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Author(s)*: Nikolaos Papanikolaou and Christian Wolff

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JEL Classification: C23; D02; G21; G28

***Corresponding Author's Address:** Tel. : +352 46 66 44 6938; Fax : 352 46 66 44 6835.
Nikolaos.papanikolaou@uni.lu

University of Luxembourg
Faculty of Law, Economics and Finance
Luxembourg School of Finance
4 Rue Albert Borschette
L-1246 Luxembourg

Leverage and risk in US commercial banking in the light of the current financial crisis

Nikolaos I. Papanikolaou[a*] and Christian C.P. Wolff[a,b]

[a]*Luxembourg School of Finance, University of Luxembourg, 4 rue Albert Borschette, L-1246 Luxembourg*

[b]*Centre for Economic Policy Research (CEPR), London, United Kingdom*

Abstract

In this paper we study the relationship between leverage and risk in commercial banking market. We employ a panel data set that consists of the biggest US commercial banks and which extends from 2002 to 2010 thus covering both the years before the outbreak of the current financial crisis as well as those followed. We make clear distinctions among different leverage types like on- and off-balance sheet leverage as well as short- and long-term leverage, which have never been made in the relevant literature. Our findings provide evidence that excessive leverage, both explicit and hidden off-the-balance sheet, rendered large banks vulnerable to financial shocks thus contributing to the fragility of the whole banking industry. In a similar vein, a direct link between short- and long-term leverage with risk is reported before the crisis, showing that leverage has been one of the key factors responsible for the serious liquidity shortages that were revealed after 2007 when the crisis erupted. We also demonstrate that banks which concentrate on traditional banking activities typically carry less risk exposure than those that are involved with modern financial instruments. Overall, our results provide a better understanding of the role of leverage in destabilizing the whole system whereas at the same time contribute to the current discussion on the resilience of the banking sector through the strengthening of the existing regulatory framework.

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[*]Corresponding author: Tel.: +352 4666446938; fax: +352 4666446835; E-mail address: nikolaos.papanikolaou@uni.lu

1. Introduction

The strength of the financial system has been tested for more than three years now. The current crisis, whose origins can be traced in the sharp increase in delinquency on US sub-prime mortgage market in 2006 and the succeeding collapse in housing prices in August 2007, has revealed several inherent problems in the operation of the banking system. Rapidly expanded balance sheets, performance-based remuneration practices and inefficient regulation of financial institutions are among the factors that have played a significant role in making the system much more fragile. There is, however, one more factor that is strongly related to the malfunctioning of the banking sector prior to the crisis and which had also contributed greatly to the buildup of vulnerabilities and adverse market dynamics in the recent past. We refer to the excessive degree of leverage of financial institutions in the years preceding the crisis, a feature that had also led to the near-failure of the hedge fund Long Term Capital Management (LTCM) in the autumn of 1998 that had been triggered by the Russian debt restructuring. Indeed, the severity of the 1998 market turmoil showed that the accumulation of excessively high leverage coupled with short-term funding is a combination capable of producing substantial instability to the system. Yet, the importance of leverage combined with both increased securitization and heavy reliance on short-term funding was disregarded by market participants and, most importantly, by national and supranational regulatory and supervisory authorities in the years running up to the current crisis.

Leverage has been always viewed as one of the main underlying features of banks' balance sheets. Traditionally, it arises directly through formal debt like, for instance, through bonds and credit lines. Nevertheless, it seems that, in the pre-crisis period, banks leveraged their positions to a much greater extent than they used to a couple of decades ago by taking advantage of financial innovation which allowed them to transfer a large part of their leverage off their balance sheets. Consistently, over the past ten years or so, banks responded to the increased demand for credit instruments with higher yield by developing financial engineering techniques and creating modern types of products. Although these developments may have come about as a result of the wider financial advances aimed at improving the efficiency of the system, they have also provided opportunities for increasing leverage and for shifting risks among market participants in highly complicated ways. Several of the new financial instruments were indeed opaque and masked the extent of leverage and interconnectedness of risk, which appeared to be spilled-over across a wide range of institutions and markets worldwide. It can be deduced from

the discussion so far that -before the crisis- a significant degree of leverage was assumed implicitly, in the sense that it was not recorded on the balance sheet.

Furthermore, banks became more and more dependent on short-term funding in the years preceding the current crisis and this widened their asset-liability mismatch and increased their funding liquidity risk. To be more specific, banks were capable of funding a growing share of long-term assets with short-term liabilities in wholesale markets through Special Investment Vehicles (SIVs) and conduits. Yet, they were exposed to both credit and liquidity risk by providing facilities to these vehicles. Along the same lines, banks also held structured credit products on their own balance sheets thus exposing themselves to embedded leverage. After the crisis erupted, banking institutions sought to deleverage their positions thus amplifying the already existing downward pressure on asset prices which, in turn, encouraged deleveraging even further. This procyclical deleveraging process was exacerbated by the large size of systemic institutions and the high degree of interconnectedness among them. Overall, the malfunctions of the banking industry were transmitted to the rest of the financial system and, later, to the real economy, resulting in a massive contraction of liquidity and credit availability.

