find that size is not related to earnings volatility. Boyd and Runkle (1993) examine the relationship between size and earnings volatility for 122 US bank holding companies over the period 1971–1990 and find an inverse relationship. Stiroh and Rumble (2006) argue that there is no relationship between size and earning volatility in a sample of 1816 financial holding companies in the US over the period 1997–2002. De Nicolo (2001) finds that the relationship between size and earnings volatility is positive for small to medium-sized banks and negative for large banks. His research includes 419 US bank holding companies over the period 1988–1998.

3. The evolution of the UK banking system

The UK banking and financial system has experienced rapid institutional, structural and operational changes over several cades. Deregulation during the 1970s and 1980s contributed cisively to the transition of the oligopolistic banking structure characterized by an interest rate cartel and protective framework into a dynamic and competitive environment with reduced legal restrictions (Carlo and Roselli, 2009). Deregulation helped UK banking institutions benefit from the forces of globalization and financial innovation.

The regulation of the UK banking system consisted of two phases of reform and a period of re-regulation during the secondary banking crisis of 1973–1975 (Lee, 1979). The main attributes of the 1960s were quantitative controls and restrictions in bank lending. According to the Radcliffe report (Davies et al., 2010), during the early 1960s, approximately 100 banking institutions had been established to review the UK monetary system. Of the London and Scottish clearing banks, 16 held approximately £8.3 billion in assets amounting to 85% of total UK banking assets and over 30% of GDP.

The regulation of the UK banking system began in 1971 with the introduction of the Competition and Credit Control (CCC) (Matthews et al., 2007), a monetary policy implemented by the Bank of England. The main objectives of the CCC were the abolition of quantitative ceilings, abandonment of the interest rate cartel, direct restrictive control and introduction of statutory ratios for all banks. During the period 1962–1979, the sterling assets of banks and building societies increased steadily from 50% to 65% of GDP (Chart 2). During the same period, foreign-owned bank began operations in the UK (Davies et al., 2010) and the international openness of the banking system increased. These velopments lead to increases in the foreign currency assets held by domestic and foreign-owned banks operating in the UK. Re-regulation occurred in 1973 under the Supplementary Special Deposit Scheme known as the "corset."

A main statutory velopment in the UK occurred with the Banking Act of 1979 (Lee, 1979). The Banking Act of 1979 enhanced the competitive character of the UK banking system, extended the central bank's regulatory powers over banking institutions and provided protections for positors. The configuration of the UK banking system at the beginning of the 1980s

Table 1
Composition of the UK banking system.

Firm	Assets		Loans and advances to customers	
	Amount (Millions of GDP)	Firm/Banking Sector (percent of total)	Amount (Millions of GDP)	Firm/Banking Sector (percent of total)
Major U.K.-owned banks	6.060.342	66.4	2.303.115	78.0
Building societies and mutuals	368.443	4.0	280.144	9.05
Foreign-owned retail banks	495.220	5.4	302.694	10.2
Foreign investment banks	2.208.055	24.2	67.462	2.3
Total	9.132.060	100.0	2.953.416	100.0

Sources: Financial System Stability Assessment Update (2011), International Monetary Fund.

continued to evolve. In 1986, the Building Society Act regulated this sector, removed restrictions on the financial services that building societies could offer and made competition with posit banks possible. Additionally, the so-called Big Bang in 1986, a reform introduced by the London Stock Exchange, created a new financial environment. The Big Bang was a series of regulatory reforms to boost the competitive practices of the London Stock Exchange and increase the international competitiveness of London's financial markets. The period 1987–2003 was characterized by mutualizations, mergers & acquisitions, consolidations and intense diversification (Davies et al., 2010).

International foreign bank subsidiaries and branches now account for nearly one-half of UK banking sector assets, while UK-owned banks hold over half of their assets outside the country. These institutions hold a total of approximately £11 trillion in assets or approximately nine times GDP, and the UK banks account for assets equivalent to five times GDP. Table 1 displays the composition of the UK banking system.

4. Model specification and data description

For the model specification, we employ panel data analysis for the period from 2000 to 2012. Our pendent variable is bank earnings volatility as measured by the standard viation of banks' return on average assets (ROAA) over two years window in order to capture changes over time. To focus on the bank-specific effects, we take the difference of a bank's earnings volatility from the mean volatility of all banks in the specific year. Our sample consists of 89 commercial and 52 investment banks. For better quality data, we have included only the banks that have available data for at least five years over the period 2000–2012. The bank earnings volatility can be expressed as follows:

$$Volatility_{i,t} = \sqrt{\frac{1}{T-1}\sum_{t=1}^{T}(ROAA_{i,t} - \frac{1}{T}\sum_{t=1}^{T}ROAA_{i,t})} \quad (1)$$

$T = \{2\}$

$$\Delta Volatility_{i,t} = Volatility_{i,t} - \sum_{i=1}^{n} Volatility_{i,t} \quad (2)$$

Our main independent variable is the bank size as measured by the log of total assets. In addition, we use a number of control variables. According to structure-conduct performance (SCP), which was developed by Mason (1939) and Bain (1951), banks that operate in a highly concentrated industry tend to collude and gain monopoly profits (Gilbert, 1984; Short, 1979). Smirlock (1985) reports that there is no relationship between concentration and bank earnings. Beck et al. (2006) argue that the effects of concentration on profitability and financial stability are ambiguous. Some studies support the idea that concentrated banking systems may enhance market power and, therefore, boost bank earnings (Porter, 1979). High profitability provides a buffer against adverse shocks and reduces incentives for managers to take excessive risks (Beck et al., 2006). Albertazzi and Gambacorta (2009) argue that bank concentration is positively associated with bank profitability. Allen and Gale (2001, 2003) argue that banks are more sensitive to potential financial crises in less concentrated banking sectors compared to banks in systems that are more concentrated.

