The Funding of Subsidiaries Equity, "Double Leverage," and the Risk of Bank Holding Companies (BHCs)

Silvia Bressan*

MODUL University Vienna

Am Kahlenberg 1, 1190 Vienna, Austria

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Abstract

"Double leverage" is the circumstance in which the parent company issues debt and acquires shares in the equity of subsidiaries (Board of Governors of the Federal Reserve System, 2012). The concern of financial authorities is that such practice reduces the group capital, and bring risk to the firm. The paper is an extensive discussion on this regulatory issue, and provides quantitative evidence on the impact from double leverage on the risk undertaken by Bank Holding Companies (BHCs). For a large sample of United States BHCs we observe that firms exhibit a huge appetite for risk while they raise in the so-called "double leverage ratio." Several tests do suggest the existence of causality. Our view is that, by double leveraging BHCs can exploit a shortfall in the consolidated capital, and are tempted to risk more. Based on our findings we give suggestions for a more effective monitoring of banking groups.

Keywords: Bank Holding Companies; Equity Financing; Double Leverage; Risk

JEL Classification: G21, G32

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1. Introduction

Financial firms are frequently organized as groups.[1] Banking organizations have become more extended and complex, and the growing levels of consolidation, internationalization, and conglomeration tend to accentuate the risk profile of the same firms and can ultimately bring systemic risk (De Nicolo´ et al. (2004)).

Consolidation often leads to the creation of Bank Holding Companies – BHCs (12 United States Code Sections 1841-48). After the Gramm-Leach-Bliley Act of 1999 well capitalized BHCs are permitted to become Financial Holding Companies, which besides the banking activity can provide also investment advisory and insurance related services. This translates into banking groups having highly extended networks, where a huge amount of resources is exchanged among the interconnected entities.

This article focuses on the financing activity from the parent firm towards the subsidiaries. More precisely, we consider the circumstance of so-called "double leverage." Double leverage arises when "debt is issued by the parent company and the proceeds are invested in subsidiaries as equity" (Board of Governors of the Federal Reserve System, Division of Banking Supervision and Regulation, 2012, "Bank Holding Company Supervision Manual"). A high degree of double leverage means that the parent firm exploits its own leverage in order to buy large shares in the subsidiaries´ equity.

Financial authorities do often mention the issue of double leverage in relation to the assessment of the group-wide capital. "When capital is double leveraged, the capital actually available to the group to meet unanticipated losses is less than the data implies" (International Monetary Fund (2004)). In order to avoid such double counting of equity, the procedures for the consolidation of balance sheets require deducting the investments into subsidiaries from the group capital. Despite of this, commenters sustain that, thanks to practices of double leveraging banking groups can do some regulatory arbitrage (Dierick (2004) and Yoo (2010)).

Departing from these views, this article is one first academic contribution addressing the issue of double leverage in the banking industry. More precisely, we ask whether this type of intra-firm funding can alter the risk-taking of the group.

[1] The group structure is often distinguished into: integrated model, parent-subsidiary model, holding company model and the horizontal group (Dierick (2004)).

In the following section we provide the example of a bank holding company, showing that, when the group increases in the degree of double leverage the risk appetite of the firm becomes very acute. The consolidated capital ratio is falling in double leverage as well, although in a much lower measure than the incentive to risk. If the firm is not obliged to take actions for preventing losses, then we argue that the group exploits the shortfall in capital in order to undertake more risk.

We analyze a large sample of United States BHCs during the period 1990-2014. The risk-taking of the BHCs is captured by the variability of the parent company stock returns. Regression results reveal a positive and significant correlation between the proxy for risk-taking and the so-called "double leverage ratio," defined as the ratio between the equity held in subsidiaries over the stand-alone equity capital of the parent company (see the Unite States Office of the Comptroller of the Currency, 2009). The estimates are robust to the inclusion of other important aspects driving the BHC risk-taking, as business model, size effects, continuation value, capital requirements, and diversification benefits.

Besides the use of ordinary least squares (OLS) and fixed effects, we employ econometric tools which help in attenuating potential endogeneity. These include the estimation of treatment effects models, propensity score matching, and regression discontinuity (RD) design. We also investigate how changes in corporate taxation interact with double leverage, and the analysis employs difference-in-difference and instrumental variables (IV). All these latter methods do never reject the hypothesis of a causality flow from double leverage on risk.

We interpret the outputs arguing that by double leveraging banking groups are encouraged to alter their risk-taking, ultimately producing losses which the consolidated capital would not fully cover. This is consistent with the claim of the regulator that double leverage is a source of risk for BHCs (Board of Governors of the Federal Reserve System, Division of Banking Supervision and Regulation, 2012, "Bank Holding Company Supervision Manual," Section 2010.1).

The article brings the following contributions. First, it faces with a more academic approach an issue that so far has been mentioned by regulators and supervisors, and offers a more extensive discussion on that.

Second, we use real-world data in order to provide quantitative evidence on the effects from double leverage inside financial firms. To our knowledge this is something that the modern empirical banking literature has ignored so far. Our sample of BHCs has got average double leverage ratio of more than 108%. This is a considerable amount. If we take the average coefficient estimated across several specifications (pooled OLS regressions), we observe that the economic impact from a marginal change in the double leverage ratio is an increase in risk of about 30%.

Based on our outcomes the main suggestion we give to policy makers is that, in order to control that practices of double leverage do not undermine the financial stability of the firm, capital regulations should be integrated by further (more effective) monitoring tools.

As previously claimed, this article treats a quite new theme in the banking literature, and we could find only brief mentions of double gearing in Holland (1975), Karna and Graddy (1984), Pozdena (1986), and Wall (1987).

Our paper can be related to the literature on the features of banking groups. The intra-firm funding is part of the so-called internal capital market. Articles on the internal capital markets of multinational banks include, among others, Houston, James, and Markus (1997), Houston and James (1998), Campello (2002), De Haas and Van Lelyveld (2010), and Cetorelli and Goldberg (2012).

We study the case in which the parent firm uses external debt for acquiring shares in the equity of the related subsidiaries. The leverage choice of business groups is studied by Bianco and Nicodano (2006), Verschueren and Deloof (2006), Manos, Murinde, and Green (2007), Luciano and Wihlborg (2013), and Luciano and Nicodano (2014). De Jong et al. (2011) discover that highly levered French pyramidal firms have also higher dividend payouts. This is consistent to a debt service hypothesis, where holding companies exploit their own leverage for acquiring the control of the operating companies, which are paying huge dividends to their owners.

From the perspective of subsidiaries instead, their funding choices have been analyzed by Chowdhry and Nanda (1994), Chowdhry and Coval (1998), and Gopalan, Nanda, and Seru (2007). All these papers look at non-financial firms, and we could not find papers dealing with a similar topic in relation to financial conglomerates.[2]

The paper is organized as follows. In Section 2 we motivate by a simple example the research question of the paper. We show that, a bank holding company rising in the degree of double

[2] Several studies have looked at capital markets internal to non-financial groups, highlighting the respective costs and benefits, and questioning on their efficiencies. These include Stein (1997), Shin and Stulz (1998), Hubbard and Palia (1999), Scharfstein and Stein (2000), Matsusaka and Nanda (2002), and Desai, Foley, and Hines (2004). Aggarwal and Kyaw (2008) say that multinational companies have a strategic competitive advantage deriving from internal financial networks. This allows subsidiaries to substitute external debt with parent debt, in order to overcome weak financial markets and institutional environments.

leverage gets large benefits from the undertaking of risky strategies. In Section 3 we analyze a large sample of United States BHCs during the period 1990-2014. Several econometric techniques are implemented in order to explore whether the "double leverage ratio" has got important influence on risk-taking. Section 4 discusses the empirical outcomes and derive policy implications from them. Section 5 includes additional tests which verify the robustness of the detected relationship. Section 6 concludes the paper.

2. Motivating Example: Double Leverage, Risk-Taking, and Capital

2.1 The Example

We examine a Bank Holding Company (BHC) and the simple composition of its balance sheet. For the legal definition of BHC see the 12 United States Code Sections 1841-48 (so-called Bank Holding Company Act of 1956). The tasks of the example are the following. First, from the balance sheet items we assess the existence of some double leverage by computing the so-called "double leverage ratio." Second, we show that, changes in this latter ratio determine a decline in the consolidated capital while have a positive impact on the incentive to risk. The consolidated capital figure is deducted by the holdings of the parent into subisdiaries´ equity. In our example the effect from double leverage of exacerbating the risk appetite is always larger in magnitude than the reduction in capital.

We conclude with some notes on the setting of the example. We focus on the parent-subsidiary relationship and we do not consider neither in the example nor in the rest of the paper the presence of branches. The terms "parent firm" and "holding company" are used interchangeably. When we do consolidated the balance sheets of the parent and its subisdiary, we apply so-called "full" consolidation method. Finally, the simple set-up excludes issues which might affect transactions, as taxes or discount rates.

2.1 The Bank Holding Company (BHC)

The Bank Holding Company (BHC) is constituted by two entities: the Holding (the parent) Company (HC) and the unique subsidiary firm (S). The two stand-alone firms have balance sheets as in the following Table 1:

Holding Company (HC)			
Assets		**Liabilities**	
Loans	L(HC)	Equity	E(HC)
		Debt	D(HC)
Total	L(HC)	Total	E(HC)+ D(HC)

Subsidiary (S)			
Assets		**Liabilities**	
Loans	L(S)	Equity	E(S)
		Debt	D(S)
Total	L(S)	Total	E(S)+ D(S)

Table 1: Stand-alone balance sheets of HC and S

HC holds the fraction *x* of the subsidiary´s equity E(S). The consolidated balance sheet of BHC results to be the following Table 2:

Consolidated Balance Sheet of Bank Holding Company (HC + S)			
Assets		**Liabilities**	
Loans	L(HC) + L(S)	Equity	E(HC) + ~~*x**(E(S))~~
~~Book Value of participation in S~~	~~*x**(E(S))~~	Minority Interests	(1−*x*)*(E(S))
		Debt	D(HC) + *x**(E(S)) + D(S)
Total	L(HC) + L(S)	Total	E(HC)+ (E(S))+ D(HC) + D(S)

Table 2: Consolidated balance sheet of BHC

We employ the items from the balance sheets above in order to compute the so-called double leverage ratio (Office of the Comptroller of the Currency formerly The Office of Thrift Supervision, 2009, “Holding Company Handbook”). This equals to the stake of the subsidiary´s equity held by the parent company divided by the parent company own equity capital, namely $DLR = [x * E(S)]/\, E(HC)$.