Although the role that leverage plays in the stability of the financial system has been discussed in a number of theoretical policy and academic studies, not enough empirical evidence has been gathered to provide definite answers to the relevance of the accumulation of leverage and the subsequent deleveraging process in the propagation and prolongation of the crisis. Most notably, little attention has been paid to the *overall* leveraging and deleveraging behavior of commercial banks before and after the outbreak of the current financial crisis. We thus make an attempt to fill part of this void by assessing the effect of leverage and reverse leverage on the soundness of the banking system. More concretely, we empirically investigate the overall leverage and deleverage behavior of US Too-Big-To-Fail (TBTF) commercial banks before and after 2007 when the crisis occurred.

Our emphasis on commercial banks allows us not only to make a distinction between on-balance sheet leverage and implicit leverage, but also to measure leverage types of different maturities, that is short- and long-term leverage. An additional reason for focusing our attention on commercial banking is because this sector is both heavily regulated and largely supervised. This is in sharp contrast to what holds for investment banks as well as near- and non-banks that do not rely on deposits and, thus, are not obliged to keep much money in the form of capital. As

a result, these institutions face no serious restrictions on the level of their leverage. Hence, an issue that we also deal with in the current paper is whether the existing capital requirements are adequate to prevent an undesirable increase in commercial banks' level of leverage.

Our findings reveal, among other things, that both on- and off-balance sheet leverage contribute to banks' overall risk. By the same token, we find that short-term leverage is negatively linked to the soundness of the banking system. Additionally, banks that concentrate on the traditional activity of taking deposits from households and making loans to agents that require capital are reported to carry less risk exposure to the system than those that are involved with new financial instruments. Overall, our results provide a better understanding of one of the root causes of the current crisis and contribute to the discussion on the enforcement of the existing regulatory framework for banks.

The remainder of the paper proceeds in the following way. In Section 2 we analyze how leverage and reverse leverage of commercial banks are linked to risk. Section 3 then provides a description of the data set and a justification of the variables used together with summary statistics. The regression model and the estimation methodology followed are also presented in this section. Section 4 discusses the empirical findings, whereas their corresponding policy implications along with the concluding remarks are presented in Section 5.

2. Leverage, deleverage and risk

Bank leverage, based on the traditional balance sheet concept, refers to the use of debt in financing new assets. More specifically, debt is used to supplement bank equity capital in financing fresh loans and investments that are expected to produce a higher rate of return compared to the interest rate that the bank has agreed to pay to its lenders (say depositors). In case the investment (or loan) return rate turns out to be lower than anticipated, bank's equity will be shrink as the bank is forced to cover the difference between deposit and lending rates by using part of its equity. But what happens when a bank loan fails? In such a case, the bank that granted the loan is not able to recover the loan, which implies that the loan will be charged off. In simple terms, this means that the bank loses an amount of assets equal to the loan loss. The charge-off also affects the liabilities side of bank's balance sheet as it reduces equity capital by the amount of the loss. If several borrowers default on their obligations, then the bank's equity will be in

peril. Should nonperforming and defaulted loans accumulate -which is a common phenomenon in bad economic times-, the equity capital would disappear. Accordingly, equity absorbs the losses a bank suffers in case loans -or other investments- go sour. In sum, traditional bank leverage maps the riskiness of a bank's asset position into the riskiness of its on-balance sheet equity stake.

Bank leverage can also be traced *off* the balance sheet. Indeed, commercial banks are allowed to transfer some part of their leverage off their balance sheets through securitization and other modern financial activities.[1] In the years running up to the current financial crisis, securitization occurred mainly through the set up of Asset Backed Commercial Paper (ABCP) conduits and Structured Investment Vehicles (SIVs) where banks were transferring their assets together with their risk.[2] As a result, conduits and SIVs contained a significant degree of leverage, known as embedded leverage. This particular type of leverage was thus achieved through the structuring of the financial instruments *per se*. The risk -though transferred to conduits- still burdened the sponsoring commercial banks that provided liquidity and credit enhancements to conduits in order to ensure funding liquidity for the vehicles. These enhancements or 'backstops' attracted a low charge under Basel I and were funded mostly by rolling over commercial paper and only by very little equity capital. Hence banks were able to free up capital to originate more assets, generally of lower quality, and hide them in the shadow banking system.[3] By doing so, commercial banks deliberately avoided issuing new (costly) equity capital to originate new assets and finance their activities in general. Nonetheless, under the aforementioned scheme of credit and liquidity backstops, investors in conduits and SIVs would return the assets back to the bank once they suffered a loss. As a consequence, commercial banks were obliged to take 'bad' assets back on their books in the light of the crisis.

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[1] Banks have a strong incentive to structure products as they can qualify for lower capital requirements. An additional advantage of securitization is that it generates fee income. Fees do not have to be returned in case securities later suffer great losses, which implies that commercial banks have an additional incentive to engage in securitized activities thus leveraging even more their positions.

[2] This action has become known as regulatory arbitrage. This type of arbitrage refers to the response of commercial banks to regulatory restrictions -especially those on capital requirements- that have been imposed by Basel I and II. Put differently, it is the game that takes place between banks and regulatory authorities whereby the former innovate and develop structured instruments in order to elude the scrutiny of supervisors and increase their returns, where the latter tighten the rules to avoid excessive risk-taking with the purpose to safeguard the stability of the financial system. For a thorough discussion of regulatory capital arbitrage via derivative instruments, see Beuer (2002).

