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

by

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Abstract

In this paper we study the relationship between leverage and risk in US commercial banking market. We employ a representative panel data set of systemically important banks that extends from 2002 to 2009 thus covering both the years before the outbreak of the current financial crisis and those that followed. Several alternative variables are used to capture both on- and off-balance-sheet leverage as well as short-term leverage. Regarding risk, it is proxied by two measures: the systemic risk potential and banks' overall risk. Our findings indicate reliably that both on- and off-balance-sheet leverage contributes to (systemic) risk, which implies that large banks do not maintain a level of leverage that could allow for equity capital to act fully as a buffer, absorbing losses and enabling the business to continue in case of financial distress. In a similar vein, a direct link between short-term leverage and risk is reported, showing that leverage is one of the main factors responsible for the serious bank liquidity shortages that were revealed in the current crisis. We also find that those banks that concentrate on traditional banking activities typically carry less risk exposure than those that are involved with new financial instruments. The latter finding could play a role in the current discussion about a possible revival of the Glass-Steagall Act. Overall, our results provide a better understanding of the main causes of the present crisis and contribute to the discussion on the reinforcement of the existing regulatory framework.

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1. Introduction

The stability and the resilience of the global financial system has been seriously tested for more than two years now. The current crisis, whose origins can be traced in the collapsing valuations in the US sub-prime mortgage market in mid-2007, has revealed several systemic inadequacies which are strongly related to the mal-functioning of the banking sector. An important aspect of these inadequacies is the extent of bank leverage in the years before the crisis.

Bank leverage, in the standard context, refers to the use of debt (*i.e.,* borrowings) in financing investments. More specifically, a loan is used to supplement bank equity capital in financing an investment project, which is expected to produce a higher rate of return compared to the interest rate paid. In case the investment return rate turns out to be smaller than anticipated, a bank's equity will shrink and might become insufficient to repay the loan. All in all, leverage maps the riskiness of an asset position into the corresponding riskiness of its on-balance-sheet equity stake.

Leverage, however, can also be traced *off* the balance sheet. Indeed, commercial banks are eligible to transfer some part of their leverage off their balance sheets through securitization and other modern financial activities.[1] In the years that preceded 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 had been transferring their assets together with their risk.[2] As a result, conduits and SIVs contained a significant degree of leverage, known as embedded or implicit leverage. Embedded leverage was thus achieved through the structuring of the financial instruments themselves. 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 Basle I and were funded mostly by rolling over commercial paper and only by very little equity capital. Hence banks were able to

[1] An additional advantage of securitization is that it generates fee income. Since fees do not have to be returned in case the securities later suffer great losses, commercial banks have a great incentive to engage in securitized activities thus leveraging even more their positions.

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

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. However, 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 had to take 'bad' assets back on their books in the light of the crisis.

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. Indeed, following 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. Reverse leverage 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 cut in cash flows can exert reverse leverage effects on the system. In the current crisis, the trigger for the de-leveraging 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

[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.

steps to strengthen their capital base in order to provide support to their assets. As a result, credit supply was sharply fallen, which negatively affected the whole economic activity.

Although the role that leverage plays with regard to 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 leverage in the propagation of a financial crisis. Moreover, little attention has been paid to the *overall* leverage behavior of financial institutions. Indeed, the importance of commercial banks' off-balance-sheet leverage in today's financial crisis has been rather neglected in the extant literature. In the current study we make an attempt to fill this void by assessing the effect of bank leverage on the soundness of the financial system. More concretely, we investigate empirically the overall leverage-taking behavior of US 'too-big-to-fail' commercial banks before and after 2007, when the crisis erupted, and to what extent leverage affected the stability of the financial system.

Our focus on commercial banks allows us not only to distinguish on-balance-sheet from off-balance-sheet leverage, but also short- from long-term leverage. Short-term (wholesale) debt via the rolling out of conduits and SIVs has been relatively cheap for commercial banks compared to long-term debt. Indeed, the costs of banks of holding much illiquid capital were 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 often 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 a proxy measure for bank short-term leverage.

An additional reason that makes the focus on commercial banking of particular interest is that the latter sector is fairly regulated not only in general terms but especially in terms of capital requirements. This is in sharp contrast to 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. This implies that the latter type of institutions face no serious restrictions on the level of

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

leverage. Hence, an issue that we deal with here is whether the existing capital restrictions are adequate to mitigate an undesirable increase in commercial banks' level of leverage.