Some previous research indicates that banking systems that are more concentrated are related to financial weaknesses. Boyd and De Nicolo (2005) argue that the standard assumption that market power enhances bank profitability ignores the potential impact of bank market power on firm behavior. In their research, they observe a positive relationship between concentration and bank fragility. Nicoló et al. (2004) find that highly concentrated banking systems exhibited higher levels of systemic risk than less concentrated systems in a sample of 100 countries. Therefore, we control for market concentration using the C_5 concentration measure calculated by dividing the assets of the five largest banks by the assets of all banks operating in the market.

The cost-to-income ratio reflects the efficiency of the management of expenses relative to revenues. Higher ratios imply less efficient management. Berger and DeYoung (1997) argue that cost efficiency may be an important indicator of financial

Table 2
Variables description.

Variables	Description
Dependent variable	
ΔVolatility (ΔVOLAT)	Difference of a bank's earnings volatility from the mean volatility of all banks in the specific year
Independent variables	
Size (SIZE)	Bank size is calculated as log total assets of bank *i* located in country at time period *t*
Size (squared)	The square of *Size*
Concentration (CONC)	The C_5 concentration measure calculated by dividing the assets of the five largest banks to the assets of all banks operating in the market
Cost-to-income ratio (COST)	The cost-to-income ratio. It provides information on the efficiency of the management regarding expenses relative to the revenues it generates. Higher ratios imply a less efficient management
Leverage (LEVER)	Leverage is calculated as the ratio of bank total assets to total equity.
Diversification (DIVER)	Diversification proxied by the share of non-interest income in total income for commercial banks and the share of net interest income in total income for investment banks.

Source: Bankscope Bureau van Dijk Database.

distress. Previous studies (Poghosyan and de Haan, 2008; Shehzad et al., 2010) use this ratio to proxy for the efficiency of bank operations.

Leverage is related to the risk taken as a result of a bank's capital structure (Shehzad et al., 2008). De Haan and Poghosyan (2012b) demonstrate that banks with higher levels of leverage face higher return volatility.

Considering diversification, Stever (2007) argues that lower levels of diversification may result in higher profits volatility. Stiroh (2006) demonstrates that banks that are most reliant on activities that generate noninterest income are characterized by greater earnings volatility. Additionally, DeYoung and Roland (2001) demonstrate that fee-based activities are related to high earnings volatility.

The basic assumption of our model is that the difference in bank earnings volatility depends on bank size and other bank-specific variables. The model can be expressed as follows:

$$\Delta Volatility_{i,t} = a_{i,t} + \beta_1 Size_{i,t+}\beta_2 Size^2_{i,t} + \gamma_1 Cost_{i,t} + \gamma_2 Leverage_{i,t} + \gamma_3 Diversification_{i,t}$$

$$+\gamma_4 Concentration_t + \varepsilon_{i,t} \quad (3)$$

where size is our proxy for size of bank *i* at time *t* and ε is an error term. To consider non-linear effects, we include the square of size. Table 2 reports the variables and their description.

The econometric analysis of the model (Eq. (3)) consists of the following steps: first, we test for stationarity of the panel using the Fisher test. The null of non-stationarity is rejected at the 5% level for all variables for commercial banks. Among investment banks, all variables are stationary except for concentration. In this case, we take the first difference of the variable and test again for stationarity. The Fisher test indicates that ΔCONC is stationary. Second, we decide between a fixed effects (FE) model and a random effects (RE) model. For this reason, we employ the Hausman test, which indicates that a fixed effects model is more appropriate for the analysis of the commercial banks (*p-value* < 0.05). For the investment banks group, the Hausman test indicates that the random effects model is more appropriate (*p-value* > 0.05). We then perform diagnostic tests for heteroskedasticity and serial correlation in the panel data. For commercial banks, the modified Wald test[8] indicates that there is heteroskedasticity in the panel data. According to the Wooldridge test,[9] we reject the null hypothesis of no first-order autocorrelation in the panel data of the commercial banks (Table 3). Likewise, we detect heteroskedasticity and serial correlation in the investment banks group. To obtain test statistics that are robust to heteroskedasticity and autocorrelation we perform panel regression analysis utilizing Driscoll-Kray standard errors estimators (Driscoll and Kraay, 1998; De Hoyos and Sarafidis, 2006; Vogelsang, 2012). In the appendix, Tables A1 and A2 provide summary statistics for the commercial banks and investment banks, respectively. Table A3 displays the correlation matrix of the commercial banks group, and Table A4 displays the correlation matrix of the investment banks group.

5. Empirical results

The results of the panel regression analysis can be summarized as follows (Table 3). First, size, calculated as the log of total assets, is related negatively to bank earnings volatility for both commercial and investment banks in the sample. Yet, the significance of the squared size indicator reveals that this effect is non-linear. That is, large banks, either commercial or investment, face less volatility in their earnings; however, there is a threshold after which volatility increases (Haan and Poghosyan, 2012). The coefficient of size squared is greater for investment banks indicating that the size issue seems to have

[8] See Greene (2003)
[9] See Wooldridge (2010)

Table 3
Panel regression results with Driscoll-Kraay standard errors: baseline model.