The supervisor asserts that a group has got some double leverage when the double leverage ratio is above 100% (Office of the Comptroller of the Currency formerly The Office of Thrift Supervision, 2009, “Holding Companies Handbook”). The reason is the following. When *DLR* is higher than one, the parent has acquired the subsidiary in a larger measure than its *solo* capital, implying that the deal has been funded with debt proceeds.

2.2 The BHC Double Leverage and the Incentive to Risk

We show how we can relate the degree of double leverage, as measured by *DLR*, to the incentive to risk for the equityholders of HC.[3] Assume that the subsidiary adopts a value neutral strategy which produces with equal probability a loss or a gain of $x\pi$. The value of HC is affected by this strategy.[4] In the Table 3 below the second and third columns report the expected value for the HC equityholders. All else equal, if S does not take any risk, the value for HC equityholders does not change. As soon as the risky project is undertaken instead, it affects E(HC). How far this latter is affected depends from the project´s profit/loss. The first row of the Table is the case in which the profit/loss is lower than the holding company equity. In that case, the potential loss will be fully covered be the parent capital, and the ultimate expected value for equityholders remains E(HC). In the second row instead, the payoff is above the holding company equity. If $x\pi$ is a loss, then HC will not have sufficient capital to cover the shortfall, and the equityholders will be wiped out. On the other side, if the same $x\pi$ is a profit, it will be fully pocketed by the equityholders. In the last column the quantity "delta" measures how much the expected value of E(HC) increases when the risk is undertaken.

Threshold in Profit/Loss	**Expected Value for HC Equityholders if S does not play the Risky Strategy (a)**	**Expected Value for HC Equityholders if S does play the Risky Strategy (b)**	**Delta (b-a)**
$\boldsymbol{x\pi \leq}$ **E(HC)**	E(HC)	0.5*(E(HC) + $x\pi$) +0.5*(E(HC) – $x\pi$) = E(HC)	0
$\boldsymbol{x\pi >}$ **E(HC)**	E(HC)	0.5*(E(HC) + $x\pi$)+0.5*(0)= 0.5E(HC) + 0.5$x\pi$	0.5*($x\pi$ – E(HC)) = 0.5*(π – E(HC)/x) = 0.5*(π – DLR^{-1}*E(S))

Table 3: Expected value for HC Equityholders depending on the profit/loss of the risky strategy

For larger payoff values "delta" is positive. Namely, the risky strategy provides a benefit to HC equityholders. In the Appendix we write "delta" in terms of *DLR*, and note that this quantity is an

[3] Our example is similar to the example of Bebchuk and Spamann (2010), who show that the risk incentive for shareholders of a holding company is higher as soon as the firm is doing some risky activities via a related subsidiary, rather than operating as a stand-alone firm.
[4] In the example we concentrate only on the benefits for shareholders and do not consider benefits for executive managers.

increasing function of *DLR*.[5] We argue that, when the group is highly double levered, it might reveal a stronger risk appetite.

2.3 The BHC Double Leverage and the Capital Ratio

Regulators are concerned on how double leverage interferes with the assessment of the group-wide capital. In the example of BHC, the *solo* capital of the two firms would overestimate the capital available to the group. The consolidation of balance sheets takes into account of the reciprocal equity holdings, and the consolidated equity capital is net from the participation into S.

To make the example more straightforward, we use some numerical values for the balance sheet items of our firms. These are summarized in the bottom line of Table 4 below. We consider two cases: in the first case HC holds the 80% of S, while in the second case HC holds the full control of S, namely $x = 100\%$.[6] By using these values, we can compare effects from two different levels of *DLR*. As a proxy for leverage, we compute the ratio of the consolidated equity over the consolidated assets. As *DLR* increases the "external" capital of the group decreases, and brings down the capital ratio. This is more evident expressing the capital ratio in terms of *DLR*, and noting that its first order derivative is negative. The Appendix reports all the calculations from this example as well as the group-wide capital assessment of the group.

The increase in *DLR* leads to a reduction in capital (third column), while increases the benefit for shareholders from the risky project, as measured by "delta" (fifth column). In the last row of the table the percentage change in "delta" is much larger than the percentage change in the capital measure. In the Appendix we show that, the derivative of "delta" is more rapidly increasing in *DLR* than how far the derivative of the capital ratio decreases in *DLR*.

[5] The first derivative of "delta" is equal to DLR^{-2}*E(S), which is always positive. See the Appenidix for more details.
[6] The holding company has got legal "control" over the subsidiary when it owns more than the 50% of the subsidiary´s outstanding common stock. For the definition of control see the Bank Holding Company Act of 1956.

Threshold in Profit/Loss $x\pi$ > E(HC) $x*40$ > 30	DLR = $[x * E(S)] / E(HC)$	Capital Ratio = $\frac{E(HC) + (1-x) * E(S)}{L(HC) + L(S)}$	Group-Wide Capital Surplus/Deficit	Delta
***x* = 80%**	133%	16%	15	1
***x* = 100%**	167%	12%	5	5
Percentage Change	+20%	-25%	-67%	+400%

Table 4: *DLR* and capital for two different values *x* of HC ownership of S.
Note: E(HC) = 30; E(S) = 50; π = 40; L(HC) = 140; L(S) = 110; D(HC) = 110; D(S) = 60

3. Empirical Analysis on the Relationship between Risk-Taking and Double Leverage

3.1 Sample and Data

We obtain data from SNL Financial LC. We focus on firms classified as “Bank Holding Company” (BHC), and use information on balance sheet and income statement of those BHCs filing the reporting forms FR Y9C and FR Y9LP to the Federal Reserve System. The frequency of observation is quarterly and our sample spans from 1990q1 till 2014q1.[7]

For the publicly traded BHCs, we get from the same source the monthly stock prices. Prices are adjusted for stock splits and stock dividends. We compute the monthly returns and calculate the quarter standard deviation of the returns, so that the series of standard deviations is merged with the data from the BHCs accountancy.

We exclude firms with only one quarter of observation, and the final sample counts a total number of 43,176 bank-quarter observations.

3.2 Risk-Taking

[7] Bank Holding Companies (BHCs) are defined as in the Bank Holding Company Act of 1956. The filing of reports to the Federal Reserve System is related to the size of BHCs. The FR Y-9C is the Consolidated Financial Statements for Bank Holding Companies report, and is filed by all domestic BHCs with total consolidated assets of $500 million or more and all multibank holding companies with debt outstanding to the general public or engaged in certain non-banking activities. The FR Y-9LP report is the Parent Company Only Financial Statements for Large Bank Holding Companies. This report is filed at the parent company level by all domestic bank holding companies that file the FR Y-9C.

The task is to explore whether the risk-taking of the BHC varies with the degree of double leverage. We identify the total risk with the equity market volatility, as in papers from Galloway, Lee and Roden (1997), Lee (2002), and Stiroh (2006). Thus, risk is measured by the standard deviation of the parent firm stock returns (*stdev*).[8] From Table 5 the average *stdev* on the whole sample is 6.7%. Table 6 reports the average *stdev* across years. We note a sharp increase in the average risk during 2008, and we believe this reflects the turmoil experienced by the United States financial market. Till 2012 *stdev* stays always above the mean annual value.

We aknowledge that we cannot observe the optimal amount of risk-taking, as well as the excessive risk-taking behaviour is inherently unobservable. Constructed proxies can be spoiled by measurement error, and there are no good instruments for this errors-in-variables problem (Kim (2013)). Nonetheless we chosen to approximate risk with the standard deviation of equity as has been previously done by several papers in the banking literature. In order to make the interpretation of our results more robust, in a following sub-section we test an alternative measure for risk-taking.

3.3 "Double Leverage Ratio"

In the previous section we explained how to compute the double leverage ratio from the balance sheet figures. We now calculate the same quantity for the BHCs of our dataset. The variable *DLR* equals the total aggregated investment of the parent company into the equity of subsidiaries divided by the equity capital of the same parent. A high *DLR* denotes the circumstance in which the parent acquires significant stakes in the equity of subsidiaries by remaining relatively low capitalized.[9]

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[8] The equity volatility is tested as a proxy for risk-taking in the papers of Saunders, Strock, and Travlos (1990), Lepetit et al. (2008), Laeven and Levine (2009), Pathan (2009), and Haq and Heaney (2012). Some earlier papers inlcude Flannery and James (1984), and Kane and Unal (1988). Zaik et al. (1996) comments that RAROC systems for assigning capital to banks are based on risk measures, and the relevant measure of risk for determining banks´ capital adequacy is the volatility of stock returns, rather than the volatility of book or regulatory capital.

[9] In order to compute *DLR* we use items reported under the FR Y9LP, section Schedule PC-A − Investments in Subsidiaries and Associated Companies. The investment into the equity of subsidiaries includes stock, goodwill and other intangibles. In practise though, most of the BHCs investment into subsidiaries´ equity coincides with stock ownership. Note that, from *DLR* we cannot know whether the parent company is investing into only few or a large number of subsidiaries, since at the numerator is the aggregate value of equity invested across all the subsidiaries of the group. Wall and Peterson (1988) claim that the double leverage ratio is an inverse function of the BHC strength.

We construct *DLR* following the definition from the "Holding Company Handbook" (2009) of the United States Office of the Comptroller of the Currency (formerly The Office of Thrift Supervision). We could find only few empirical papers which employ measures for double leverage. In Mayne (1980) and Karna and Graddy (1984) the double leverage ratio is the quotient between the investment in subsidiaries equity and the parent company net worth, minus one. Wall and Peterson (1988) divide the investment in subsidiaries equity by the BHC consolidated net worth less goodwill. Krainer and Lopez (2009) compute the double leverage ratio as we do in this paper.