Our sample consists of quarterly data for the largest US commercial banks and extends from 2002q1 to 2009q3. The whole data period is divided into two time segments where the cut-off point is defined by the outbreak of the crisis. Several alternative leverage measures are employed in the regression analysis to test whether and to what degree banks accumulated leverage not only on- but also off- their balance sheets and how this affected their risk profile. Risk is captured with two different proxies: one for the health of the systemically important sample banks which indicates the likelihood of the occurrence of systemic risk events, and a second for total bank risk-taking which relies on the overall variability of the individual banks' stock market prices. The former risk measure is constructed with accounting data and is thus backward-looking, whereas the latter is a pure market measure of risk and as such it tends to be forward-looking. Last, several control variables that the literature has reported to affect risk are employed in our regression model.

Our findings reveal, among other things, that both on- and off-balance-sheet leverage contribute to systemic risk potential and to banks' overall risk. By the same token, we find that short-term leverage is directly linked to the two measures of risk we use in our empirical analysis. Importantly, banks that concentrate on traditional banking activities of taking deposits from households and making loans to agents that require capital are found to carry less risk exposure than those that are involved with new financial instruments. Overall, our results provide a better understanding of the main causes of the current crisis and contribute to the discussion on the reinforcement of the current regulatory framework.

The remainder of the paper proceeds in the following way. Section 2 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 3 discusses the empirical findings, whereas their corresponding policy implications along with the concluding remarks are presented in Section 4.

2. Empirical analysis

2.1. Data

Our empirical analysis is based on a data set that consists of the 17 largest US commercial banks as reported by the Federal Reserve Board (the bank names can be found in Appendix I).[5] The banks that are examined are representative of the population of the large US commercial banks as they possess about 60% of the total assets.[6]

There are at least two reasons why we decide to include large and not small or mid-sized commercial banks in our sample. First, large 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 Stiroh, 2003) has showed that large banks are very prone to universal banking activities in contrast to small and medium-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 current study, is expected to be more apparent for a sample consisting exclusively of the largest banks. A second reason is that the sample banks are regarded as 'too-big-to-fail' 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 17 largest commercial banks that comprise our data sample provide the bulk of financing to industry and households in US, meaning that, if any one 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.

It is important at this point to also justify why we focus our research on the US and not on some other banking system. The first reason is that the present 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

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[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 of 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 192 as of the end of February 2010 according to the relevant FDIC list) is ranked among the first one hundred large commercial banks.

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 most large European banks follow is somewhat less opaque on this issue as they require from banking institutions to keep records of this kind of activities *on* their balance sheets. Therefore, US commercial banks have an additional incentive to undertake a higher degree of implicit leverage.

The data we employ are of quarterly frequency and cover the period 2002q1-2009q3. The whole 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 (2007q3-2009q3) refers to the crisis period in which financial turbulence and economic recession prevailed. We chose not to examine the years before 2002 for the following reasons. First, the two big financial crises in Asia and Russia at the end of the 90s, but most importantly the Long Term Capital Management (LTCM) crisis of 1998 partly destabilized the US financial system also affecting the operation of banks until the beginning of the 00s. And second, no considerable regulatory or other similar changes have taken place in the US banking environment during the examined period, which could have affected the behavior of banks.[8]

Regarding our data sources, all the 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.

[8] In fact, the latest legislative activity in the US that largely influenced the operation of the banking industry 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.

2.2. Variables definition

We now turn to describe the variables employed in the econometric analysis. All variables are summarized in Appendix II**,** whereas Appendix III reports summary statistics.

2.2.1. Dependent variables

We employ two measures of risk as dependent variables: the systemic risk potential and total bank risk. To proxy for systemic risk potential (*SYSTRISK*), we construct an index of the joint insolvency risk of all sample banking institutions following De Nicolo et al. (2004). This index relies upon Altman's Z-score and is calculated as follows:

$$Z_q = \frac{(\overline{ROA}_{iq} + \overline{TE_{iq} / TA_{iq}})}{\sigma(ROA_{iq})}, \qquad i = 1, 2..., N=17;\ q=2002q1, 2002q2,...,Q=2009q3$$

where $\overline{ROA}_{it}$ stands for the period average Return On Assets calculated by the mean ratio of net income to total assets (TA_{iq}); $(\overline{TE_{iq} / TA_{iq}})$ is the mean average of total equity to total assets; and $\sigma(ROA_{iq})$ is the period standard deviation of ROA that captures the volatility of returns. Hence, *Z*-index combines profitability, capital risk, and return volatility in a single measure. Evidently, the index is increasing in banks' average profitability and capital strength and decreasing in return variability. Overall, larger values of the *Z*-index imply lower systemic risk potential and thus greater financial soundness.