	Dependent variable ΔVolatility Commercial banks[a]	Dependent variable ΔVolatility Investment banks[a]
Size	−1.3635 (0.000)***	−3.4271 (0.000)***
Size (squared)	0.0361 (0.004)**	0.0874 (0.000)***
Cost to income ratio	0.0039 (0.001)***	0.0206 (0.001)***
Leverage	0.0111 (0.125)	−0.0008 (0.391)
Diversification	−0.0005 (0.204)	−0.0002 (0.989)
Concentration	2.2936 (0.107)*	−5.662 (0.330)
Constant term	10.088 (0.000)***	32.138 (0.000)***
R-squared	0.3518	0.1219
Prob (F statistic)	(0.000)	(0.000)
Hausman test *(p-value)*	(0.000)	(0.0673)
Modified Wald test *(p-value)*	(0.000)	(0.000)
Wooldridge test *(p-value)*	(0.000)	(0.000)
Number of obs.	732	425
Number of banks	89	52

Notes: *p-values* in parentheses. Significance levels are indicated by */**/*** on the 10%/5%/1% level.
[a] Estimations are performed using the pooled OLS estimators.

more significant impact to investment banks. The estimation of the threshold averages at approximately £159 million for commercial banks and £327 million for investment banks.[10] The relationship between size and bank earnings volatility is consistent with previous studies of earnings volatility and banking profitability (Demirgüç-Kunt and Detragiache, 2000; De Nicolo, 2001; De Haan and Poghosyan, 2012).

The cost-to-income ratio, which is related to management efficiency, is statistically significant for the earnings volatility of commercial and investment banks. As expected, the coefficient of the cost-to-income ratio is positive and indicates that an increase (decrease) of the ratio causes more (less) volatility in the profits. Leverage is positively related to earnings volatility in the case of commercial banks and negatively in the case of investment banks. However, leverage is not statistically significant for either type of banking. Likewise, the degree of diversification is negatively associated with volatility but is not statistically significant in either case. The concentration of the market is marginally significant at the 10% significance level for commercial banks. Specifically, market concentration is associated positively to earnings volatility. Lastly, the explanatory power of model is much higher for commercial banks (R^2 equal to 0.3518 compared with 0.1219 for investment banks).

Next, we examine whether the relationship between size and earnings volatility was affected by the recent financial crisis. Therefore, we investigate whether bank earnings volatility is different during the pre-crisis and the post-crisis period. We introduce the indicator variable *Crisis* that takes the value one after the bank run on Northern Rock and its nationalization occurred and zero otherwise into the model (Eq. (3)). In order to test for the presence of structural break we use Wald test. The null hypothesis of the test supposes that there is no structural break. The *p-value* is greater than 0.05, so we accept the null hypothesis. Therefore, the coefficients do not vary over the periods defined by the known date 2007. To identify the impact of financial crisis, we introduce the following interaction terms (size-crisis, cost-crisis and concentration-crisis):

$$\Delta Volatility_{i,t} = a_{i,t} + \beta_1 Size_{i,t+}\beta_2 Size^2_{i,t} + \beta_3 Crisis_t + \beta_4 Crisis_t \times Size_{i,t} + \beta_5 Crisis_t \times Cost_{i,t} + \beta_6 Crisis_t$$

$$\times Concentration_t + \gamma_1 Cost_{i,t} + \gamma_2 Leverage_{i,t} + \gamma_3 Diversification_{i,t} + \gamma_4 Concentration_t + \varepsilon_{i,t} \quad (4)$$

According to the results (Table 4), the financial crisis had a negative impact on return volatility. For the commercial banks, the financial crisis affects larger banks more significantly than smaller banks as indicated by the positive interaction term size-crisis. The positive coefficient of the interaction term cost-crisis indicates that the impact of the financial crisis accrued to banks with higher cost to income ratios rather than those with lower cost to income ratios. More concentrated markets experienced higher earnings volatility during the financial crisis (i.e., a positive interaction term for concentration-crisis). In contrast to the baseline model (Table 3), leverage and diversification are significant and negatively related to earnings volatility.

The results for investment banks indicate that the impact of the financial crisis on earnings volatility is higher for smaller investment banks than larger investment banks (negative interaction term size-crisis). Similarly to commercial banks, the coefficient of the interaction term cost-crisis is positive, indicating that the impact of the financial crisis hit investment banks with higher cost to income ratio rather than those with lower cost to income ratio. In contrast to the baseline model (Table 4), leverage is significant negatively related to earnings volatility.

[10] Consistent with Haan and Poghosyan (2012), the threshold is estimated by taking the first derivative of Eq. (3) with respect to the log of total assets and equalizing it to zero.

Table 4
Panel regression results with Driscoll-Kraay standard errors: pre and post-crisis period.

	Dependent variable ΔVolatility Commercial banks[a]	Dependent variable ΔVolatility Investment banks[a]
Size	−0.0825 (0.008)***	−2.8337 (0.001)***
Size (squared)	0.0021 (0.036)**	0.0767 (0.003)***
Cost to income ratio	0.0037 (0.117)	0.0107 (0.007)***
Leverage	−0.0346 (0.000)***	−0.0102 (0.075)*
Diversification	−0.0104 (0.023)**	0.0080 (0.595)
Concentration	2.6363 (0.109)	−5.3932 (0.300)
Crisis	−9.5249 (0.011)**	3.6145 (0.207)
Interaction:		
size-crisis	0.0382 (0.031)**	−0.3808 (0.059)**
cost-crisis	0.0107 (0.001)**	0.0477 (0.009)***
concentration-crisis	10.2470 (0.036)**	−5.8245 (0.473)
Constant term	−1.3535 (0.181)	25.8874 (0.001)***
R-squared	0.2200	0.1661
Prob (F statistic)	(0.000)	(0.000)
Number of obs.	710	411
Number of banks	89	52

Notes: *p-values* in parentheses. Significance levels are indicated by */**/*** on the 10%/5%/1% level.
[a] Estimations are performed using the pooled OLS estimators.