On average, our BHCs have *DLR* of 108.5%.[10] During the recent crisis there are not large changes in *DLR*, since the average values during the turmoil are not strikingly different with respect to the annual values before and afterwards.

We want to see how the relationship between risk and double leverage reveals in the data in unconditional terms. In Table 7 we distinguish BHCs by their level of risk, and "riskier" firms would be those BHCs with *stdev* above the first, the second, and the third quartiles of the distribution. These firms have always higher *DLR* as compared to the rest of the sample. The difference is, at maximum, almost 5%, and in all cases is significant according to the Wilcoxon signed-rank test, which compares the distribution of the two selected sub-samples. The estimated probability that BHCs in the upper quartiles of risk have also higher *DLR* is always above the 50%. In the following sub-sections the same relationship is explored in conditional terms, and several types of regression analyses will be performed.

3.4 Control Variables

The set of control variables in our regressions reflects the characteristics of the firm which we deem contribute in determinaning risk-taking. The Appendix defines the variables, while Table 5 summarizes the main statistical features.

The firm capital structure is measured by the capital asset ratio. We test effects from both the book value of the capital asset ratio (*CAP*) as well as the regulatory risk weighted capital ratio (*RISKBASED CAP*), computed as the sum of tier 1 plus tier 2 capital over risk weighted assets. In general, the capital asset ratio is inversely related to the degree of leverage, and highly levered

[10] Wall and Peterson (1988) estimate an average double leverage ratio in the three-year period 1982-1984 of almost 115%, and this high value is said to be driven by the peak in double leverage during 1984, as the ratio was above 127%. More recently, Krainer and Lopez (2009) work on a large sample of BHCs during 1988-2004, and compute an average double leverage ratio of 82.02%.

firms (those with lower *CAP* and *RISKBASED CAP*) are expected to risk more. The continuation value in the BHC activities is proxied by the market to book ratio (*MKB*). When *MKB* is high the firm could make higher profits by continuing the current business, and it might prefer to avoid that risky strategies bring instability.[11] Finally, the size of the organization (*SIZE*) might attenuate risk, so that larger banks can diversify and reduce the variance of their revenues.

The variables so far characterise our baseline regression for risk-taking. Lee (2002) studies the effect on risk-taking from insider ownership, and the control set of his regression of the standard deviation of stock returns includes the variables *CAP*, *MKB*, and *SIZE* as defined in our paper. In a further specification we test the effect from additional covariates. We control for the business model of the firm by normalizing the amount of loans by deposits (*LOANS_DEPOSITS*). The complexity of the organization might matter for explaining risky attitudes. A BHC with numerous subsidiaries might have more opportunities to diversify risk.[12] We count the number of non-bank subsidiaries (*NONBANK SUBS*), and the number of depository subsidiaries (*DEPOSITORY SUBS*). Depository institutions are banks or savings associations (12 United States Code Section 3201). In order to inspect implications on risk from income diversification, we compute the ratio of non-interest income to total assets (*NONINTEREST INCOME*), which measures the profits of the bank deriving from non-interest (or fee-based) activities. We include the interaction term between *DLR* and capital, in order to see whether the marginal effect from double leverage on risk varies according to the capitalization of the company. Finally, to consider potential effects from the crisis of 2007-2009, we also interact *DLR* with a dummy assuming value one during the crisis period, which we let go from 2008q2 till 2009q4.[13]

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[11] A negative relationship between banks´ risk-taking and charter value is documented by, among others, Anderson and Fraser (2000), Konishi and Yasuda (2004), and Haq and Heaney (2012). This evidence is opposite to the outputs from Saunders and Wilson (2001), who rather show a positive relationship between the two. A more extensive discussion on banks charter value in relation to risk-control regulation, we send to Galloway, Lee and Roden (1997).

[12] For an overview on the most important motives for conglomeration we send, among many, to Dierick (2004). One explanation for conglomeration is the achievement of diversification benefits. This view is often opposed by an opinion which rather contends that conglomeration destroys value. Papers have often verified the hypothesis of "inefficient capital markets." A survey on this issue is Maksimovic and Phillips (2008), while for evidence on financial conglomerates we send to Laeven and Levine (2007) and Schmid and Walter (2009). Our measure for income diversification is similar to DeYoung and Roland (2001) and Stiroh and Rumble (2006).

[13] We looked at the average *stdev* across quarters. During the interval 2008q2 - 2009q4 we observe that the standard deviation of the BHCs´ stock returns remains above the value of 10 (in 2008q1 it was about 7) across all quarters. We also verify that the quality of the results remains unchanged extending the length of the crisis period, namely from 2007q2 till 2009q4. The coefficient on *DLR* persists to be positive and significant if we split the sample into three groups coinciding to the pre-crisis period, the crisis period, and the post crisis period. In another specification the regressors include the control variables plus the interaction of all these variables with the crisis dummy. We do not report these latter results for not overloading the set of outputs.

3.5 Empirical Models for Risk-Taking

We estimate regression models which relate the risk-taking of the BHC to the double leverage ratio and the other control variables. To our knowledge, none of the previous empirical studies has considered that the risk-taking of a business group can be determined by intra-firm financing. In particular, double leverage effects have never been estimated.

Table 8 reports the outcomes from different econometric specifications for *stdev*. Panel A reports the output from an OLS regression on the pooled observations with inclusion of quarter fixed effects. Standard errors are clustered at the bank level in order to control for the correlation of errors along the time dimension. All the explanatory variables are one period lagged, so that we relate the ex-ante risk-taking incentive to the ex-post risk-taking. This regression resembles the empirical studies from Galloway, Lee, and Roden (1997), Lee (2002), and Stiroh (2006). We additionally include the first lag of the dependent variable as regressor, thus we assume that the equation for the stock return standard deviation has got a recursive structure.[14]

The pooled OLS specification might not be capturing the cross-sectional dimension of the results, so that there could be some unobserved heterogeneity among the firms which is not properly taken into account. In order to attenuate this concern, in Table 8-Panel B the coefficients are estimated using Panel data techniques. All the variables are contemporaneous. In this case we include both firm and quarter fixed effects, and standard errors are clustered at the bank level.[15]

3.6 Empirical Results

Across the outputs of Table 8 the estimated sign on *DLR* is always positive and statistically relevant. When parent firms are funding the equity of their subsidiaries in a larger proportion with respect to their own equity capital (high *DLR*), their stock returns become ultimately more volatile. For example, take the OLS output of Table 8-column (1): all else equal, a one-standard-deviation increase in *DLR* is associated with an increase of 0.029 standard deviations in risk-taking. In economic terms, this would lead risk to be the 22% bigger.

[14] OLS specifications are adopted by several empirical studies on risk-taking. For instance, Laeven and Levine (2009) perform OLS regressions on pooled observations while modelling the bank z-score. Lepetit et al. (2008) run OLS regressions on some cross-sections of banks and use alternative proxies for banks´ risk and insolvency.
[15] Papers analysing the bank risk-taking implementing panel regressions include, among others, Saunders, Strock, and Travlos (1990), Anderson and Fraser (2000), Konishi and Yasuda (2004), Stiroh and Rumble (2006), and Brandão-Marques, Correa, and Sapriza (2013).

In the OLS specification of Table 8-Panel A the first lag of the dependent variable is highly and significantly positive, with the highest estimated coefficient among the regressors. Namely, the standard deviation at (*t-1*) is the variable which mostly captures the variability of the standard deviation at *t*. This path could be interpreted as a reflection of some "mean-reversion" in the volatility.[16]

Concerning the remaining set of covariates, we note that BHCs smaller in size and with high continuation value would be less induced to risk.[17] In the third column of Table 8-Panel B the negative and significant impact from *NONINTEREST INCOME* could hint that risk would be mitigated if the firm is doing some non-fee income generating activities.[18]

Double leverage and risk-taking become more correlated during the crisis period. Nonetheless the marginal impact from *DLR* remains significant also outside the crisis, and we cannot address the estimated pattern only to the recent turmoil.

As expected, risk is contained by the bank capital. The negative sign on the interaction term with *DLR* suggests that, BHCs rising in double leverage would display less variability in their equity when are endowed by lot of capital.

3.7 Granger Causality Test

The outputs from the previous regressions might be affected by certain endogeneity. As a very first attempt for pinning down this issue we perform the Granger causality test (Granger (1969)), where we ask whether we are better in predicting *stdev* using also the history of *DLR*, instead than using only the past history of *stdev*.

Through a reiterative procedure, we calculate the Granger causality test for each BHC of the sample. The output is reported in Table 9. For the 14% of the firms we reject the null hypothesis

[16] "Mean reversion" of volatility is a well-documented stylized fact in econometrics. When variance mean reverts, it has time-dependent, autoregressive dynamics. Given the relatively low absolute value in the lagged *stdev* though, we are cautious in making any claim on a second stylized fact of "clustering" behavior in the standard deviation of stock returns. The idea of volatility clustering in financial returns goes back to Mandelbrot (1963), and has been heavily employed for the modeling of financial time series, especially starting with Engle (1982) and Bollerslev (1986).

[17] Demsetz and Strahan (1997) show that there exists a positive relationship between BHCs size and diversification, which, though, does not result in a negative relationship between BHC size and stock return variance.

[18] Evidence on the correlation between risk-taking and off-balance sheet activities is mixed. Papers arguing that off-balance-sheet activities increase risk are, among others, Wagster (1996), Angbazo (1997), Fraser, Madura, and Weigand (2002), and Haq and Heaney (2012). Other works do rather sustain that off-balance sheet activities reduce risk, for example Lynge and Lee (1987), Boot and Thakor (1991), Hassan, Karels, and Peterson (1994), Angbazo (1997), and Esty (1998). Further evidence about the implication from non-interest income on risk-taking can be found in DeYoung and Roland (2001), DeYoung and Rice (2004), Stiroh (2004 and 2006), and Lepetit et al. (2008).

that the lagged *DLR* is statistically equal to zero (thus, no causality in the sense of Granger), with a 5% level of statistical significance. Put differently, in the 14% of the cases *DLR* is Granger causal for risk, i.e. the current values of *DLR* help in forecasting the future risk.