Our second measure of risk represents total bank risk-taking (*TOTRISK*) and is calculated as the quarterly standard deviation of each sample bank's weekly stock market returns.[9] 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.[10]

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

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

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

[10] The shares of five sample banks are not actively traded on the stock market. This means that, in the regression model in which *TOTRISK* is employed as the dependent variable, 12 out of the 17 banks are utilized in total.

where R_{iw} denotes the weekly (*w=1, 2, …, W*) stock market returns of bank *i* (*i=1,2,…, 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:

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

where σ_{iq} is the quarterly (*q=2002q1, 2002q2,…, 2009q3*) standard deviation of bank *i*'s weekly returns and $\overline{R}_{iq}$ is the quarterly average of bank *i*'s weekly returns.

2.2.2. Regressors

2.2.2.1. Leverage measures

We measure on-balance-sheet leverage with three different metrics. In particular, we use the so-called gross balance sheet leverage ratio that is calculated as the ratio of total assets to total book equity capital (*LEV1*), as well as the debt-to-equity ratio that is expressed either as the ratio of total borrowed funds to total assets (*LEV2*), or, in a broader way, as the ratio of total liabilities to total assets (*LEV3*). To measure embedded leverage (*EMBEDLEV*), we follow Beuer (2002) and utilize 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, in the regressions that follow later in the paper, we also use a measure of off-balance-sheet leverage (*OBSLEV*) given by the nominal value of off-balance-sheet liabilities scaled by total assets. Finally, short-term leverage (*SHORTLEV*) is measured as the ratio of short-term assets to total assets.

2.2.2.2. Control variables

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.

Since it is well-established in the banking literature that risky portfolios increase total bank risk exposure undermining the stability of the financial system, we 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. Moreover, two proxies for possible alterations in the traditional borrowing and lending bank activities are also included in our model as additional control variables. We use banks' asset composition measured as the ratio of net loans to total assets (*ASSETCOMP*) to account for changes in bank lending activity. To capture changes in the traditional funding sources of banks, we employ a proxy measure for the composition of bank liabilities, which is the ratio of demand deposits to total liabilities (*LIABCOMP*).

Economic performance is widely thought to affect 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 natural log value of GDP (*LGDP*) to control for variations in economic growth.

2.2.3. The model

In order to evaluate the relationship between leverage and risk, we estimate the following panel data model:

$$Y_{iq} = \alpha_{iq} + \sum \beta_k lev_{iq,k} + \sum \gamma_m x_{iq,m} + \varepsilon_{iq}, \quad i = 1, 2..., N=17; \quad q=2002q1, 2002q2,...,Q=2009q3$$

$$k=6 \text{ (the total number of leverage variable measures)}$$

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

where Y_{iq} stands for the risk variables;[11] 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 mentioned earlier, the model is run using OLS for the two periods examined. Possible endogeneity bias is resolved by the use of fixed effects and instrumental variables.

3. Discussion of the results

The regression results are presented in Tables 1 to 8. More precisely, Tables 1-4 report the results for the time period that precedes the emergence of the current crisis, whereas Tables 5-8 contain the empirical results for the crisis period.

3.1. Pre-crisis period

The results in Tables 1 and 2 refer to the regressions where the *Z*-index is employed as the dependent variable. A negative and statistically significant relationship between *SHORTLEV* and *Z* is documented, which implies that short-term leverage increases systemic risk potential. However, the coefficients on the rest of the leverage variables are not statistically significant revealing that on-balance-sheet leverage as well as *EMBEDLEV* (Table 1) and *OBSLEV* (Table 2) do not significantly affect systemic risk. Moreover, market turmoil as reflected in the increased level of interest rate risk (*INTRISK*) increases systemic risk. As regards the log of *GDP*, it is positively linked to *Z*-index. In fact, a number of theoretical and empirical studies

[11] When the dependent variable is the *Z*-index, the subscript *i* is omitted since *Z* is calculated on a mean average basis.

have reached the same conclusion (see, e.g., Uhde and Heimeshoff, 2009; Berger et al., 2009).[12] It is noteworthy that the use of *LEV2* or *LEV3* in the place of *LEV1* as well as *CREDRISK2* instead of *CREDRISK1* further reinforces the above findings.