Besides, in terms of methodology, we specify a dynamic model by including a lagged dependent variable. We apply two step generalized method of moments (GMM) methodology in order to take into account the potential impact of omitted variables and endogeneity (Arellano and Bond, 1991; Arellano and Bover, 1995; Blundell and Bond, 1998). The GMM methodology provides less biased coefficient estimates; more robust standard errors and uses lagged values of the dependent variables in level and in differences as instruments (Bond, 2002; Roodman, 2009). Arellano and Bond (1991) derived a consistent GMM estimator for the parameters of the model. Eqs. (5) and (6) describe the dynamic nature of our model.

$$\Delta Volatility_{i,t} = a_{i,t} + \beta_0 \Delta Volatility_{i,t-1+} + \beta_1 Size_{i,t+} \beta_2 Size^2_{i,t} + \gamma_1 Cost_{i,t} + \gamma_2 Leverage_{i,t} + \gamma_3 Diversification_{i,t} + \gamma_4 Concentration_t + \varepsilon_{i,t} \quad (5)$$

$$\Delta Volatility_{i,t} = a_{i,t} + \beta_0 \Delta Volatility_{i,t-1} + \beta_1 Size_{i,t} + \beta_2 Size^2_{i,t} + \beta_3 Crisis_t + \beta_4 Crisis_t * Size_{i,t} + \beta_5 Crisis_t * Cost_{i,t} + \beta_6 Crisis_t * Concentration_t + \gamma_1 \mathrm{Cost}_{i,t} + \gamma_2 \mathrm{Leverage}_{i,t} + \gamma_3 \mathrm{Diversification}_{i,t} + \gamma_4 \mathrm{Concentration}_t + \varepsilon_{i,t} \quad (6)$$

The results of the dynamic panel models (Tables A5 and A6) show that in the first case in which the variable of crisis is not taken into consideration, leverage and diversification are statistically important for the volatility of commercial banks in contrast to the first static model in which the aforementioned variables are not significant. As regards the squared size indicator, the results show that in the case of commercial banks of our sample is not important suggesting that the impact of size is linear. For the investment banks of our sample, the only difference between the static and the dynamic model is that in the latter model the variable of leverage is statistically important and it is associated negatively to the pendent variable. The postestimation tests indicate that in both cases (commercial and investment banks) the model is well fitted (Wald test). According to Sargan test there is no evidence of over-identifying restrictions. The tests for autocorrelation show that the residuals in first difference are serially correlated. However, the presence of first order autocorrelation does not cause problems to the consistency of estimates because the hypothesis of autocorrelation is rejected by the test for second order autocorrelation (Tables 5 and 6).

In the second dynamic panel model in which we examine the impact of the recent financial crisis, for the commercial banks the only difference from the static model is that the concentration is statistically important and it is related positively with the pendent variable. It should be noted that the diagnostics tests show fine goodness of the model fit, no evidence of over-identifying restrictions and absence of second order autocorrelation. The dynamic analysis for the investment banks differs from the respective static analysis in the variable of diversification which is statistically important and in the variable of crisis which has effect on the earnings volatility. Likewise the results of commercial banks, all the postestimation tests are valid for the model.

Table 5
Dynamic panel model regression results: Arellano-Bond GMM estimator.

	Dependent variable ΔVolatility Commercial banks	Dependent variable ΔVolatility Investment banks
ΔVolatility (lagged)	0.5909 (0.000)***	0.4426 (0.000)***
Size	−0.2587 (0.000)***	−6.9631 (0.000)***
Size (squared)	−0.0004 (0.658)	0.2376 (0.000)***
Cost to income ratio	0.0033 (0.000)***	0.1271 (0.000)***
Leverage	0.0083 (0.000)***	−0.0006 (0.020)**
Diversification	−0.0002 (0.000)***	−0.0006 (0.459)
Concentration	3.3125 (0.000)***	−0.4940 (0.108)
Constant term	3.0035 (0.000)***	32.138 (0.000)***
Wald-test[a] *(p-value)*	(0.0000)***	(0.000)***
Sargan test[b] *(p-value)*	(0.9879)	(1.000)
AB[c] test AR(1) *(p-value)*	(0.0001)***	(0.4254)
AB[c] test AR(2) *(p-value)*	(0.4061)	(0.1897)
Number of obs.	540	305
Number of banks	89	52

Notes: *p-values* in parentheses. Significance levels are indicated by */**/*** on the 10%/5%/1% level.
[a] Wald-test indicates fine goodness of model fit.
[b] Sargan test is the test for over-identifying restrictions in GMM dynamic model estimation.
[c] AB test AR(1) and AR(2) are the test for first order and second order autocorrelation respectively. It should be noted that the presence of first-order autocorrelation does not imply that the results are inconsistent because the hypothesis of autocorrelation is rejected by the AB test AR(2) (Arellano and Bond, 1991).

Table 6
Dynamic panel model regression results: Arellano-Bond GMM estimator (pre and post-crisis period).