3.9 Analysis on the BHCs with Double Leverage Ratio above 100%

3.9.1 The Sub-Sample and Ordinary Least Squared (OLS) Model

When a certain group has got a double leverage ratio above 100 percent, then we can argue that there is some double gearing in the organization (Office of the Comptroller of the Currency formerly The Office of Thrift Supervision, 2009, "Holding Companies Handbook"). We refer to BHCs with *DLR* above 100% as "double levered" firms, and identify them by the variable *DLR_DUMMY*, which is a dichotomous variable assuming value one if the BHC has got *DLR* above 100%, while zero otherwise. Table 10-Panel A shows results from the univariate Wilcoxon test on the two sub-samples. BHCs with *DLR* above 100% have higher risk and lower capital ratios. In particular, their stock price is about 31% more variable than in the other firms. We then perform on the two sub-samples the same type of OLS regression from the first column of Table 8-Panel A. The results are displayed in Table 10-Panel B. We discover that the significant effect from *DLR* on *stdev* is driven by those BHCs with *DLR* above 100%, for which the coefficient is always statistically significant, while it remains not relevant for the other BHCs.

These results suggest that the estimated relationship is presenting a structural break. The impact from *DLR* on risk would be almost flat while *DLR* stays below 100%, while the risk function would start having a positive slope when *DLR* goes above 100%. We verify this view by performing the Chow test (Chow (1960)). The Chow test assumes that the break is known before looking at the data. As motivated few rows above, the ratio of 100% is the threshold in *DLR* which identifies an excessive recourse to double leverage financing inside the group. This is why we expect a discontinuity at *DLR* equal to 100%. Consistently, the Chow test rejects the null hypothesis of no break, while it detects a structural break in the coefficients of the regressors explaining *stdev*. In Section 3.9.4 we test whether this discontinuity is confirmed by using a regression discontinuity (RD) approach.

3.9.2 Model with Endogenous Treatment Effects

As already mentioned, we cannot exclude that our regressions suffer from endogeneity problems in the form of omitted variables or reverse causality. Potential endogeneity can be attenuated by the estimation of a model with endogeneous treatment effects. This type of modelling is appropriate when the treatment can be characterized by a dichotomous indicator, and the effect from the treatment is typically estimated with instrumental variables or variants of the control function approach, as motivated by Heckman (1978, 1979). For this purpose we use *DLR_DUMMY*, which assumes value one if *DLR* is above 100%, while zero otherwise. Namely, the treated units are the BHCs where the intra-firm financing has led to an "excessive" degree of double leverage.

The model with treatment effects assumes that the errors in the equation for risk and in the equation for the double leverage dummy are bivariate normal $[0,0,\sigma_{\epsilon},1,\sigma]$.[19] Under this assumption, Table 10-Panel C reports the coefficients estimated both with maximum likelihood and with a two-step procedure (Heckman (1976, 1978), and Maddala, 1983). The coefficient on *DLR_DUMMY* is the estimated average treatment effect - ATE. The ATE quantifies the expected gain in risk-taking from being double levered for a randomly selected unit from the population. For both type of estimations the ATE is positive and significant. The Wald test indicates that we can reject the null hypothesis of no correlation between the treatment errors and the outcome errors.

3.9.3 Propensity Score Matching

In this sub-section treatment effects are estimated by propensity score matching. Propensity score matching goes back to Rosenbaum and Rubin (1983), who propose the method for attenuating the bias in the estimation of treatment effects with observational data sets. Due to lack of randomization, in the context of an observational dataset, we could not make any causal inference from *DLR* to risk. Thus, we cannot know whether the difference in risk between treated and control (untreated) BHCs is due to the treatment, or is due to differences in other BHCs´ characteristics.

The treatment is again defined on the base of the severity in double leverage, i.e. treated units are firms with *DLR* above 100%. The propensity score works as a method for estimating the effect of receiving the treatment when a random assignment of the treatment to the subjects is not feasible. Treated and control units are matched if they have similar values in the propensity score and

[19] This is assumption is unverifiable. Little (1985) argues that the identification of the model depends upon non-linearities and the estimated parameters might not be reliable.

in other covariates, while remaining unmatched unites are discarded (Rubin (2001)). In this way, differences between the two groups should be accounted for, and not due to the observed covariates. For each BHC the propensity score is defined as the conditional probability of being double levered (the treatment) conditional on the observed covariates. We use the nearest neighbor *n-to-n* matching, where for each treated unit we look for the control unit with the closest propensity score (i.e. the nearest neighbor). The difference in *stdev* between the two groups is used for estimating the effect from the treatment on risk.

We have implemented several types of *n-to-n* matching, and decide to show the results where the matching has provided the best outfit among the several attempts. The matching is done with replacement and caliper, and the propensity scores are estimated using a probit model.[20] Table 11-Panel A tests the success of the matching on the covariates. The t-test indicates that, after the matching, the mean value of each variable is the same between treated and control group. The average bias after the matching is lower than 3%, hence the starting unbalancing has been satisfactorily reduced.[21] As we see in Figure 1 the common support assumption holds, since in each propensity score class there is a certain number of treated and non-treated firms.

Figure 2 illustrates the risk for the double levered (i.e. treated) firms and the matched not-double levered (i.e. not-treated) firms, as a function of the propensity score. For both groups we observe that *stdev* is rising in the propensity score. Across all propensity scores the risk associated to the matched not-double levered banks stays below the risk of the double levered firms. The estimated ATE is 0.478. Table 11-Panel B shows also the average treatment effect on the treated – ATT, which is the gain in risk-taking due to the treatment for those units which were actually treated. In our case the ATT is close to the ATE.[22]

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[20] The caliper equals to 0.00001. The low value of the caliper reduces significantly the subsample of matched observations. On the other hand using higher caliper values we could not get good matching, in terms of balancing of the covariates and reduction of bias after the matching. We further checked that, using a logit model for the estimation of the propensity score does not change the results. Recent applications of propensity score matching for the correction of self-selection bias on financial data include Drucker and Puri (2005), Bharath et al. (2009), Saunders and Steffen (2011), and Michaely and Roberts (2012).

[21] The standardised percentage bias is the percentage difference of the sample means in the treated and control subsamples as a percentage of the square root of the average of the sample variances in the treated and control groups (Rosenbaum and Rubin (1985)).

[22] In the model of Table 10 ATE and ATT coincide since the treatment indicator variable has not been interacted with any of the outcome covariates. In other terms, the ATT is the average difference between the potential risk from double leverage and the potential risk from absence of double leverage computed on the BHCs which have *DLR* above 100%. In the majority of the studies evaluating policy interventions the ATT is the most important parameter of interest. According to Heckman (1997) the ATE would be less relevant, since it includes the effects on units for which the intervention was not intended.

Finally, we perform the same type of regression of Table 8-Panel A on the matched sample. The coefficient on *DLR* is significantly positive. The quality of results from previous regressions is preserved. Based on the outputs from the matching exercise we affirm that an excessive double leverage encourages BHCs to have higher risk appetite.

3.9.4 Regression Discontinuity Design

The approach is now of a regression discontinuity (RD) design. This method is alternative to the previous tools based on matching estimators and endogenous treatment effects, and is helpful for detecting causality in the data.[23] Our outcome variable is *stdev*, the assignment (or, treatment) variable is *DLR*, and the treatment is based on the 100% *DLR* cut-off. The idea behind the RD design is that, under certain conditions, in the neighbourhood of the cut-off a discontinuous jump in *stdev* can be attributed to the level of treatment. Near the discontinuity the treatment can be seen as if it would be assigned randomly. Thus, the assignment of a BHC to either the right or the left of the 100% cut-off would be random. We implement a sharp RD and the estimation is done using the non-parametric technique of triangle kernel regressions following Imbens and Kalyanaraman (2009).

Table 12 reports the Wald estimator computed at the optimal bandwidth, as well as at multiples (50 and 200 percent, namely half and twice) of the optimal bandwidth, which we check for robustness. The Wald estimator measures the jump in the outcome at the cut-off, when the jump in treatment is one. Namely, it measures the jump in risk occurring when *DLR* goes above 100%. This is the estimated causal impact from high double leverage (i.e. the treatment) on risk. The coefficient on the Wald test is highly positive and significant. The Panels of Figure 3 visualize the change in risk due to the treatment, plotting *stdev* as a function of the distance from the cut-off. In Panels A and B the estimated pattern is the one corresponding on the optimal bandwidth for the 100% cut-off, and the two graphs differ only in the number of points where the local linear regression is calculated. Using fewer points, Panel B is neater in showing that the two variables move in the same direction. The risk measure tends to increase while the firm approaches and overcomes

[23] The RD design was first introduced by Thistlethwaite and Campbell (1960). We check discontinuities using non-parametric designs. The non-parametric way of estimating treatment effects in an RD design started with Hahn, Todd, and Van der Klaauw (2001). Researchers often use also parametric strategies in RD studies; for a review see Van der Klaauw (2008) and Cook (2008). Recent applications of RD on corporate finance studies include Rauh (2006) and Chava and Roberts (2008).

the cut-off.[24] This trend is though discontinuous, and we note a jump in *stdev* corresponding on the 100% limit.

With the same approach, we test the existence of discontinuities on other percentiles in the distribution of *DLR*. On other cut-off values the Wald estimator does not find a discontinuity, and from the Panels C-F of Figure 3 we cannot see evident jumps in risk.

Overall, the results based on the RD technique are consistent with the previous tests. We have further support that a causal relationship between double leverage and risk cannot be disconfirmed.

4. Discussion on the Empirical Outputs and Policy Implications

We sum up the results from the previous analyses, interpret the outputs, and derive some policy implications. The baseline regressions estimated a positive correlation between *DLR* and risk-taking, as approximated by the parent equity volatility. In a robustness check, we further verified that *DLR* is negatively related to the z-score, suggesting consistent implications on the default probability.