When *TOTRISK* is used as the regressand of the model (see Tables 3 and 4), 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, *OBSLEV* is found to have a significantly positive effect on total bank risk-taking. Overall, these results show that banks which are highly levered (either on- or off-balance sheet) exert higher risk. Neither *EMBEDLEV*, nor *SHORTLEV* are found to significantly affect *TOTRISK*. In spite of these non-significant effects, the positive link between leverage and individual bank risk-taking is dominant. Moreover, total bank risk increases with the low quality of loans and leases offered as is evident from the significantly negative relationship between *CREDRISK1* and *TOTRISK*.[13] 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.

Economic performance, as measured by *LGDP*, is found to reduce total bank risk as was the case when *SYSTEMRISK* was used as the dependent variable of the model. More interestingly, *ASSETCOMP* exerts a significantly negative effect on *TOTRISK*. This means that those banks that concentrate on traditional banking activities are in a better position in terms of their overall risk exposure than those that are involved with new financial instruments. In general, the relationship between bank product diversification and risk could be negative, but also positive. There are two channels through which output diversification leads to a reduction in overall bank risk-taking. The first is related to the conventional wisdom among bank scholars and practitioners and shows that non-interest (fee) income is less sensitive to changes in the economic and business environment than interest income. This is to say that banks that rely more on the former type of income are 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

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

weak correlation between the 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.

Each coin has two sides. 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 is 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 one, traditional activities like lending generate relatively stable relationships between banks and their customers as switching and information costs for both lenders and borrowers are high and hence it is not in the interest of either side to walk away. In contrast, these 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, which leads to an increase in its operating leverage. A higher operating leverage, in turn, amplifies revenue volatility into higher profit volatility. Again, the involvement in non-traditional activities is related to a higher degree of risk. Finally, the existing banking regulations allow 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. The differences in capital requirements suggest an enhanced financial leverage, which is related with higher earnings volatility for non-traditional activities, which is perfectly in line with the current empirical findings.

3.2. Crisis period

Let us now turn to the analysis of the regression results for the crisis period. Interestingly, none of the leverage variables has a significant effect on *Z*-index (see Tables 5 and 6). This resembles the rather weak link between bank leverage and systemic risk potential that was reported in the pre-crisis period (see above). A significantly negative relation between credit risk (both *CREDRISK1* and *CREDRISK2*) and *Z* is found, which indicates that credit risk increases

systemic risk. Since no similar result is reported before the onset of the crisis, we interpret the present result as suggesting that the low-quality loans and leases offered by large US commercial banks before 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. Regarding *INTRISK*, it also has a negative sign indicating that the systemic risk potential is higher when the variability of short-term bond rates increases. A traditional banking focus on the liabilities side of banks' balance sheets reduces the likelihood of systemic risk since *LIABCOMP* is positively linked with *Z*, whereas economic growth is again found to boost the resilience of the financial system.

In case *TOTRISK* is employed as the dependent variable in our analysis (see Tables 7 and 8), we find that on-balance-sheet leverage (represented by *LEV3*) is positively and significantly related to total bank risk. This is verified when we replace *LEV3* with *LEV2* (but not when *LEV1* is used instead). In the same context, *SHORTLEV* and *OBSLEV* are found to increase total bank risk, whereas the coefficient of *EMBEDLEV* is not statistically significant. In sum, the negative influence of the degree of leverage on total bank risk that was documented before the crisis is corroborated in the crisis period. Furthermore, operating leverage has a negative effect on *TOTRISK*; this result provides strong support to the analysis previously made. Paradoxically, macroeconomic conditions do not seem to have a statistically significant effect on *TOTRISK*.

4. Concluding remarks and policy implications

We studied how leverage affects risk in the US commercial banking sector. Employing a representative panel data set of large banks that covers both the pre-crisis and crisis periods we model the relationship between (systemic) risk and various forms of on- and off-balance sheet leverage as well as short-term leverage

Our formal evidence indicates reliably that leverage contributes to systemic risk potential and to banks' overall risk. Thus, we corroborate the many claims to this end that appeared in the popular press. Indeed, we lend support to the view that systemically important 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 the off-balance-sheet leverage. Moreover, 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 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 the maturity mismatch raising the probability of bank runs and rendering the financial system more fragile. In sum, the direct link between leverage and (systemic) risk provides the necessary condition to the current discussions on further leverage regulation through the imposition of stricter leverage ratios.