	Dependent variable ΔVolatility Commercial banks	Dependent variable ΔVolatility Investment banks
ΔVolatility (lagged)	0.5701 (0.000)***	0.4586 (0.000)***
Size	0.0455 (0.000)***	−6.9815 (0.000)***
Size (squared)	−0.0114 (0.000)***	0.2441 (0.000)***
Cost to income ratio	0.0032 (0.000)***	0.0122 (0.000)***
Leverage	0.0031 (0.001)**	−0.0006 (0.050)**
Diversification	−0.0003 (0.000)***	−0.0028 (0.007)**
Concentration	3.2423 (0.000)***	−0.5056 (0.116)
Crisis	−2.9026 (0.000)***	9.0334 (0.000)***
Interaction:		
size-crisis	0.0344 (0.000)***	−0.2508 (0.000)***
cost-crisis	0.0016 (0.000)***	−0.0044 (0.056)*
concentration-crisis	3.0121 (0.000)***	−6.1520 (0.000)***
Constant term	1.0430 (0.015)**	44.00 (0.000)***
Wald-test[a] *(p-value)*	(0.000)***	(0.000)***
Sargan test[b] *(p-value)*	(0.9857)	(1.000)***
AB[c] test AR(1) *(p-value)*	(0.000)***	(0.4891)
AB[c] test AR(2) (p-value)	(0.1649)	(0.2294)
Number of obs.	540	305
Number of banks	89	52

Notes: *p-values* in parentheses. Significance levels are indicated by */**/*** on the 10%/5%/1% level.
[a] Wald-test indicates fine goodness of model fit.
[b] Sargan test is the test for over-identifying restrictions in GMM dynamic model estimation.
[c] AB test AR(1) and AR(2) are the test for first order and second order autocorrelation respectively. It should be noted that the presence of first-order autocorrelation does not imply that the results are inconsistent because the hypothesis of autocorrelation is rejected by the AB test AR(2) (Arellano and Bond, 1991).

6. Conclusions and future research

The recent global financial crisis has highlighted the issue of banks' size and especially the too-big-to-fail (TBTF) issue and started an intense bate among regulators, supervisory authorities and central bankers. In the UK, the Bank of England has participated in policy discussions of splitting up of banks to reduce their size and complexity. In this context, the examination of the relationship between bank size and earnings volatility is of great importance to forthcoming banking restructuring.

In this study, we examine bank earnings volatility in the United Kingdom, an interconnected, global financial system that contributes significantly to global financial stability. This study focuses on the relationship between bank size and earnings volatility while controlling for bank-specific and market structure variables and compares commercial and investment banking institutions. The results of our analysis indicate that size has a negative effect on earnings volatility for both com-

mercial and investment bank; the coefficient is negative, which suggests that an increase (crease) in size is associated with less (more) volatility in profits. The significance of size squared reveals that this effect is non-linear. That is, small banks, either commercial or investment, face more volatility in their earnings; however, there is a threshold after which volatility diminishes.

For commercial banks, the cost-to-income ratio, which provides information on management expenses relative to revenues, is statistically significant and positively related to earnings volatility. Concentration exhibits a marginal and positive association with volatility, which indicates that structures that are more concentrated are associated with earnings that are more volatile. Leverage and diversification are positively and negatively related to volatility, respectively, but these variables are statistically insignificant. For investment banks, the cost-to-income ratio has a negative effect on earnings volatility. The results for additional control variables, such as leverage, diversification and concentration, are statistically insignificant.

The results of this study produce important policy implications for the structural reforms which are related to the size of banking institutions that have begun in the United Kingdom. The negative relationship between size and earnings volatility indicates that splitting up large banks could cause greater volatility. However, because the relationship is non-linear, the crucial threshold after which volatility begins to crease provides information for the termination of the appropriate size of banks. In this context, the results of this research are important because according to the current velopments in UK banking system, the biggest banks will need to raise big bailout amounts in order to boost their capital buffers. The velopments of our models provide, also, information for a set of bank-specific variables such as cost-to-income ratio, leverage and diversification which are very important for the top management of the banking institutions. UK regulatory authorities try to termine the appropriate size of the financial institution in order to avoid banking crises in the future and to avoid the need for taxpayers to contribute to banks' save. Therefore, the empirical results regarding the size of the commercial and the investment banks constitute significant evidence for the limitation of the size.

Further research on the simultaneous impacts of the macroeconomic environment and bank-specific variables is sirable to extend our knowledge on bank earnings volatility in the UK banking system. Additionally, comparative research that includes other veloped banking systems will provide useful knowledge of earnings volatility.

Appendix A.

See Tables A1–A4.

Table A1
Summary statistics of commercial banks.

Variable	Mean	Standard Deviation	Minimum	Maximun
ΔVolatility	−0.5170	1.5266	−2.0857	10.2006
Size	14.0306	2.7015	3.2188	21.4425
Cost	63.7777	28.4572	2.1700	197.4900
Leverage	12.8272	11.5449	1.0000	87.2047
Diversification	1.4190	7.6073	−136.3441	58.5000
Concentration	0.7250	0.0719	0.5616	0.8648

Number of banks: 89.
Number of obs: 732.

Table A2
Summary statistics of investment banks.

Variable	Mean	Standard Deviation	Minimum	Maximun
ΔVolatility	3.5642	8.9721	0.0000	92.9265
Size	14.0663	2.9994	4.5538	20.6130
Cost	81.3676	38.5931	1.5800	369.2300
Leverage	19.7330	34.1532	−5.5712	392.14
Diversification	0.3503	7.8609	−76.2811	43.1250
Concentration	0.8253	0.0600	0.7459	0.9091

Number of banks: 52.
Number of obs: 425.

Table A3
Correlation matrix (commercial banks).