[3] Shadow banking consists of non-bank financial institutions like hedge funds, insurance funds, investment funds, pension funds, SIVs, conduits, to name the most important ones.

It should be apparent thus far that leverage (either on- or off-balance sheet) can be potentially harmful for financial stability. In case of over-leverage, a rapid and simultaneous unwinding of leveraged positions of financial institutions triggered by an adverse event -like the adverse price movements in the sub-prime sector of the securitized US mortgage market- can seriously threaten the soundness of the system. Moreover, in an economy-wide financial turmoil, highly leveraged firms are more likely to fall into financial distress, thus worsening their performance. Consistent with the corporate finance literature, distress deepens the interest conflicts between bondholders and shareholders and eventually increases the agency costs of debt (Jensen and Meckling, 1976). In a similar vein, the role of leverage as a disciplinary device that reduces free cash flow problems (Jensen, 1986) as well as its signaling power of conveying positive messages to the market (Titman and Trueman, 1986) both become less important when the firm is financially distressed.

Equally -if not more- harmful than leverage *per se* is the so-called reverse leverage that refers to the phenomenon in which financial intermediaries all together attempt to shrink their balance sheets by reducing their debt. Deleveraging puts additional downward pressure on financial markets, especially in a system that consists of highly leveraged institutions. Any serious fall in asset prices or any large losses in loans or securities or any cut in cash flows can exert reverse leverage effects on the system. In the current crisis, the trigger for the deleveraging process was the deceleration of housing prices that was accompanied by an increase in mortgage default rates. The value of mortgage-backed securities was thus dampened, making financial institutions and other investors less willing to hold these securities in their portfolios. The downward spiral was further amplified by the downgrades of the majority of securitized products by the ratings agencies. Since a small downgrade can cause a big fall in the price of the downgraded asset, banks had to take immediate steps to strengthen their capital base in order to provide support to their assets. As a result, credit supply was sharply fallen and this, in turn, negatively affected the whole economic activity.

To continue, short-term (wholesale) debt via the rolling out of conduits and SIVs is relatively cheap for commercial banks compared to long-term debt. Indeed, the costs of banks of holding much illiquid capital is largely removed with short-term debt. Nevertheless, short-term borrowing can cause serious liquidity problems, especially in case of financial distress: the funding of long-term investments through short-term securitized debt widens maturity and

liquidity gaps, making banks much more vulnerable to runs. Moreover, when the asset growth at banks is funded with short-term debt, the funding risk is increased due to the higher volatility of these funding sources compared to more stable retail deposits. Surprisingly, the crisis literature does not relate leverage to other aspects of the crisis, notably, liquidity tides and shortages.[4] These relationships are also addressed in this paper, using proxy measures for bank short- and long-term leverage.

3. Empirical analysis

3.1. Data

Our empirical analysis is based on a data set that consists of the 12 largest US commercial banks as reported by the Federal Reserve Board (the bank names can be found in Appendix I).[5] The institutions that are examined are representative of US commercial banking as they possess about 50% of the sector's total assets whereas their relative importance is increasing throughout the data period.[6] This is to say, our sample banks are regarded as being TBTF in the sense that US government would be rather reluctant to let any of these banks to go bankrupt as this would have shattering effects on the whole financial system.[7] Indeed, the 12 largest commercial banks that comprise our data sample provide the bulk of financing to industry and households in US, meaning that, if any of these banks were allowed to fail, this would inevitably cause, *inter alia*, serious systemic liquidity shortages in the economy. This is to say that we focus on some of the most systemically important financial institutions worldwide, which is a fundamental characteristic of our study.

Moreover, large commercial banks have been engaged in off-balance sheet activities to a much greater extent than their smaller counterparts. Indeed, the literature (see, e.g., Rime and

[4] Berger and Bouwman (2009) stress the lack of tangible liquidity measures as the main reason why liquidity is overlooked in the existing literature.

[5] The US Federal Reserve Board compiles quarterly data on domestically chartered large commercial banks from 2001 onwards.

[6] Other recent studies that also belong to the burgeoning crisis literature and focus exclusively on systemically important financial institutions are those of Adrian and Shin (2010), who examine the procyclicality in leverage of the 5 largest US investment banks before the crisis and Huang et al. (2009), who construct a framework for measuring and stress testing the systemic risk of 12 US major commercial and investment banks.

[7] To provide support to this argument, we mention that not a single US commercial bank amongst those failed from the beginning of the current financial crisis (which amount to 294 as of the end of September 2010 according to the relevant FDIC list) is ranked among the first one hundred large commercial banks.

Stiroh, 2003) has showed that big banks are very prone to universal banking activities in contrast to small and mid-sized banks which are less diversified and resemble single-line businesses. Hence, the distinction between on- and off-balance sheet leverage, which is in the focus of the present study, is expected to be made easier by using a sample that consists exclusively of big banks like ours.

We think it is important to justify at this point why we focus our research on the US and not on some other banking system. The first reason is that the ongoing crisis originated in the US before spilled over to other Western-type economies. Hence, by investigating the US banking sector, we can trace some of the root causes of the crisis. Second, Generally Accepted Accounting Principles (GAAP) allow US commercial banks to treat their SIVs and ABCP conduits as being entirely *off* their balance sheets. In contrast, the International Financial Reporting Standards (IFRS) that European institutions follow is somewhat less tolerant toward off-balance sheet business as they require from banks to keep record of their SIVs and ABCP conduits on their balance sheets. Apparently, GAAP provide US banks with an additional incentive to undertake a higher degree of implicit leverage, which is in the center of our analysis.