We also 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.[14] 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 both measures of risk used in our analysis regardless of the specific period examined. Although such tranches were often AAA-rated and thus apparently 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 non-interest income business, is found to lower systemic risk potential. All things considered, these findings could play a role in the current discussion about a possible revival of the Glass-Steagall Act.

[14] 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).
[15] The latter side of things was often not taken into serious consideration by the rating agencies before the crisis.

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Appendix I: Sample of banks	
1. BANK OF AMERICA NA	10. SUNTRUST BANK
2. JP MORGAN CHASE BANK	11. PNC BANK NATIONAL ASSN
3. CITIBANK NATIONAL ASSN	12. WACHOVIA BANK NATIONAL ASSN
4. US BANK NA	13. NATIONAL CITY BANK (OH)
5. WELLS FARGO BANK NA	14. LASALLE BANK NATIONAL ASSN
6. BANK OF NEW YORK	15. MELLON BANK NATIONAL ASSN
7. HSBC BANK USA	16. FIRST TENNESSE BANK NAT ASSN
8. STATE STREET BANK&TRUST CO	17. NORTHERN TRUST & CO
9. KEYBANK NATIONAL ASSN	

Appendix II: Variables			
Variable	**Abbreviation**	**Definition**	**Data source**
Systemic Risk Potential	*SYSTRISK*	The sum of returns on assets and book equity ratio divided by the standard deviation of returns of assets	FDIC Reports on Condition and Income
Total bank risk	*TOTRISK*	The quarterly standard deviation of each sample bank's weekly stock market returns	Thomson Datastream
On-balance sheet leverage	*LEV1*	The ratio of total assets to book value of total equity	FDIC Reports on Condition and Income
	LEV2	The ratio of borrowed funds to total assets	
	LEV3	The ratio of total liabilities to total assets	
Embedded leverage	*EMBEDLEV*	The ratio of notional amounts of all 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 total assets	FDIC Reports on Condition and Income
Short-term leverage	*SHORTLEV*	The ratio of short-term assets to total assets	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	*LGDP*	The natural logarithm of GDP	Bureau of Economic Analysis, US Department of Labor

Appendix III: Summary statistics

Variable	Mean	Median	Max	Min	Std. Dev.	No of obs
Panel A						
Z-index	6001.91	5009.53	15378.32	2181.80	3372.73	373
TOTRISK	1.48	1.33	4.24	0.30	0.78	263
LEV1	12.53	12.57	17.58	8.41	1.98	372
LEV2	0.08	0.07	0.32	0.00	0.06	372
LEV3	0.89	0.89	0.94	0.83	0.02	372
EMBEDLEV	187.31	36.95	29193.20	1.56	1527.78	367
OBSLEV	0.12	0.00	4.27	0.00	0.50	284
SHORTLEV	3.25	2.62	11.06	0.93	2.10	236
CREDRISK1	0.01	0.01	0.03	0.00	0.00	372
CREDRISK2	0.01	0.01	0.02	0.00	0.00	351
INTRISK	0.09	0.09	0.19	0.02	0.05	372
OPERLEV	0.01	0.01	0.02	0.00	0.00	372
ASSETCOMP	0.53	0.57	0.85	0.05	0.20	372
LIABCOMP	0.07	0.07	0.21	0.00	0.04	372
LGDP	10.09	10.09	10.12	10.06	0.02	372
Panel B						
Z-index	2602.48	1896.08	5239.75	1234.25	1414.03	153
TOTRISK	3.30	2.89	10.06	0.37	1.84	108
LEV1	11.31	11.23	23.97	3.30	3.12	149
LEV2	0.10	0.09	0.31	0.00	0.06	144
LEV3	0.87	0.88	0.95	0.69	0.04	149
EMBEDLEV	124.19	38.38	846.99	3.75	181.08	138
OBSLEV	0.04	0.04	3.25	0.00	0.29	127
SHORTLEV	3.23	2.42	12.49	0.18	2.46	149
CREDRISK1	0.02	0.02	0.05	0.00	0.01	149
CREDRISK2	0.02	0.02	0.06	0.00	0.01	141
INTRISK	0.31	0.33	0.69	0.03	0.22	153
OPERLEV	0.01	0.01	0.03	0.00	0.00	149
ASSETCOMP	0.52	0.55	0.82	0.05	0.21	149
LIABCOMP	0.06	0.06	0.24	0.00	0.04	149
LGDP	10.12	10.12	10.13	10.11	0.00	153

This Appendix reports the summary statistics for all regression variables used in the present paper. Panel A relies on data from 2002q1 to 2007q2. In Panel B we use data over the period 2007q3-2009q3.