Variable	ΔVolatility	Size	Size (squared)	Cost	Leverage	Diversification	Concentration
ΔVolatility	1.0000						
Size	−0.2305	1.000					
Size (squared)	0.2241	0.9938	1.000				
Cost	0.2409	−0.1648	−0.1414	1.000			
Leverage	−0.2913	0.6253	0.6356	0.0709	1.000		
Diversification	−0.0658	−0.0615	−0.0745	0.0097	−0.0218	1.000	
Concentration	0.0557	0.1196	0.1177	−0.0231	0.0795	−0.0035	1.000

Table A4
Correlation matrix (investment banks).

Variable	ΔVolatility	Size	Size (squared)	Cost	Leverage	Diversification	Concentration
ΔVolatility	1.0000						
Size	−0.3066	1.000					
Size (squared)	−0.2912	0.9922	1.000				
Cost	0.2178	−0.0603	−0.0445	1.000			
Leverage	−0.1693	0.4896	0.5088	−0.0286	1.000		
Diversification	−0.0020	−0.0674	−0.0807	−0.1231	−0.0838	1.000	
Concentration	−0.0279	−0.0151	−0.0179	0.0343	−0.0644	0.0017	1.000

References

Abreu, José Filipe, Gulamhussen, Mohamed Azzim, 2013. The stock market reaction to the public announcement of a supranational list of too-big-to-fail banks during the financial crisis. J. Int. Financ. Mark. Inst. Money 25 (0), 49–72.

Albertazzi, Ugo, Gambacorta, Leonardo, 2009. Bank profitability and the business cycle. J. Financ. Stab. 5 (4), 393–409.

Allen, Franklin, Gale, Douglas, 2001. Comparing Financial Systems. MIT Press Books 1. The MIT Press.

Allen, Franklin, Gale, Douglas M., 2003. Competition and Financial Stability. NYU Working Paper No. S-FI-03-06.

Arellano, Manuel, Bond, Stephen, 1991. Some tests of specification for panel data: monte carlo evidence and an application to employment equations. Rev. Econ. Stud. 58 (2), 277–297 (Oxford University Press).

Arellano, Manuel, Bover, Olympia, 1995. Another look at the instrumental variable estimation of error-components models. J. Econometrics 68 (1), 29–51 (Elsevier).

Bain, Joe S., 1951. Relation of profit rate to industry concentration: American manufacturing, 1936–1940. Quarterly J. Econ. 65 (3), 293–324 (Oxford University Press).

Barth, James R., Prabha, Apanard Penny, 2012. Current Views | Just How Big Is the Too Big to Fail Problem ? Just How Big Is the Too Big to Fail Problem? (March).

Committee Basel, 2011. Basel Committee on Banking Supervision Consultative Document Global Systemically Important Banks: Assessment Methodology and the Additional Loss Absorbency Requirement (November).

Beck, Thorsten, Demirgüç-Kunt, Asli, Levine, Ross, 2006. Bank concentration, competition, and crises: first results. J. Bank. Finance 30 (5), 1581–1603.

Berger, Allen N., De Young, Robert, 1997. Problem loans and cost efficiency in commercial banks. J. Bank. Finance 21 (6), 849–870 (Elsevier).

Berger Allen, N., Gerald Hanweck, A., David Humphrey, B., 1987. Competitive viability in banking: scale, scope, and product mix economies. J. Monet. Econ. 20 (3), 501–520.

Bernanke, Ben S., 2010. Testimony by Chairman Ben S. Bernanke, 0–27.

Bertay, Ata Can, Demirgüç-Kunt, Asli, Huizinga, Harry, 2013. Do we need big banks? evidence on performance, strategy and market discipline. J. Financ. Intermediation 22 (4), 532–558 (Elsevier Inc.).

Blundell, Richard, Bond, Stephen, 1998. Initial conditions and moment restrictions in dynamic panel data models. J. Econometrics 87 (1), 115–143 (Elsevier).

Bond, Stephen R., 2002. Dynamic panel data models: a guide to micro data methods and practice. Portuguese Econ. J. 1 (2), 141–162 (Springer).

Boyd, John H., De Nicolo, Gianni, 2005. The theory of bank risk taking and competition revisited. J. Finance 60 (3), 1329–1343 (Wiley Online Library).

Boyd, John H., Heitz, Amanda, 2012. The Social Costs and Benefits of Too-big-to-fail Banks: A'bounding'exercise. University of Minnesota Working Paper.

Boyd, John H., Jagannathan, Ravi, 2009. Avoiding the Next Crisis. The Economists' Voice, pp. 6.

Boyd, John H, Runkle, David E., 1993. Size and performance of banking firms: testing the predictions of theory. J. Monetary Econ. 31 (1), 47–67 (Elsevier).

Boyd, John H., Jagannathan, Ravi, Kwak, Sungkyu, 2009. What caused the current financial mess and what can we do about it? SSRN Electron. J., http://dx.doi.org/10.2139/ssrn.1463064.

Elijah III, Brewer, Jagtiani, Julapa, 2013. How much did banks pay to become too-big-to-fail and to become systemically important? J. Financ. Serv. Res. 43 (1), 1–35 (Springer).

Calomiris, Charles, 2009. In the World of Banks, Bigger can be better. Wall Str. J., 19.

Carlo, G., Roselli, A., 2009. In: Molyneux, P. (Ed.), The UK Banking System and Its Regulatory and Supervisory Framework. Palgrave Macmillan Studies in Banking and Financial Institutions.

Couto, Rodrigo Luis Rosa, 2002. Framework for the Assessment of Bank Earnings. Bank for International Settlements, Financial Stability Institute.