The data we employ are of quarterly frequency and cover the period 2002q1-2010q2. The whole data period is divided into two sub-periods: the earlier one (2002q1-2007q2) includes the years before the outbreak of the crisis, which were characterized by stable financial conditions and strong economic expansion. The second period (2007q3-2010q2) refers to the crisis period in which financial turbulence and recession prevailed in the economy. We chose not to examine the years before 2002 for two main reasons. First, the two big financial crises in Asia and Russia at the end of the 90s and -most importantly- the Long Term Capital Management (LTCM) crisis of 1998 exerted a destabilizing effect on the US financial system also affecting the banking industry. Second, no considerable regulatory or other similar reforms have taken place in the US banking environment throughout the examined period, which means that the operation of banks has remained largely unaffected.[8] If this had not been the case, the results concerning banks' leverage behavior might have been biased due to changes in the regulatory structure.[9]

[8] In fact, the latest legislative activity in the US that largely influenced the operation of the banking sector as a whole was the Gramm-Leach-Bliley Act of 1999, which opened up the US financial market allowing commercial and investment banks, securities firms and insurance companies to merge their activities.

[9] It is well established in the banking literature that regulation strongly affects industry structure and alters the behavior of banks in terms of performance and risk-taking (see, e.g., Brissimis et al, 2008).

Regarding our data sources, all bank-specific accounting variables are taken from the FDIC Reports on Condition and Income (Call Reports). To construct the proxy measure for embedded leverage we collect data from the Office of the Comptroller of the Currency (OCC)'s Quarterly Reports on Bank Derivatives Activities. The market interest rates used in the construction of total bank risk are from Thomson Reuters Datastream, whereas the short-term interest rates which are needed for the construction of interest rate risk measure are found on Federal Reserve Board website. Finally, macroeconomic variables are obtained from the Bureau of Economic Analysis of the US Department of Labor.

3.2. Variables definition

We now turn to describe the variables employed in the econometric analysis.[10] The dependent variable of the model is total bank risk-taking (*TOTRISK*). It is calculated as the quarterly standard deviation of each sample bank's daily stock market returns.[11] This metric of risk captures the total volatility of stock market prices for each individual bank incorporating credit risk, interest rate risk, and liquidity risk.

To calculate *TOTRISK*, we first obtain the weekly returns for each individual bank using its stock market prices:

$$R_{iw} = \ln \overline{P}_{iw} - \ln \overline{P}_{iw-1}$$

where R_{iw} denotes the weekly ($w=1, 2, \ldots, W$) stock market returns of bank i ($i=1,2,\ldots, N$), and $\ln \overline{P}_{iw}$ stands for the natural logarithm of the weakly average of bank i's stock market daily price P. Total bank risk is then given by the following formula:

$$\sigma_{iq} = \sqrt{\frac{\sum_{w=1}^{W} (R_{iw} - \overline{R}_{iq})^2}{W-1}}$$

[10] All variables are summarized in Appendix II**,** whereas Appendix III reports summary statistics.

[11] Similar risk measures have been used in the study of Galloway et al. (1997) and more recently in that of Gonzalez (2005).

where σ_{iq} is the quarterly (*q=2002q1, 2002q2,…, 2010q2*) standard deviation of bank *i*'s daily returns and $\overline{R}_{iq}$ is the quarterly average of bank *i*'s weekly returns.

Turning to the right-hand-side variables of the empirical model, we utilize three different ways to measure on-balance sheet leverage. These are: the so-called gross balance sheet leverage ratio that is calculated as the ratio of total assets to the book value of total equity capital (*LEV1*), the inverted Tier 1 leverage ratio (*LEV2*) and, finally, the ratio of total liabilities to book equity capital (*LEV3*). Moreover, two proxies for implicit leverage are employed in our analysis: embedded leverage (*EMBEDLEV*) and off-balance sheet leverage (*OBSLEV*). To measure the former one, we follow Beuer (2002) and use the on-balance sheet asset equivalent component of the exposure implied by off-balance sheet items. This is calculated as the ratio of total notional values of all derivatives outstanding to total regulatory capital comprised by Tier 1 and Tier 2 capital. The numerator stands for the own funds (*i.e.*, equity capital) and borrowed funds (*i.e.*, debt) equivalent bank derivative positions in a replicating portfolio of assets. Put simply, off-balance sheet derivative positions are mapped onto their on-balance sheet equivalents. As an alternative to *EMBEDLEV* we use *OBSLEV*, which is calculated as the nominal value of off-balance sheet liabilities scaled by total equity. To capture leverage of different maturity we use short-term leverage (*SHORTLEV*) that is measured as the ratio of borrowing with a maturity less than one year to total equity as well as long-term leverage (*LONGLEV*) calculated as the sum of other borrowings larger than one year with manadatory convertible securities and subordinated notes and debentures divided by total equity.