Table 1

Variable	Coefficient	t-statistic
constant	-573252.60***	-5.25
LEV1	31.82	0.32
EMBEDLEV	-0.11	-1.00
SHORTLEV	-164.89**	-1.91
CREDRISK1	-7340.21	-0.19
INTRISK	-10570.64***	-3.26
ASSETCOMP	-418.75	-0.44
LIABCOMP	-1836.34	-0.37
LGDP	57542.21***	5.35

Regression results for the pre-crisis period (2002q1-2007q2). The dependent variable is the systemic risk potential (*Z*-index). As independent variables we include on-balance-sheet leverage (*LEV1*), embedded bank leverage (*EMBEDLEV*), short-term leverage (*SHORTLEV*), allowance for loan and lease losses scaled by total loans (*CREDRISK1*), interest rate risk (*INTRISK*), banks' asset composition (*ASSETCOMP*), banks' liabilities composition (*LIABCOMP*), and the level of economic development (*LGDP*). The number of total (unbalanced) observations is 372.
***, **, * correspond to 1%, 5%, and 10% level of significance respectively for a two-tailed distribution.

Table 2

Variable	Coefficient	t-statistic
constant	-560924.20***	-4.85
LEV1	20.59	0.20
OBSLEV	131.42	0.29
SHORTLEV	-160.33*	-1.84
CREDRISK1	-8022.71	-0.21
INTRISK	-10381.86***	-3.20
ASSETCOMP	-358.57	-0.35
LIABCOMP	-2724.64	-0.51
LGDP	56332.48***	4.99

Regression results for the pre-crisis period (2002q1-2007q2). The dependent variable is the systemic risk potential (*Z*-index). As independent variables we include on-balance-sheet leverage (*LEV1*), off-balance-sheet leverage (*OBSLEV*), short-term leverage (*SHORTLEV*), allowance for loan and lease losses scaled by total loans (*CREDRISK1*), interest rate risk (*INTRISK*), banks' asset composition (*ASSETCOMP*), banks' liabilities composition (*LIABCOMP*), and the level of economic development (*LGDP*). The number of total (unbalanced) observations is 372.
***, **, * correspond to 1%, 5%, and 10% level of significance respectively for a two-tailed distribution.

Table 3

Variable	Coefficient	t-statistic
constant	120.49***	3.83
LEV1	0.07***	2.76
EMBEDLEV	0.00	-0.96
SHORTLEV	-0.02	-0.78
CREDRISK1	20.24*	1.86
INTRISK	0.36	0.42
ASSETCOMP	-0.86***	-3.04
LIABCOMP	1.50	0.95
LGDP	-11.82***	-3.80

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 bank leverage (*EMBEDLEV*), short-term leverage (*SHORTLEV*), allowance for loan and lease losses scaled by total loans (*CREDRISK1*), interest rate risk (*INTRISK*), banks' asset composition (*ASSETCOMP*), banks' liabilities composition (*LIABCOMP*), and the level of economic development (*LGDP*). The number of total (unbalanced) observations is 263.
***, **, * correspond to 1%, 5%, and 10% level of significance respectively for a two-tailed distribution.

Table 4

Variable	Coefficient	t-statistic
constant	158.25***	5.37
LEV2	1.52*	1.79
OBSLEV	3.57*	1.84
SHORTLEV	-0.00	-0.09
CREDRISK1	21.07**	2.01
INTRISK	0.37	0.43
ASSETCOMP	-1.04***	-3.49
LIABCOMP	0.32	0.22
LGDP	-15.47***	-5.30

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*), allowance for loan and lease losses scaled by total loans (*CREDRISK1*), interest rate risk (*INTRISK*), banks' asset composition (*ASSETCOMP*), banks' liabilities composition (*LIABCOMP*), and the level of economic development (*LGDP*). The number of total (unbalanced) observations is 263.