In order to claim some causality, we explored effects on risk from situations of "excessive" double leverage. These are identified by a value of *DLR* above 100%, and we constructed a dummy variable which different econometric tools have used for detecting causality. Tests relying on *DLR_DUMMY* do never reject the hypothesis of causality from double leverage on risk. In all our estimations we control for the regulatory capital ratio of the firms.

We interpret the outputs as confirming the hints we got from the example of Section 2. In front of highly risky projects, the equityholders of a more double leveraed HC would have greater benefits. Our view is that, when parent firms are more largely exposed to their subsidiaries and increase their degree of double leverage, they can exploit a shortcoming in capital accounting that leads them to take more risk than what the actual amount of available capital would warrant.

This statement is consistent with the opinion from several commenters. Dierick (2004) and Yoo (2010) say that the type of intra-group transactions we discuss in the paper allow to arbitrage regulatory capital. Thus, the BHC capitalizes on the misalignment between the actual risks taken

[24] The patterns in Figure 3 are consistent with the pattern we got from the matching exercise of Figure 2, in the sense that in both cases the two graphs display an increasing relationship between risk, which in both figures is on the y-axis, while the "severity" of the double leverage problem is on the x-axis.

and the sectoral regulatory requirements that it needs to comply with (Yoo (2010)). Jackson (2005) claims that the system of consolidated capital requirements developed under Basel II is not capturing subtle issues related to the risk of financial conglomerates. According to Kuritzkes, Schuermann, and Weiner (2003), one limitation of the silo approach for the capital regulation of financial conglomerates is the increased potential for regulatory arbitrage.

The main conclusion for policy makers from our findings is that, in order to address potential perverse effects on risk due to intra-firm financing, the rules for the computation of capital should be supplemented from more effective monitoring instruments, e.g. supervisory inspections, moral suasion, or formal issuance of supervisory letters. Regulators should design their interventions in a way to more directly control the flow of funds among firms of the same organization, where entities are also frequently subject to different disciplines and supervisors. This would contribute to reinforce the power of authorities over BHCs, which seems to be weaker than the current enforcement power over single banks (Elliot (2010)).[25]

5. Further Tests

5.1 Disentangling the Effect on Risk from the Parent Investment in the Equity of Different Type of Subsidiaries

[25] Michael Moore (2001) sustains that the development of mixed conglomerates which combines financial and non-financial entities tends to obscure the detection of double leveraging and makes the application of prudential and compliance rules more difficult. In his view the effective supervision of conglomerates should designate to separate authorities the supervision of financial *versus* non-financial entities, with some additional "firewalls." These latter "firewalls" include also a sliding capital approach at the holding company level, where the firm might be requested to adjust its capital on a sliding scale, for example increasing risk weights in a proportional way to the participation into the subsidiaries (Michael Moore, "Conglomerates Supervision – Group Support, Double Leverage and Double Gearing," presentation held at the World Bank/International Monetary Fund/Federal Reserve System Seminar for Senior Bank Supervisors from Emerging Economies, October 17 - 28, 2011, Federal Reserve System Training Center, Washington). Van Lelyveld and Schilder (2003) argue the need of intervention on financial conglomerates in cases of "regulatory inconsistency," as is the cases of "double" or "excessive" leveraging. Finally, we mention two recent measures on the capital of groups which should improve the stability of more complex organizations. The first is the so-called 2013 rule. United States Agencies have proposed to strengthen the leverage requirements for United States banking organizations as compared to the Basel III final rules. Central to this proposal is the introduction of a more stringent system of leverage standards for certain Bank Holding Companies (so called "covered" Bank Holding Companies) and their Subsidiary Insured Depository Institutions. See http://www.federalreserve.gov/newsevents/press/bcreg/20130709a.htm. The second intervention regards the discipline of multinational banks. At the beginning of 2014 the Federal Reserve has approved new standards for the largest foreign banks operating in the United States via some subsidiaries. Those foreign firms will be forced to consolidate United States operations into a unique subsidiary, which will be subject to the same liquidity and capital requirements as the United States domestic peers. For the European banks operating in the United States this implies that they would have to meet higher capital levels within 2016.

We test whether the risk-taking of the parent company varies depending on whether the firm invests into subsidiaries belonging to the banking or non-banking sector.

The variable *EQUITY IN BANKING SUBS* is the ratio of the parent holdings of equity into affiliated banks and other bank holding companies, over the total parent equity. The variable *EQUITY IN NON-BANKING SUBS* instead comprises the equity holdings into affiliated firms which are not operating in the banking industry. In general, non-banking subsidiaries do not offer both lending and depository services. Typically, they offer non-bank products and services, such as insurance and investment advice, and do not provide Federal Deposit Insurance Corporation insured banking products.[26] In our sample parent firms have large participations inside banking firms, which are about the 105% of their equity, while maintain a smaller exposure to non-banking firms, corresponding to the 2% of their equity.[27] From the regressions in the two Panels of Table 8-column (4), we see a higher statistical significance on the coefficient of *EQUITY IN BANKING SUBS*. The risk attitude of the parent seems to be more acute when it is investing into banking rather than into non-banking subsidiaries.

5.2 Alternative Measures for the Parent Holdings of Subsidiaries Equity

We now change the denominator of *DLR* and construct two more variables, both capturing the exposure of the parent firm towards the subsidiaries´ equity. First, we calculate the ratio of the equity invested into subsidiaries over the parent total assets (*EQUITYINSUBS_TA*). Second, the quotient is computed over the parent total investment into subsidiaries (*EQUITYINSUBS_TINV*). In this latter case the denominator is the value of all the securities issued by subsidiaries and held

[26] For the definition of "non-bank subsidiaries" see the Board of Governors of the Federal Reserve System, Instructions for Preparation of Quarterly Financial Statements of Nonbank Subsidiaries of Bank Holding Companies - Reporting Form FR Y–11Q, reissued March 2002.

[27] Note that, the values of *EQUITY IN BANKING SUBS*, and *EQUITY IN NON-BANKING SUBS* which we report in Table 5 do not perfectly sum to *DLR*, because not all our BHCs have participations in the equity of both banking and non-banking firms. Wall (1987) works on a sample of BHCs during 1976-1984 and estimates that the investment in non-bank activities is the 7% of the total BHC investment in subsidiaries. Our measure *EQUITY IN NON-BANKING SUBS* is about 2%, when the proportion is calculated with respect to the parent equity capital. For a review on papers discussing the impact of non-banking subsidiaries on risk-taking see Brewer, Fortier, and Pavel (1988). Among others, non-bank subsidiaries are found to be risk-moderating rather than risk-accentuating in the papers from Wall (1987), and Brewer (1989). According to Meinster and Johnson (1979) the diversification into non-bank activities can reduce the volatility of the firm cash. Vander Vennet (2002) says that conglomerates diversifying into non-bank activities are more likely to have higher consolidated revenues, lower operating costs, and lower funding costs. The opposite view that non-banking activities promote risky behaviours is sustained by De Young and Roland (2001), Stiroh and Rumble (2006), and Bebchuk and Spamann (2010).

by the parent on its balance sheet. These securities include equity plus loans, debt, and other receivables issued by subsidiaries.

The two Panels of Table 8-columns (5/6) do not estimate an important effect on these two variables. Thus, only if *DLR* enters the specification we observe that *stdev* reacts in a significant way.

The test of this sub-section is important for remarking what *DLR* captures. *DLR* tells how far the parent equity can respond in front of losses suffered from the subsidiary. *DLR* can be seen as a rough measure for the sharing of capital between the two firms, and informs on the measure in which the distressed subsidiary would rely on the parent capital. The most critical situation would be when the parent holds a huge participation in the subsidiary but has very low capital. Since *EQUITYINSUBS_TA* and *EQUITYINSUBS_TINV* are not measured *vis-à-vis* the parent capital, we might explain why they lack of explanatory power in the specifications.

5.3 Effect of Tax Increases on the Double Leverage Ratio

In this sub-section we want to verify more deeply how changes in *DLR* do reflect information on intra-firm funding. We inspect the impact that an increase in the local corporate tax rate produces on double leverage. A higher tax rate enlarges the tax shield, and firms might will to use debt more extensively.[28] The parent company would find convenient to use debt proceeds for its own funding, as well as for financing the acquisition into subsidiaries. Our expectation is that, when the tax rate increases, the parent is willing to assume much more debt in order to benefit from the tax shield, and, at the same time, is also willing to exploiting double leverage techniques so to save on capital requirements.

We consider the tax changes analysed by Schandlbauer (2014). These are 13 tax increases occurred in 11 different countries of the United States (see Table 13-Panel A). The change in taxation is used as the natural experiment for a difference-in-difference estimation, where we examine how the degree of double leverage of our BHCs responds to the intervention on taxes from the local government.

[28] Schandlbauer (2014) shows that banks react to increases in the local corporate tax rate by adjusting both sides of their balance sheets. For the better capitalized firms of his sample the author observes that the tax increase relates to an increment in the non-depository leverage ratio of the firms. In our analysis we consider the same changes in taxation examined by Schandlbauer (2014). Our Table 13-Panel A is taken from Schandlbauer (2014) and we send to the same paper for information of where the data on the tax changes are taken, and for information on the magnitude of the tax increases.