The combination of the recent financial stability literature (see, e.g., Berger et al., 2009; Uhde and Heimeshoff, 2009) and the bank risk literature (see, e.g., Gonzalez, 2005) provides us with the basis for the selection of the bank-specific and macroeconomic control variables that are expected to have an effect on risk. Consistently, it is well-established in the latter literature that risky portfolios increase total bank risk exposure thus undermining the stability of the financial system. We thus employ banks' provisions for loan and lease losses divided by total loans (*CREDRISK1*) to control for credit risk and loan-portfolio quality. We also use the ratio of non-accrual loans and lease finance receivables to total loans (*CREDRISK2*) as an alternative measure of credit risk. The quarterly standard deviation of the day-to-day 3-month T-bill rate is used to capture interest rate risk (*INTRISK*). This variable is expected to reveal the interest rate cycle movements that influence the deposit-taking and lending activities of banks. Further, the

ratio of the book value of fixed assets to total assets is incorporated in our regression model to proxy for the ex-ante operating leverage (*OPERLEV*). Indeed, the impact of operating leverage on risk has been found to be analogous to that of the financial leverage, *i.e.*, to play the role of a multiplier to both gains and losses. Additionally, two proxies for possible alterations in the traditional borrowing and lending activities of banks are included in our model as additional control variables. In particular, we proxy banks' asset composition with the ratio of net loans to total assets (*ASSETCOMP*) so as to account for changes in bank lending activity. In order to capture any changes in the traditional funding sources of banks we employ a measure for the composition of bank liabilities, which is calculated as the ratio of demand deposits to total liabilities (*LIABCOMP*). It is widely thought that economic performance has a considerable effect on the demand and supply of banking services. More precisely, high levels of banking activity are generally related to favorable economic conditions. In this context, the macroeconomic environment is largely considered to have an impact on the stability of the financial sector. We thus employ the GDP output gap (*GDP*) to control for variations in economic growth.

3.3. The model

To evaluate the relationship of bank soundness with leverage as well as reverse leverage, we estimate the following panel data model:

$$Y_{iq} = \alpha_{iq} + \sum \beta_k lev_{iq,k} + \sum \gamma_m x_{iq,m} + \varepsilon_{iq}, \quad i = 1, 2\ldots, N=12; \quad q=2002q1, 2002q2,\ldots,Q=2010q2$$

$$k=7 \text{ (the total number of leverage variable measures)}$$

$$m=7 \text{ (the total number of control variables)}$$

where Y_{iq} stands for the risk variables; the vector $lev_{iq,k}$ includes all different measures of leverage described above; $x_{iq,m}$ represents the vector of the bank-specific and macroeconomic control variables; ε_{iq} is the regression error term, whereas the vectors α, β, γ contain the parameters of interest to be estimated.

As parameter estimates from OLS will be biased in case regressors are endogenously determined along with the dependent variable, we estimate the model by means of two-stage least squares (2SLS) instrumental variable regression for the two periods examined. In particular,

one- to three-period lags are used as instruments. To further address the issue of possible endogeneity we also use fixed effects in the instrumental variables regression. Last but not least, we lag some of the control variables to avoid simultaneity.

4. Discussion of the results

The regression results are presented in Tables 1 to 4. More precisely, Tables 1 and 2 report the results for the time period preceding the emergence of the current crisis, whereas Tables 3 and 4 contain the empirical results for the crisis period.

4.1. Pre-crisis period

A positive and statistically significant effect of *LEV1* on total bank risk is reported. Notably, this relationship remains positive and significant even if (any of) the alternative leverage measures (*i.e., LEV2, LEV3*) are utilized. Along the same lines, both *EMBEDLEV* and *OBSLEV* are found to have a significantly positive impact on total bank risk-taking. Overall, these results show that banks which are highly levered (either on- or off-balance sheet) exert higher risk to the system. As regards leverage of different maturity, *SHORTLEV* increases *TOTRISK* while *LONGLEV* has a negative and significant relationship with the dependent variable of the model. In addition, market turmoil as reflected in the increased level of interest rate risk (*INTRISK*) imparts an upward pressure to bank total risk, whereas *GDP* and *OPERLEV* are negatively linked to *TOTRISK*, a finding which is in line with both theoretical and empirical literature (see, e.g., Uhde and Heimeshoff, 2009; Berger et al., 2009).[12]

More interestingly, *ASSETCOMP* has a significantly negative effect on *TOTRISK*. This implies that those banks that were concentrated on traditional bank lending activities before the crisis contributed less to the overall bank risk than those that were entangled with new financial instruments.[13] Evidently, the relationship that holds between the diversification of bank output through the production and release of modern financial items with risk could be either negative or positive. In the former case, there are at least two channels through which product

[12] We also use the quarterly change in the US inflation rate taken by the US Bureau of Labor Statistics to verify that favorable macroeconomic conditions mitigate *TOTRISK*.

[13] The banking literature provides ample empirical evidence on the upsurge in the volume of modern activities of US banking institutions before the crisis (see, e.g., Rogers and Sinkey, 1999; Stiroh, 2004).

diversification leads to a reduction in the overall bank risk-taking. The first is largely related to the conventional wisdom among bank scholars and practitioners and shows that non-interest (fee) income -which is produced by innovative financial assets- is less sensitive to changes in the economic and business environment than interest income -which is produced by traditional assets, like bank loans. This is to say that banks which rely more on the former type of income are typically exposed to less risk as they manage to reduce the cyclical variations in profits and revenue. Turning to the second channel, in case there is a negative or a weak correlation between the above two sorts of income, then -according to the traditional banking and portfolio theories (see, e.g., Diamond, 1984)- any observed increase in the share of fee-generating activities in the overall portfolio of banking items reduces the volatility of total earnings via diversification effects; as a result, risk is again reduced.