Crockett, Andrew, 1997. Why is financial stability a goal of public policy?, 7–36.

Cumming, Christine, Eisenbeis, Robert A, 2010. Resolving Troubled Systemically Important Cross-Border Financial Institutions: Is a New Corporate Organizational Form Required? Federal Reserve Bank of New York.

Davies, Richard, Tracey, Belinda, 2014. Too big to be efficient? The impact of implicit subsidies on estimates of scale economies for banks. J. Money Credit Bank. 46 (s1), 219–253.

Davies, Richard, Richardson, Peter, Katinaite, Vaiva, Manning, Mark, 2010. Evolution of the UK Banking System. Bank of England Quarterly Bulletin (Q4).

Demirgüç-Kunt, Ash, Huizinga, Harry, 1999. Determinants of commercial bank interest margins and profitability: some international evidence. World Bank Econ. Rev. 13 (2), 379–408 (World Bank).

Demirgüç-Kunt, Asli, Detragiache, Enrica, 2000. Monitoring banking sector fragility: a multivariate logit approach. World Bank Econ. Rev. 14 (2), 287–307 (World Bank).
Demirgüç-Kunt, Aslı, Huizinga, Harry, 2000. Financial Structure and Bank Profitability, vol. 2430. World Bank Publications.
Demirgüç-Kunt, Asli, Huizinga, Harry, 2013. Are banks too big to fail or too big to save? International evidence from equity prices and CDS spreads. J. Bank. Finance 37 (3), 875–894.
Haan, Jakob de, Poghosyan, Tigran, 2012. Size and earnings volatility of US Bank holding companies. J. Bank. Finance (Elsevier).
De Haan, Jakob, Poghosyan, Tigran, 2012a. Bank size, market concentration, and bank earnings volatility in the US. J. Int. Financ. Mark. Inst. Money 22 (1), 35–54 (Elsevier).
De Haan, Jakob, Poghosyan, Tigran, 2012b. Bank size, market concentration, and bank earnings volatility in the US. J. Int. Financ. Mark. Inst. Money 22 (1), 35–54.
De Hoyos, Rafael E., Sarafidis, Vasilis, 2006. Testing for cross-sectional dependence in panel-data models. Stata J. 6 (4), 482–496 (StataCorp LP).
De Nicolo, Gianni, 2001. Size, charter value and risk in banking: an international perspective. EFA 2001 Barcelona Meetings.
DeYoung, Robert, Roland, Karin P., 2001. Product mix and earnings volatility at commercial banks: evidence from a degree of total leverage model. J. Financ. Intermediation 10 (1), 54–84.
Demirgüç-Kunt, Asli, Huizinga, Harry, 2011. Do We Need Big Banks? Evidence on Performance, Strategy and Market. Evidence on Performance, Strategy and Market (February 1, 2011). World Bank Policy Research Working Paper Series.
Demsetz, Rebecca S., Strahan, Philip E., 1997. Diversification, size, and risk at bank holding companies. J. Money Credit Bank., 300–313 (JSTOR).
Driscoll, John C., Kraay, Aart C., 1998. Consistent covariance matrix estimation with spatially dependent panel data. Rev. Econ. Stat. 80 (4), 549–560 (MIT Press).
Huberto, Ennis, Malek, H. Sam, 2005. Bank risk of failure and the Too-Big-to-Fail policy. FRB Richmond Econ. Quarterly 91 (2), 21–44.
Financial Stability Board, 2010. Reducing the Moral Hazard Posed by Systemically Important Financial Institutions: Interim Report to G20 Leaders. Financial Stability Board.
Financial System Stability Assessment Update, International Monetary Fund, 2011. United Kingdom: Financial System Stability Assessment International Monetary Fund Financial System Stability Assessment Update Prepared by the Monetary and Capital Markets and European Departments Approved by José Viñals and Antonio Borges.
Flannery, Mark J., 2010. What to do about TBTF? In: Federal Reserve Bank of Atlanta 2010 Financial Markets Conference—Up From the Ashes: The Financial System After the Crisis. Atlanta, May, vol. 12.
Gilbert, R. Alton, 1984. Bank market structure and competition: a survey. J. Money Credit Bank. 16 (4), 617–645 (JSTOR).
Golin, Jonathan L., 2001. The Bank Credit Analysis Handbook: A Guide for Analysts, Bankers and Investors. Wiley New York.
Gonzalez-Hermosillo, Brenda, 1999. Determinants of Ex-Ante Banking System Distress: A Macro-Micro Empirical Exploration of Some Recent Episodes. International Monetary Fund.
Greene, William H., 2003. Econometric Analysis, 5/e. Pearson Education India.
Haberman, Gary, 1987. Capital Requirements of Commercial and Investment Banks: Contrasts in Regulation. Quarterly Review. Aut. Federal Reserve Bank of New York, pp. 1–10.
Hefferman, S., 2005. Modern Banking. John Wiley & Sons Ltd., England.
Hughes, Joseph P., Mester, Loretta J., 2013. Who said large banks don't experience scale economies? Evidence from a risk-return-driven cost function. J. Financ. Intermediation 22 (4), 559–585 (Elsevier Inc.).
Iannotta, Giuliano, 2010. Investment Banking: A Guide to Underwriting and Advisory Services. Springer.
Johnson, Simon, Kwak, James, 2011. 13 Bankers: The Wall Street Takeover and the next Financial Meltdown, Vintage.