The sample restricts to the period 2000-2011, since we exploit the information on the tax changes occurred during that horizon. The majority of the tax changes are enacted on the 1st of January, and we assume that the BHCs become subject to higher tax rates starting from the first quarter of the year of enactment. The treated units are the BHCs whose parent firm is incorporated in those countries where the local government has increased the corporate taxation. The control group is defined using propensity score matching, where the matching is done on the base of the same characteristics we used in the Section 3.9.3. We work on the matched sample rather than on the entire sample in order to reduce the presence of confounding effects.[29] We estimate the following regression model:

$$\Delta DLR_{i,t} = \alpha + \beta * Tax\ Increase + \epsilon_{i,t} \qquad (1)$$

The dependent variable *ΔDLR* is the change in *DLR* from one quarter to the other. *Tax Increase* is an indicator variable equal to one if a tax increase occurred in a certain state and quarter, while is equal to zero in the other cases. The subscripts *i* and *t* indicate the BHC and the year quarter, respectively. The coefficient of *Tax Increase* measures the impact from the tax increase on the degree of double leverage. The first column of Table 13-Panel B shows that the estimated *ß* is positive and statistically relevant. This confirms our prediction that, if parent companies find more convenient to issue debt, then part of the proceeds from the issuance might be diverted to fund the affiliated firms.[30]

We also check whether the same tax changes sort an effect in the variation of the variable *EQUITYINSUBS_TA*, which weights the participation into the subsidiaries over the parent total assets. Consistently with the finding from the previous sub-section there is no important effect from *Tax Increase* on *ΔEQUITYINSUBS_TA*.

The difference-in-difference analysis has showed that *DLR* reacts to changes in the corporate tax rate. Based on this result, we decide to use *Tax Increase* as an instrument for *DLR* in the equation for risk-taking. Using a two-stage least squares procedure (2SLS), we regress *stdev* on

[29] We analyse the matched sample for which the matching procedure brings the initial bias to be lower than 4%. The treated units are matched with five control units, with no replacement in the sample. Carlson, Shan, and Warusawitharana (2013) survey the impact from regulatory capital requirements on bank lending, and advocate the benefits from the usage of matching procedures for dealing with the presence of confounding effects in the sample.
[30] The results remain qualitatively similar if we estimate the equation (1) using a panel approach with both quarter and BHC fixed effects. Note that, we observe a positive and significant sign on *ΔDLR* also on the first lag of *Tax Increase*.

NONBANK SUBS, *DEPOSITORY SUBS*, and *DLR*, where *DLR* is instrumented by *Tax Increase*. The instrumental variable (IV) approach is another way to deal with the potential endogeneity of *DLR*, and integrates the several methods implemented in the previous sub-sections. While the previous tests were based on the dichotomous variable *DLR_DUMMY* in this sub-section the IV approach uses the continuous version of *DLR*.

Table 13-Panel C reports the output from the two-stage least squares estimation. In the first stage regression we get the expected positive sign from *Tax Increase* on DLR. The second stage regression estimates positive and significant coefficients on both *DLR* and *SIZE*. Diagnostic checks verify that *DLR* is endogeneous and is not a weak instrument in the risk equation.[31] To conclude, in this sub-section we have discovered that tax changes have important implications on risk-taking via the effect they have on the double leverage of BHCs. These outputs integrate the previous results, offering a stronger support to the claim that we cannot reject the existence of some causality in the inspected relationship.

5.4 Alternative Measure for Risk-Taking

We test the effect from *DLR* on an alternative proxy for the BHC risk, namely the z-score.[32] The z-score is computed as the return on assets plus the capital asset ratio, further divided by the

[31] Some notes on the IV regression are the following. In the equation for *stdev* we excluded on the right hand side *MKB* and *RISKBASED CAP* which we rather had in the OLS specification of Table 8-column (1). The reason is that we encounter some endogeneity problems also on these two variables. We prefer to omit them from the reduced form equation and use the IV approach for facing only the endogeneity of *DL*R in the equation of *stdev*. Finally, some comments on our diagnostic checks. The first-stage regression *F* statistic is slightly below 10. Stock, Wright, and Yogo (2002) say that *F* statistics above 10 would indicate that the employed instruments are not weak, and that the inference based on the 2SLS estimator is reliable. According to the first-stage Angrist-Pischke *F* statistic our instrument is not too weak. In the *C*-test (or, "GMM distance" test) the null hypothesis is that the specified endogenous regressors can actually be treated as exogenous (Baum, Schaffer, and Stillman (2007)). In this case we are largely rejecting the exogeneity of *DLR*. With the Stock and Yogo test instead, we verify whether our instrument is weak. The test is based on the *F* statistic of the Cragg-Donald statistic. The null hypothesis is that the estimator is weakly identified, in the sense that it is subject to bias that the investigator finds unacceptably large. To reject the null, the Cragg-Donald *F* statistic must exceed the critical values tabulated by Stock and Yogo (2005). According to the Stock and Yogo test our equation would not to be weakly identified. For example, if we are willing to accept a rejection rate of at most 10%, than we reject the null of weak identification, since the Cragg-Donald *F* statistic is above the critical value, which in this case would be 16.38.

[32] The z-score is a proxy for banks´ risk-taking in the papers of Boyd and Graham (1988), Brewer (1989), Boyd, Graham, and Hewitt (1993), Stiroh and Rumble (2006), Lepetit et al. (2008), and Laeven and Levine (2009). Onali (2012) investigates the relationship between banks´ dividends and risk-taking. The author argues that the z-score includes at the numerator the ratio of equity to total assets, and this makes the z-score a more appropriate measure for the risk of banks as compared to the standard deviation of returns, because of the importance of equity inside banks. The computation of the z-score is done treating each BHC as a single consolidated organization which survives or fails as a unique company. In this sense we are ignoring the possibility that some subsidiaries might survive, while other subsidiaries are defaulting (Boyd and Graham (1988)).

standard deviation of the return on assets. Since we only have the quarterly values of the returns on assets, we pick the respective standard deviation along years, and the entire z-score is computed on an annual basis. It can be showed that the z-score is inversely related to the probability of insolvency. Thus, a low z-score denotes a high probability of distress. In other terms, the z-score indicates the number of standard deviations below the mean, by which profits would have to fall in a single period in order to eliminate equity, and thus for the firm to become insolvent. The average annual z-score in our sample is 85, and the positive skew reveals that the mass of the distribution is concentrated around relatively low values of insolvency probability.

The z-score is the dependent variable in Table 14. We discover a negative and significant relationship between *DLR* and *zscore*, suggesting that situations of double gearing make the distress of groups more probable.

6. Conclusion

The paper discusses how the risk-taking of banking groups is related to their degree of double leverage. The analysis on United States BHCs shows the existence of a positive correlation between risk and the double leverage ratio, while several econometric tools offer outputs consistent with the hypothesis of a causality nexus between the two.

When BHCs increase in double leverage the group consolidated capital decreases. Despite of this, we claim that double leverage enhances risk appetite in a stronger manner than it brings to a decline in the capital measure. The estimated effect on risk due to intra-firm funding can be seen as reflecting what the United States supervisory authority has defined to be "risk of interdependence" (Board of Governors of the Federal Reserve System, Division of Banking Supervision and Regulation, 2012, Bank Holding Company Supervision Manual, Section 2010.1).[33]

Our suggestion to supervisors and policy makers is to more effectively monitor the dynamics of double leverage financing, and integrate the current capital rules with further monitoring instruments. This would be helpful for containing the adverse economic effects that capital shortfalls at the largest systemically important institutions may have (FDIC Chairman Martin J. Gruenberg, 9 July 2013,
https://www.fdic.gov/news/news/press/2013/pr13060.html).

[33] Previous papers from Black, Miller, and Posner (1978) and Karna and Graddy (1984) talk about a "risk of affiliation."

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Appendix

A1. The View of Financial Authorities on the "Double Leverage" of Banking Groups of Firms

Several authorities make some comments on double leverage while they give recommendations for the discipline of large and complex corporate structures in the financial industry. We now summarize the views from the most representative organizations.

The Board of Governors of the Federal Reserve System defines double leverage as "the situation in which debt is issued by the parent company and the proceeds are invested in subsidiaries as equity" (Board of Governors of the Federal Reserve System, Division of Banking Supervision and Regulation, 2012, "Bank Holding Company Supervision Manual"). A similar definition is given by the Joint Forum, which affirms that situations of "excessive leverage" inside financial conglomerates can give rise to "double gearing," which occurs whenever one entity holds regulatory capital issued by another entity within the same group, and the issuer is allowed to count the capital in its own balance sheet (Joint Forum, July 2001, "Compendium of Documents Produced by the Joint Forum").[34]

More often the issue of double leverage arises in relation to the assessment of the group capital. The reason is that, without taking into account of the reciprocal equity holdings among firms, the capital of groups would be overestimated. The International Monetary Fund defines double leveraging of capital as "situations where related entities share capital (...) Entities are resting activity on the same pool of capital. When capital is double leveraged, the capital actually available to the group to meet unanticipated losses is less than the data implies" (International Monetary Fund (2004)). A similar view relies in the words from the United States Office of the Comptroller of the Currency (formerly The Office of Thrift Supervision), where double leverage is the situation in which "the same capital is used simultaneously as a buffer against risk in two or more legal entities" (Holding Company Handbook (2009)).

[34] The Joint Forum is the international authority deputed to the regulation and the supervision of financial conglomerates. The Joint Forum held its first meeting in January 1996 and has met regularly three times a year since. It is comprised of an equal number of senior bank, insurance and securities supervisors representing each supervisory constituency. Thirteen countries are represented in the Joint Forum: Australia, Belgium, Canada, France, Germany, Italy, Japan, Netherlands, Spain, Sweden, Switzerland, United Kingdom and United States. The European Commission is attending in as an observer capacity (Joint Forum (1999)). The principles dictated by the Joint Forum cover different fields on the regulation and the supervision of financial conglomerates. In particular, the application of those principles should ensure that financial conglomerates are adequately capitalized.

The consequence is that, measures of *solo* capital for banking groups can be misleading, since "only capital issued to external (i.e., non-group) investors provides support to the group" (Joint Forum, 2001, "Compendium of Documents produced by the Joint Forum"). For this reason it is recommended to give evidence in the group-wide capital assessment on the reciprocal exposures existing among the group entities.[35] In general, following the procedures for the consolidation of balance sheets such double counting of capital would be avoided.[36]

According to the United States Office of the Comptroller of the Currency (2009) the degree of double leverage for a certain group can be measured via the so-called "double leverage ratio," defined as the ratio between the equity held in subsidiaries over the stand-alone equity capital of the parent company ("Holding Companies Handbook"). When the double leverage ratio is above 100% the parent firm holds a participation into the subsidiaries which overcomes (in aggregated terms) its stand-alone equity capital, hence the acquisition has been financed using debt proceeds.