Nevertheless, each coin has two sides. In line with our empirical findings, DeYoung and Roland (2001) argue that non-interest income is less stable compared to its interest counterpart, implying that non-traditional activities increase bank riskiness. This happens due to the following three reasons: the nature of bank-customer relationships, input mixes, and lower capital requirements for the fee-generating activities. To start with the first cause, traditional activities like lending generate relatively stable relationships between banks and their customers as switching and information costs for both lenders and borrowers are rather high and hence it is not in the interest of either side to walk away. In contrast, the above-mentioned costs are lower in the case of modern financial activities and this renders the demand for the latter lines of business far from solid and continuous. Accordingly, whereas interest income appears to be rather stable, non-interest income is likely to fluctuate more over time. Second, a bank can extend a lending relationship only with a burden on its variable cost (*i.e.*, interest expense). However, if the bank takes the decision to increase the volume of non-traditional services offered to its customers, it will have to hire additional fixed labor inputs and this will lead to an increase in its operating leverage. A higher operating leverage, in turn, is expected to amplify revenue volatility into higher profit volatility. That is, the involvement in non-traditional activities is again related to a higher degree of risk. Finally, the existing banking regulatory environment, as described in Basel I and II, allows banks to hold just a small amount of capital against fee-based activities in comparison with the amount that they are forced to hold for traditional items and which is much

higher. The differences in capital requirements suggest an enhanced financial leverage that is related with higher earnings volatility for non-traditional activities.

4.2. Crisis period

Let us now turn to the analysis of the regression results for the crisis period. We first show that on-balance sheet leverage (represented by *LEV2*) is positively and significantly related to total bank risk as exactly was the case before the outbreak of the crisis. This finding is verified when we replace *LEV2* with *LEV3* (but not when *LEV1* is used instead). Consistently, the coefficients of both *OBSLEV* and *EMBEDLEV* that stand for implicit leverage are also positive and statistically significant. Interestingly, neither *SHORTLEV* nor *LONGLEV* is found to have any significant relationship with *TOTRISK*. In general, the picture we obtain from these results remains the same with that before the crisis thus throwing further light to the positive link between leverage and bank total risk.

Moreover, total bank risk increases with the low quality of loans and leases offered as is evident from the significantly positive relationship between *CREDRISK1* and *TOTRISK*.[14] Since no similar result is reported in the pre-crisis period, we interpret this last finding as suggesting that the low-quality loans and leases offered by TBTF US banks before the onset of the current crisis put immense pressure on the soundness of the financial system. Consequently, a serious threat to systemic stability is formed by the large number of bad loans that big banks still hold in their portfolios. This suggests that large commercial banks need to focus more on credit risk management, which has proved to be problematic the years before the crisis. Indeed, considerable banking problems have arisen from the failure of banks to recognize impaired assets and create reserves for writing off these assets. Regarding *INTRISK*, it has also a positive sign indicating that total bank risk is higher when the variability of short-term bond rates becomes higher.

Further, if we focus on the liabilities side of banks' balance sheets we could argue that traditional banking activities like deposit-taking reduce total bank risk as *LIABCOMP* is found to be negatively linked with *TOTRISK*. The negative impact of *OPERLEV* on *TOTRISK* that we also report is in line with the latter finding as well as with the DeYoung and Roland (2001) view

[14] An overall negative relationship is confirmed by the use of *CREDRISK2*.

(see above) and, in fact, acts as a complement to the negative relationship between ASSETCOMP and TOTRISK that has been documented in the years before the crisis.

5. Concluding remarks and policy implications

In this paper, we studied how leverage affects risk in the US commercial banking sector. To this aim, we employed a representative panel data set of very large banks that covers both the pre-crisis and the crisis periods and modeled the relationship between total bank risk and various forms of on- and off-balance sheet leverage as well as short- and long-term leverage.

Our formal evidence indicates reliably that leverage contributes to total bank risk thus corroborating the claims towards this end that appear in the relevant literature as well as in the popular press. In specific, we lend support to the view that TBTF commercial banks do not maintain a level of leverage that could allow equity capital to act as a buffer, absorbing losses and enabling the business to continue in case of a financial turmoil. Instead, banks accumulate leverage, both on- and off- balance sheet, forcing the system to either fail or consider large-scale bailouts. From the investors' viewpoint, even the most sophisticated ones may tend to underestimate the overall level of an institution's leverage and hence to undervalue risk, as they are not capable of properly pricing implicit leverage.

To continue, the positive relationship that we document between short-term leverage and risk shows that leverage is one of the main factors responsible for the severe bank liquidity shortages in the pre-crisis era. By largely relying on new financial products before the crisis, banks managed to extend the short-term funding of their medium- and long-term assets. This increased maturity mismatch raising the probability of bank runs and rendering the financial system more fragile. This last finding is verified by the negative link between long-term leverage and bank risk for the period before the crisis. In sum, the direct link between leverage and risk provides the necessary condition to the current debate on stricter bank regulation through the imposition of explicit, non-risk-based leverage ratios as it is the case in Canada for many years now (see Bordeleau et al., 2009).