***, **, * correspond to 1%, 5%, and 10% level of significance respectively for a two-tailed distribution.

Table 5

Variable	Coefficient	t-statistic
constant	2036713.00***	8.28
LEV1	-54.12	-1.10
EMBEDLEV	0.24	0.39
SHORTLEV	14.05	0.21
CREDRISK1	-23800.45*	-1.92
INTRISK	-7551.71***	-10.57
OPERLEV	-28441.01	-1.27
ASSETCOMP	245.20	0.38
LIABCOMP	4819.29*	1.82
LGDP	201085.50***	8.27

Regression results for the crisis period (2007q3-2009q3). The dependent variable is the systemic risk potential (*Z*-index). As independent variables we include on-balance-sheet leverage (*LEV1*), embedded bank leverage (*EMBEDLEV*), short-term leverage (*SHORTLEV*), allowance for loan and lease losses scaled by total loans (*CREDRISK1*), interest rate risk (*INTRISK*), banks' asset composition (*ASSETCOMP*), banks' liabilities composition (*LIABCOMP*), and the level of economic development (*LGDP*). The number of total (unbalanced) observations is 149.
***, **, * correspond to 1%, 5%, and 10% level of significance respectively for a two-tailed distribution.

Table 6

Variable	Coefficient	t-statistic
constant	2035953.00***	8.31
LEV1	-45.35	-0.94
OBSLEV	268.84	0.79
SHORTLEV	9.79	0.16
CREDRISK1	-23337.17**	-1.98
INTRISK	-7515.75***	-10.52
OPERLEV	-29766.93	-1.33
ASSETCOMP	258.15	0.44
LIABCOMP	5092.77**	1.98
LGDP	201014.80***	8.30

Regression results for the crisis period (2007q3-2009q3). The dependent variable is the systemic risk potential (*Z*-index). As independent variables we include on-balance-sheet leverage (*LEV1*), embedded bank leverage (*EMBEDLEV*), short-term leverage (*SHORTLEV*), allowance for loan and lease losses scaled by total loans (*CREDRISK1*), interest rate risk (*INTRISK*), banks' asset composition (*ASSETCOMP*), banks' liabilities composition (*LIABCOMP*), and the level of economic development (*LGDP*). The number of total (unbalanced) observations is 149.
***, **, * correspond to 1%, 5%, and 10% level of significance respectively for a two-tailed distribution.

Table 7

Variable	Coefficient	t-statistic
constant	-490.13	-0.95
LEV3	57.64***	2.51
EMBEDLEV	-0.00	-0.92
SHORTLEV	0.20*	1.73
CREDRISK2	5.17	0.23
INTRISK	-1.30	-0.88
OPERLEV	-330.26***	-2.70
ASSETCOMP	-0.12	-0.08
LIABCOMP	-1.17	-0.23
LGDP	43.58	0.86

Regression results for the crisis period (2007q3-2009q3). The dependent variable is total bank risk (*TOTRISK*). As independent variables we include on-balance-sheet leverage (*LEV3*), embedded bank leverage (*EMBEDLEV*), short-term leverage (*SHORTLEV*), the ratio of non-accrual loan and lease finance receivables to total loans (*CREDRISK2*), interest rate risk (*INTRISK*), banks' asset composition (*ASSETCOMP*), banks' liabilities composition (*LIABCOMP*), and the level of economic development (*LGDP*). The number of total (unbalanced) observations is 108.
***, **, * correspond to 1%, 5%, and 10% level of significance respectively for a two-tailed distribution.

Table 8

Variable	Coefficient	t-statistic
constant	-459.98	-0.92
LEV3	69.11**	2.92
OBSLEV	16.76*	1.92
SHORTLEV	-0.10	-0.90
CREDRISK2	9.20	0.43
INTRISK	-1.46	-1.00
OPERLEV	-420.05***	-3.42
ASSETCOMP	2.64	1.36
LIABCOMP	0.86	0.17
LGDP	39.31	0.79

Regression results for the crisis period (2007q3-2009q3). The dependent variable is total bank risk (*TOTRISK*). As independent variables we include on-balance-sheet leverage (*LEV3*), off-balance-sheet leverage OBS*LEV*), short-term leverage (*SHORTLEV*), the ratio of non-accrual loan and lease finance receivables to total loans (*CREDRISK2*), interest rate risk (*INTRISK*), banks' asset composition (*ASSETCOMP*), banks' liabilities composition (*LIABCOMP*), and the level of economic development (*LGDP*). The number of total (unbalanced) observations is 108.

***, **, * correspond to 1%, 5%, and 10% level of significance respectively for a two-tailed distribution.