One important concern of financial authorities is that practices of double leveraging can undermine the stability of the group. "If (the parent) borrowing results in double leverage, the risk is increased since less "hard" capital is available for support (Board of Governors of the Federal Reserve System, Division of Banking Supervision and Regulation, 2012, "Bank Holding Company Supervision Manual," Section 2010.1).

Double leverage situations involve some "upstream" of dividends. Thus, the invested subsidiary is supposed to pay dividends to the parent. The dividends flow can bring instability, since it "can generate substantial pressure on the thrift to maintain its earnings to support future dividend payments, thereby increasing the temptation for the thrift to engage in higher risk operations (the

[35] The Supplement to the Capital Adequacy Principles Paper (1999) of the Joint Forum provides an example illustrating a situation of double leverage. The firms capital should take into account these circumstances. "Supervisors should require that capital adequacy assessment and measurement techniques address excessive leverage and situations where a parent issues debt and downstreams the proceeds in the form of equity to a subsidiary (Joint Forum, 2011, "Principles for the Supervision of Financial Conglomerates"). "Capital should also be addressed at the parent company level by specifying the degree of double leverage that the parent is willing to accept. The parent's capital policy should provide some measure of assessing each individual subsidiary's capital adequacy in the context of the double leverage within the organization" (Board of Governors of the Federal Reserve System, Division of Banking Supervision and Regulation, 2012, "Bank Holding Company Supervision Manual").

[36] The Basel Capital Accord applies the regulatory capital standard on financial groups on the base of consolidated balance sheets. In general, for subsidiaries not included in the consolidated items of the parent company, holds the principle that the capital invested into those entities has to be deducted from the group capital (Basel Committee, 1999, "A New Capital Adequacy Framework," Consultative Paper Issued by the Basel Committee on Banking Supervision, Bank for International Settlements, Basel).

Office of the Comptroller of the Currency formerly The Office of Thrift Supervision, 2009, "Holding Companies Handbook"). Moreover, the parent firm will rely on the subsidiary´ s dividend for the service of its debt, and this can create some mismatching in the cash flows (Wall and Peterson (1988)). Finally, it should be mentioned that, such upstream of dividends might be subject to limitations on banking dividends imposed by Sections 5199(b) (12 United States Code 60) and 5204 (12 United States Code 56) of the United States Revised Statutes, and by effects from Intercorporate Dividend Taxation − IDT (see Nicodano and Regis (2015)).

A2. Motivating Example: Double Leverage, Capital Ratios, and the Holding Company Risk-Taking

We present in more detail the example of Section 2. Bank Holding Company (BHC) is constituted by the Holding Company (HC) and the subsidiary firm (S). Below are the two stand-alone balance sheets and the consolidated balance sheet: [37]

Holding Company (HC)			
Assets		**Liabilities**	
Loans	L(HC)	Equity	E(HC)
		Debt	D(HC)
Total	L(HC)	Total	E(HC)+ D(HC)

Subsidiary (S)			
Assets		**Liabilities**	
Loans	L(S)	Equity	E(S)
		Debt	D(S)
Total	L(S)	Total	E(S)+ D(S)

[37] The two balance sheets are fully consolidated. Our example is similar to the example we find in the Appendix B from the Office of Thrift Supervision, 2003, "Regulatory Handbook," Section 940B. According to international working groups, the regulation of group-wide capital of financial conglomerates should follow one of the following two approaches: i) capital regulation on a consolidated basis and ii) a solo-plus approach to capital regulation. When capital regulation is applied on a consolidated basis all balance sheets of the group members are consolidated into a unique one, and the capital requirements are applied on the consolidated entity. According to the solo-plus approach instead, the group entities are subject to their own sector regimes, and the supervision is integrated by a group-wide quantitative and qualitative assessment. Common to both approaches is the measurement of group-wide capital adequacy. On this regard, the Financial Conglomerates Directive lists four calculation methods: the accounting consolidation method, the deduction and aggregation method, the book value and/or requirement deduction method, and a combination of all methods. All the four methodologies take care that double leverage effects do not lead to over-counting of capital.

Consolidated Balance Sheet of Bank Holding Company (HC + S)			
Assets		**Liabilities**	
Loans	L(HC) + L(S)	Equity	E(HC) + ~~x*(E(S))~~
~~Book Value of participation in S_A~~	~~x*(E(S))~~	Minority Interests	(1−x)*(E(S))
		Debt	D(HC) + x*(E(S)) + D(S)
Total	L(HC) + L(S)	Total	E(HC)+ (E(S))+ D(HC) + D(S)

The degree of double leverage is measured by the double leverage ratio, expressed as:

$$DLR = \frac{x * E(S)}{E(HC)}$$

Assume that the subsidiary adopts a value neutral strategy which produces with equal probability a loss or a gain of $x\pi$. The libility of HC is limited to its participation into S.[38] Depending on the value of $x\pi$, the table below reports in the second and third columns the expected value of E(HC) depening on whether the strategy is chosen or not. The quantity "delta" in the fourth column is the difference in the expected E(HC) between the two situations, and measures the benefit for HC equityholders from taking the risky project.

Threshold in Profit/Loss	**Expected Value for Equityholders inside HC if S does not play the Risky Strategy (a)**	**Expected Value for Equityholders inside HC if S does play the Risky Strategy (b)**	**Delta (b-a)**
$x\pi \leq$ **E(HC)**	E(HC)	0.5*(E(HC) + $x\pi$) +0.5*(E(HC) – $x\pi$) = E(HC)	0
$x\pi >$ **E(HC)**	E(HC)	0.5*(E(HC) + $x\pi$)+0.5*(0) = 0.5E(HC) + 0.5$x\pi$	0.5*($x\pi$ – E(HC)) = 0.5*(π – E(HC)/x) = 0.5*(π – DLR^{-1}*E(S))

[38] In a parent-subsidiary relationship the principles of limited liability and corporate personality do apply. Although, according to the so-called "source of strength doctrine" there are circumstances in which the holding company provides financial support to distressed subsidiaries (among others, see Gilbert (1991) and Ashcraft (2008), and for a more legal perspective of the topic see Duncan (1987) and the Bureau of National Affairs (1987)). As a matter of fact the parent may or may not be liable for the losses suffered by subsidiaries depending on the type of legal agreement which the firms do have. For instance, firms might be related by Capital Maintenance Agreements (11 United States Code Section 507). In addition, Galgano (1991) notes that the board of the subsidiary works under the influence of the parent, since directors in the subsidiary owe their positions to the parent company. This often brings to confidential directions issued by the controlling shareholders and with which the directors spontaneously comply.

We write "delta" as a function of *DLR* and compute its first order derivative with respect to *DLR*:

$$Delta = 0.5 * \left(x\pi - E(HC)\right) = 0.5 * \left(x\pi - \frac{1}{DLR}E(S)\right)$$

$$\frac{\partial(Delta)}{\partial DLR} = \frac{1}{DLR^2} * 0.5 * E(S)$$

This latter quantity is positive for any *DLR*, namely "delta" is an increasing function of *DLR*.

We measure the capital ratio for BHC as the quotient between the consolidated equity and the consolidated assets. The capital ratio is expressed in terms of *DLR* as follows:[39]

$$Capital\ Ratio = \frac{E(HC) + (1-x)E(S)}{L(HC) + L(S)} = \frac{E(HC) + E(S) - DLR * E(HC)}{L(HC) + L(S)}$$

The first order derivative of the capital ratio with respect to *DLR* is:

$$\frac{\partial(Capital\ Ratio)}{\partial DLR} = -\frac{E(HC)}{L(HC) + L(S)}$$

This latter quantity is always negative for positive values of the corresponding balance sheet items. By comparing the two absolute values of the first order derivatives, we can argue which of the two quantities is more rapidly varying in *DLR*. The increase in "delta" is larger than the reduction in the capital ratio if the following condition holds:

[39] Note that the firm capital includes minority interests. The treatment of minority interests can affect the capital position, therefore supervisors require to take the due attention in applying the method of capital assessment which more properly deals with the relevance of the minority interests held in the various entities of the group (see the Joint Forum, 1999, "Capital Adequacy Principles Paper"). In general, in the Basel environment minority interests are included in the regulatory capital. After the first Basel Accord, several amendments on the definition of BHCs capital have posed some restrictions on the conditions under which minority interests can be classified as capital. Under Basel II tier 1 capital includes qualifying minority interests issued by consolidated depository institutions or foreign bank subsidiaries. Other types of qualifying minority interests are part of tier 2 capital. Basel III has placed qualitative and quantitative limits on the ability of a banking organization to count minority interests towards its consolidated regulatory capital (see the Basel Committee on Banking Supervision, 2010, "Basel III: A Global Regulatory Framework for More Resilient Banks and Banking Systems," available from http://www.bis.org/publ/bcbs189.pdf).

$$\frac{1}{DLR^2} * 0.5 * E(S) > \frac{E(HC)}{L(HC) + L(S)}$$

$$\frac{E(HC)^2}{x^2 * E(S)^2} * 0.5 * E(S) > \frac{E(HC)}{L(HC) + L(S)}$$

$$\frac{E(HC)}{x^2 * E(S)} * 0.5 > \frac{1}{L(HC) + L(S)}$$

$$\frac{1}{x * DLR} * 0.5 > \frac{1}{L(HC) + L(S)}$$

$$\frac{L(HC) + L(S)}{x} * 0.5 > DLR$$

Since *x* can be at maximum 100%, changes in "delta" are greater than changes in the capital ratio when *DLR* is less than the half of the consolidated assets. Given the high order of magnitude that L(HC) and L(S) have inside balance sheets, this condition is very likely to be satisfied using real world data.