Lastly, we find quite clearly that those banks that concentrate on traditional banking activities typically carry less risk exposure than those that are involved with new financial instruments. On the asset side of banks' balance sheets, the replacement of traditional loans with tranches of

Asset Backed Securities (ABS), Collateralized Debt Obligations (CDO) and other associated derivatives increases total bank risk regardless of the specific period examined. Although such tranches were often AAA-rated and thus of low risk, the newer assets originated by banks were down-the-quality-curve.[15] Turning to the liability side of the balance sheets, the traditional business of taking deposits from households, which has been relatively declined compared to the non-interest income business, is found to lower total risk. All things considered, the latter findings could play a role in the current discussion about a possible revival of the Glass-Steagall Act.

[15] This was often not taken into serious consideration by rating agencies before the crisis.

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Appendix I: Sample of banks	
1. BANK OF AMERICA NA	7. STATE STREET BANK&TRUST CO
2. JP MORGAN CHASE BANK	8. KEYBANK NATIONAL ASSN
3. CITIBANK NATIONAL ASSN	9. SUNTRUST BANK
4. US BANK NA	10. PNC BANK NATIONAL ASSN
5. WELLS FARGO BANK NA	11. NATIONAL CITY BANK (OH)
6. BANK OF NEW YORK	12. NORTHERN TRUST & CO

Appendix II: Variables			
Variable	**Abbreviation**	**Definition**	**Data source**
Total bank risk	*TOTRISK*	The quarterly standard deviation of each bank's weekly stock market returns	Thomson Datastream
On-balance sheet leverage	*LEV1*	The ratio of total assets to book equity capital	FDIC Reports on Condition and Income
	LEV2	The inverted Tier 1 leverage ratio	
	LEV3	The ratio of total liabilities to book equity capital	
Embedded leverage	*EMBEDLEV*	The ratio of notional amounts of derivatives outstanding to Tier 1 & 2 regulatory capital	OCC Quarterly Report on Bank Derivatives Activities
Off-balance sheet leverage	*OBSLEV*	The ratio of the nominal value of off-balance sheet liabilities to book equity capital	FDIC Reports on Condition and Income
Short-term leverage	*SHORTLEV*	The ratio of short-term borrowing to book equity capital	FDIC Reports on Condition and Income
Long-term leverage	*LONGLEV*	The sum of other borrowings larger than one year with mandatory convertible securities, subordinated notes and debentures divided by book equity capital	FDIC Reports on Condition and Income
Credit risk	*CREDRISK1*	Allowance for loan and lease losses scaled by total loans	FDIC Reports on Condition and Income
	CREDRISK2	The ratio of non-accrual loan and lease finance receivables to total loans	
Interest rate risk	*INTRISK*	The quarterly standard deviation of the day-to-day 3-month T-bill rate	Federal Reserve Board
Operating leverage	*OPERLEV*	The ratio of fixed assets to total assets	FDIC Reports on Condition and Income
Asset composition	*ASSETCOMP*	The ratio of net loans and leases to total assets	FDIC Reports on Condition and Income
Liability Composition	*LIABCOMP*	The ratio of demand deposits to total liabilities	FDIC Reports on Condition and Income
Macroeconomic conditions	*GDP*	GDP output gap	Bureau of Economic Analysis, US Department of Labor

Appendix III: Summary statistics

Variable	Mean	Median	Max	Min	Std. Dev.	No of obs
Panel A						
TOTRISK	1.39	1.31	3.59	0.34	0.72	263
LEV1	11.67	11.74	18.64	9.01	2.13	261
LEV2	0.11	0.10	0.38	0.02	0.05	262
LEV3	1.02	0.98	1.20	0.80	0.04	263
EMBEDLEV	192.08	38.07	28754.91	2.75	1198.96	260
OBSLEV	0.10	0.01	4.87	0.01	0.49	260
SHORTLEV	4.88	4.93	12.84	1.44	1.80	256
LONGLEV	3.71	3.67	11.03	1.12	2.08	259
CREDRISK1	0.02	0.02	0.04	0.00	0.00	261
CREDRISK2	0.01	0.01	0.03	0.00	0.00	257
INTRISK	0.11	0.10	0.21	0.02	0.04	258
OPERLEV	0.01	0.01	0.03	0.00	0.00	260
ASSETCOMP	0.57	0.55	0.84	0.05	0.19	258
LIABCOMP	0.07	0.07	0.20	0.01	0.04	263
GDP	10.87	10.81	10.12	10.05	0.03	263
Panel B						
TOTRISK	3.27	3.02	9.78	0.41	1.98	131
LEV1	12.55	12.51	25.54	3.30	2.86	129
LEV2	0.12	0.11	0.35	0.01	0.07	129
LEV3	1.12	1.10	1.78	0.72	0.06	130
EMBEDLEV	119.43	34.70	902.01	4.98	170.21	130
OBSLEV	0.05	0.05	4.10	0.00	0.32	127
SHORTLEV	3.25	2.45	13.98	0.18	2.34	129
LONGLEV	2.26	2.01	11.97	0.12	1.76	128
CREDRISK1	0.01	0.01	0.04	0.00	0.01	131
CREDRISK2	0.02	0.02	0.06	0.00	0.01	130
INTRISK	0.29	0.28	0.73	0.02	0.24	131
OPERLEV	0.01	0.01	0.03	0.00	0.00	130
ASSETCOMP	0.58	0.57	0.79	0.05	0.19	127
LIABCOMP	0.06	0.06	0.27	0.00	0.05	128
GDP	10.14	10.13	10.15	10.12	0.00	131

This Appendix reports the summary statistics for all regression variables used in the empirical analysis. Panel A relies on data from 2002q1 to 2007q2. In Panel B we use data over the period 2007q3-2010q2.