Kaufman, George G., 2002. George Too Big to Fail in Banking: what remains? 42, 423–436.
Krugman, Paul. 2009. "Too big to fail FAIL." New York Times, June 18. http://krugman.blogs.nytimes.com/2009/06/18/too-big-to-fail-fail.
Lee, T. Peter, 1979. Significant developments in the United Kingdom in 1979. J. Comp. Corp. L. Sec. Reg. 2, 335 (HeinOnline).
Mason, Edward S., 1939. Price and production policies of large-scale enterprise. Am. Econ. Rev. 29 (1), 61–74 (JSTOR).
Matthews, Kent, Murinde, Victor, Zhao, Tianshu, 2007. Competitive conditions among the major British banks. J. Bank. Finance 31 (7), 2025–2042.
Mercieca, Steve, Schaeck, Klaus, Wolfe, Simon, 2007. Small European Banks: benefits from diversification. J. Bank. Finance 31 (7), 1975–1998.
Micco, Alejandro, Panizza, Ugo, Yañez, Monica, 2007. Bank ownership and performance. Does politics matter? J. Bank. Finance 31 (1), 219–241, http://dx.doi.org/10.1016/j.jbankfin.2006.02.007.
Morgan, Donald, Stiroh, Kevin, 2005. Too Big to Fail after All These Years. FRB of NY Staff Report.
Morrison, A.D., 2012. Systemic risks and the 'Too-Big-to-Fail' problem. Oxf. Rev. Econ. Policy 27 (3), 498–516, http://dx.doi.org/10.1093/oxrep/grr020.
Moshirian, Fariborz, Wu, Qiongbing, 2012. Banking industry volatility and economic growth. Res. Int. Bus. Finance 26 (3), 428–442.
Nicoló, Gianni De, Bartholomew, Philip, Zaman, Jahanara, Zephirin, Mary, 2004. Bank consolidation, internationalization, and conglomeration: trends and implications for financial risk. Financ. Mark. Inst. Inst. 13 (4), 173–217 (Wiley Online Library).
Pasiouras, Fotios, Kosmidou, Kyriaki, 2007. Factors influencing the profitability of domestic and foreign commercial banks in the European Union. Res. Int. Bus. Finance 21 (2), 222–237.
Poghosyan, Tigran, de Haan, Jakob, 2008. Determinants of Cross-Border Bank Acquisitions in Transition Economies: A Latent Class Analysis. CESifo Working Paper.
Porter, Michael E., 1979. How competitive forces shape strategy. Harv. Bus. Rev.
Fisher, Richard W., 2011. Taming the Too-Big-to-Fails: Will Dodd-Frank Be the Ticket or Is Lap-Band Surgery Required? Remarks before Columbia University's Politics and Business Club, New York City.
Roodman, David, 2009. A note on the theme of too many instruments. Oxf. Bull. Econ. Stat. 71 (1), 135–158 (Wiley Online Library).
Rose, Andrew K., Wieladek, Tomasz, 2012. Working Paper No. 460 Too Big to Fail: Some Empirical Evidence on the Causes and Consequences of Public Banking Interventions in the United Kingdom. Working Paper No. 460 Causes and Consequences of Public Banking, no. 460.
Shehzad, Choudhry Tanveer, Scholtens, Bert, De Haan, Jakob, 2008. Bank Size Income Composition and Earning Volatility.
Shehzad, Choudhry Tanveer, de Haan, Jakob, Scholtens, Bert, 2010. The impact of bank ownership concentration on impaired loans and capital adequacy. J. Bank. Finance 34 (2), 399–408.
Short, Brock K., 1979. The relation between commercial bank profit rates and banking concentration in Canada, Western Europe, and Japan. J. Bank. Finance 3 (3), 209–219 (Elsevier).
Smirlock, Michael, 1985. Evidence on the (non) relationship between Concentration and profitability in banking. J. Money Credit Bank. 17 (1), 69–83 (JSTOR).
Stever, Ryan, 2007. Bank Size, Credit and the Sources of Bank Market Risk. Bank for International Settlements.
Stiroh, Kevin J., Rumble, Adrienne, 2006. The dark side of diversification: the case of {US} financial holding companies. J. Bank. Finance 30 (8), 2131–2161.
Stiroh, Kevin J., 2006. Portfolio view of banking with interest, noninterest activities. J. Money Credit Bank., 1351–1361 (JSTOR).
Tamakoshi, Go, Hamori, Shigeyuki, 2016. Time-varying co-movements and volatility spillovers among financial sector CDS indexes in the UK. Res. Int. Bus. Finance 36 (January), 288–296.
Tsomocos, Dimitrios P., 2003. Equilibrium analysis, banking and financial instability. J. Math. Econ. 39 (5–6), 619–655, http://dx.doi.org/10.1016/S0304-4068(03)00045-4.
Völz, Manja, Wedow, Michael, 2011. Market discipline and too-big-to-fail in the CDS market: does banksö size reduce market discipline? J. Empir. Finance 18 (2), 195–210 (Elsevier B.V.).

Vogelsang, Timothy J., 2012. Heteroskedasticity, autocorrelation, and spatial correlation robust inference in linear panel models with fixed-effects. J. Econometrics 166 (2), 303–319 (Elsevier).
Wheelock, David C., Wilson, Paul W., 2012. Do large banks have lower costs? New estimates of returns to scale for U.S. Banks. J. Money Credit Bank. 44 (1), 171–199, http://dx.doi.org/10.1111/j.1538-4616.2011.00472.x.
Wooldridge, Jeffrey M., 2010. Econometric Analysis of Cross Section and Panel Data. MIT Press.