Table 1

Variable	Coefficient	t-statistic
constant	3.49***	2.59
LEV1	2.54***	4.78
EMBEDLEV	1.67**	1.85
SHORTLEV	3.89**	1.79
LONGLEV	-1.54**	-1.91
CREDRISK1	0.78	0.99
INTRISK	0.36**	1.69
OPERLEV	-1.23***	-4.24
ASSETCOMP	-3.54**	-1.84
LIABCOMP	0.43	0.56
GDP	-6.82***	-4.78

Regression results for the pre-crisis period (2002q1-2007q2). The dependent variable is total bank risk (*TOTRISK*). As independent variables we include on-balance sheet leverage (*LEV1*), embedded leverage (*EMBEDLEV*), short-term leverage (*SHORTLEV*), long-term leverage (*LONGLEV*), credit risk (*CREDRISK1*), interest rate risk (*INTRISK*), operating leverage (*OPERLEV*), banks' asset composition (*ASSETCOMP*), banks' liabilities composition (*LIABCOMP*), and the level of economic development (*GDP*).
***, **, * correspond to 1%, 5%, and 10% level of significance respectively for a two-tailed distribution.

Table 2

Variable	Coefficient	t-statistic
constant	3.76***	1.85
LEV2	2.50***	2.75
OBSLEV	2.43**	1.92
SHORTLEV	4.11**	1.88
LONGLEV	-1.56**	-1.78
CREDRISK2	0.65	0.64
INTRISK	3.65***	2.87
OPERLEV	-2.85**	-1.84
ASSETCOMP	-3.32**	-1.81
LIABCOMP	-0.23*	-1.45
GDP	-10.47***	-6.23

Regression results for the pre-crisis period (2002q1-2007q2). The dependent variable is total bank risk (*TOTRISK*). As independent variables we include on-balance sheet leverage (*LEV2*), off-balance sheet leverage (*OBSLEV*), short-term leverage (*SHORTLEV*), long-term leverage (*LONGLEV*), credit risk (*CREDRISK2*), interest rate risk (*INTRISK*), operating leverage (*OPERLEV*), banks' asset composition (*ASSETCOMP*), banks' liabilities composition (*LIABCOMP*), and the level of economic development (*GDP*).
***, **, * correspond to 1%, 5%, and 10% level of significance respectively for a two-tailed distribution.

Table 3

Variable	Coefficient	t-statistic
constant	10.13*	1.64
LEV2	5.67***	3.87
EMBEDLEV	4.76**	1.81
SHORTLEV	0.20*	1.73
LONGLEV	0.17	0.23
CREDRISK1	5.17***	3.78
INTRISK	4.76***	2.88
OPERLEV	-8.98***	-6.90
ASSETCOMP	-0.03	-0.61
LIABCOMP	-5.01***	-4.79
GDP	4.74**	2.98

Regression results for the crisis period (2007q3-2010q2). The dependent variable is total bank risk (*TOTRISK*). As independent variables we include on-balance sheet leverage (*LEV2*), embedded bank leverage (*EMBEDLEV*), short-term leverage (*SHORTLEV*), long-term leverage (*LONGLEV*), credit risk (*CREDRISK1*), interest rate risk (*INTRISK*), operating leverage (*OPERLEV)*, banks' asset composition (*ASSETCOMP*), banks' liabilities composition (*LIABCOMP*), and the level of economic development (*GDP*). ***, **, * correspond to 1%, 5%, and 10% level of significance respectively for a two-tailed distribution.

Table 4

Variable	Coefficient	t-statistic
constant	5.98**	1.92
LEV3	6.11***	4.87
OBSLEV	9.85***	4.30
SHORTLEV	-0.10	-0.70
LONGLEV	0.75	0.12
CREDRISK2	7.24***	4.75
INTRISK	3.78***	2.61
OPERLEV	-2.32***	-3.97
ASSETCOMP	-0.14	1.23
LIABCOMP	-3.63***	-3.87
GDP	8.31***	3.21

Regression results for the crisis period (2007q3-2010q2). The dependent variable is total bank risk (*TOTRISK*). As independent variables we include on-balance sheet leverage (*LEV3*), off-balance sheet leverage (*OBSLEV*), short-term leverage (*SHORTLEV*), long-term leverage (*LONGLEV*), credit risk (*CREDRISK2*), interest rate risk (*INTRISK*), operating leverage (*OPERLEV*), banks' asset composition (*ASSETCOMP*), banks' liabilities composition (*LIABCOMP*), and the level of economic development (*GDP*).
***, **, * correspond to 1%, 5%, and 10% level of significance respectively for a two-tailed distribution.