To the generic letters we substitute some numbers and study the example in more detail. Assume the following figures:

E(HC) = 30; E(S) = 50; L(HC) = 140; L(S) = 110; D(HC) = 110; D(S) = 60

S can pursue a value neutral strategy providing with equal probability the payoff $\pi = 40$. The table below differentiates the case in which HC holds the share x=80% of S equity, to the situation of full ownership, namely when x=100%.[40]

[40] When $x < 100\%$ HC has not the full control of its subsidiary. When a subsidiary is less than wholly owned, a portion of its income accrues to its non-controlling shareholders and this will be excluded from the consolidated net income (Baker et al. (2005)).

Threshold in Profit/Loss $x\pi > E(HC)$ $x*40 > 30$	**DLR =** $[x * E(S)]/\, E(HC)$	**Capital Ratio =** $\frac{E(HC)+(1-x)*E(S)}{L(HC)+L(S)}$	**Group-Wide Capital Surplus/Deficit**	**Delta**
***x* = 80%**	133%	16%	15	1
***x* = 100%**	167%	12%	5	5
Percentage Change	+20%	-25%	-67%	+400%

The second and third columns report the *DLR* and the capital ratio, respectively. For the two cases, we also report the group-wide capital assessment in the table below.[41] In the fourth column is the ultimate capital surplus/deficit. The capital assessment exercise is done as follows. First, we establish the fraction of capital which the two firms are required to have for regulatory purposes, fixing this share equal to the 10% of the total assets. The capital surplus/deficit stems from the difference between the firm equity capital and the required capital. HC has to subtract from its equity capital the investment in S. The group-wide capital is then the sum of the capital surplus/deficit computed for both firms. The two tables below show the calculations for the two levels of ownership:

***x* = 80%**	**HC**	**S**	**Group-Wide Total**
Equity Capital	30	50	80
Deduct Investment in S	-40	0	-40
Capital Required (10%*Assets)	-14	-11	-25
Capital Surplus / Deficit (-)	-24	39	15

[41] We follow the so-called full accounting consolidation method for the group-wide capital assessment.

x = 100%	HC	S	Group-Wide Total
Equity Capital	30	50	80
Deduct Investment in S	-50	0	-50
Capital Required (10%*Assets)	-14	-11	-25
Capital Surplus / Deficit (-)	-34	39	5

The example had the following tasks. First, we displayed how to compute the double leverage ratio from looking at the balance sheets of HC and S. Second, we related the risk-taking incentive measured by “delta” to the degree of double leverage, measured by *DLR*. An upward change in DLR increases “delta” while reduces the capital ratio. The change in capital is lower in magnitude than the change in risk.

A3. Definition of Variables

Variable Name	Description
stdev (%)	Quarterly standard deviation of parent company stock returns
zscore	Annual z-score: (*ROA* + *CAP*) / Standard Deviation of *ROA*
DLR (%)	Parent company total equity investments in subsidiaries as a percent of the total equity capital of the parent company
DLR_DUMMY	Dummy variable assuming value 1 if *DLR*>100%, while assuming value 0 if *DLR*≤100%
CAP (%)	Total equity as a percent of total assets (from consolidated balance sheet)
RISKBASED CAP (%)	Total risk based capital ratio (consolidated): total capital (tier 1 core capital + tier 2 supplemental capital)/risk-adjusted assets For Call Report and FRY-9C filers, depending on institution attributes and time period, represents total risk-based capital reported under either the U.S. Basel III (B3) revised regulatory capital rules, Advanced Approaches rules or otherwise, or the General Risk-Based (GRB) regulatory capital rules. Preference between the GRB, B3 and B3-Post Parallel Run values is given based on the nature of the filing and the attributes of the various total capital ratios
MKBK (%)	Parent company price as a percent of book value per share
SIZE	Natural logarithm of parent company total assets
LOANS (%)	Net loans as a percent of total deposits (from consolidated balance sheet)
NONINTEREST INCOME (%)	Total non-interest income as a percent of total assets (from consolidated balance sheet)
NONBANK SUBS (# of)	Parent company total number of nonbank subsidiaries
DEPOSITORY SUBS (# of)	Parent company total number of federally insured banking or thrift subsidiaries owned
EQUITY IN BANKING SUBS (%)	Parent company equity investments in bank subsidiaries and associated banks (common and preferred stock) as a percent of the total equity capital of the parent company. Banking subsidiaries include: subsidiary banks and associated banks, subsidiary bank holding companies and associated bank holding companies.
EQUITY IN NON-BANK SUBS (%)	Parent company equity investments in nonbank subsidiaries and associated nonbank companies (common and preferred stock) as a percent of the total equity capital of the parent company
EQUITYINSUBS_TA (%)	Parent company equity investments in subsidiaries (common and preferred stock) as a percent of the total assets of the parent company.

EQUITYINSUBS_TINV (%)	Parent company equity investments in subsidiaries (common and preferred stock) as a percent of the total investments of the parent company in subsidiaries.

Table 5: Summary Statistics for Risk and Bank Holding Company (BHC) characteristics

Results refer to a total number of 465,115 BHC-quarter observations.
All the variables are winsorized at the 1st and 99th percentiles.

Name	Mean	Std dev	1st Quartile	Median	3rd Quartile
Dependent Variables					
stdev (%)	6.704	7.601	2.153	4.564	8.408
zscore (Annual)	85.377	123.369	24.534	54.397	104.126
Regressors					
DLR (%)	108.505	22.453	97.870	100.000	116.570
DLR_DUMMY	0.496	0.500	0.000	0.000	1.000
CAP (%)	9.305	2.939	7.470	8.960	10.650
RISKBASED CAP (%)	15.310	5.359	11.920	14.030	17.050
MKBK (%)	141.741	71.736	91.200	130.100	178.300
SIZE (Natural Log)	11.009	1.560	9.999	10.723	11.553
LOANS (%)	78.871	18.112	67.590	79.290	90.610
NONINTEREST INCOME (%)	1.245	2.492	0.580	0.880	1.300
NONBANK SUBS (N of)	1.582	5.258	0.000	0.000	1.000
DEPOSITORY SUBS (N of)	1.073	0.369	1.000	1.000	1.000
EQUITY IN BANKING SUBS (%)	105.225	25.546	95.611	99.962	115.031
EQUITY IN NON-BANK SUBS (%)	2.056	6.245	0.000	0.000	0.972
EQUITYINSUBS_TA (%)	91.054	14.284	89.236	95.694	98.809
EQUITYINSUBS_TINV (%)	97.493	6.899	98.959	100.000	100.000

Table 6: BHC Risk, Double Leverage Ratio and Risk-Based Capital by Years during 1990-2014

Year	*stdev* (%) (N of Observations)	*DLR* (%) (N of Observations)	*RISKBASED CAP* (%) (N of Observations)
1990	7.356 (357)	116.220 (1988)	14.374 (87)
1991	6.390 (388)	114.611 (2166)	14.572 (1444)
1992	6.097 (413)	112.650 (2343)	15.401 (1602)
1993	6.082 (451)	110.075 (2501)	16.468 (1745)
1994	6.068 (598)	103.632 (2049)	16.550 (1953)
1995	4.746 (877)	102.573 (2247)	16.509 (2151)
1996	4.381 (1068)	102.113 (1903)	16.277 (2421)
1997	5.057 (1298)	101.688 (2932)	16.170 (2806)
1998	6.300 (1553)	101.620 (3426)	16.068 (3310)
1999	5.589 (1763)	103.058 (3929)	15.595 (3813)
2001	5.731 (1940)	104.930 (4750)	14.815 (4664)
2002	5.263 (2012)	106.171 (5231)	15.097 (5163)
2003	4.557 (2100)	107.269 (5779)	15.329 (5734)
2004	4.661 (2220)	109.244 (6337)	15.342 (6266)
2005	4.279 (2355)	110.059 (6702)	15.125 (6608)
2006	3.817 (2448)	113.027 (2659)	13.972 (2662)
2007	5.137 (2537)	111.939 (3133)	13.750 (2759)
2008	10.637 (2616)	112.498 (3293)	13.400 (2882)
2009	11.997 (2644)	111.547 (3674)	14.065 (3182)
2010	9.380 (2669)	113.113 (3953)	14.922 (3404)

2011	9.323 (2688)	112.195 (4165)	15.829 (3585)
2012	7.554 (2701)	111.134 (4387)	16.231 (3734)
2013	6.241 (2737)	109.771 (4568)	16.233 (3899)
2014 (q1)	5.829 (692)	108.730 (1175)	16.258 (1006)

Table 7: Double Leverage Ratio by Level of BHC Risk

The Table reports the output from the Wilcoxon rank-sum test. * p < 0.10, ** p < 0.05, *** p <0.01

BHCs	Lower Risk (a)	Higher Risk (b)	Significance of Difference |a-b|	Prob {*DLR*(a) ≤ *DLR*(b)}
	stdev < 1st quartile	*stdev* ≥ 1st quartile		
DLR	103.811%	106.481%	***	55%
N	5712	21455		
	stdev < 2st quartile	*stdev* ≥ 2nd quartile		
DLR	104.222%	107.464%	***	55.4%
N	12947	14220		
	stdev < 3rd quartile	*stdev* ≥ 3rd quartile		
DLR	104.763%	109.384%	***	56.8%
N	20368	6799		

Table 8: The Determinants of Bank Holding Company (BHC) Risk

Panel A: Pooled OLS regression of *stdev* on BHC characteristics and quarter dummies (not reported) for 1990q1-2014q1. Panel B: Panel Regression of *stdev* on BHC characteristics, quarter and BHC dummies (not reported) for 1990q1-2014q1. Robust standard errors are clustered at the BHC level and are reported in parentheses.* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

	Panel A: *stdev* (Pooled OLS)					
	(1)	(2)	(3)	(4)	(5)	(6)
stdev (t-1)	0.314***	0.337***	0.320***	0.332***	0.321***	0.341***
	(0.019)	(0.022)	(0.021)	(0.028)	(0.020)	(0.028)
DLR (t-1)	0.029***	0.024***	0.080***			
	(0.006)	(0.008)	(0.022)			
SIZE (t-1)	0.107**	0.166***	0.201**	0.100*	0.090*	0.122*
	(0.048)	(0.054)	(0.084)	(0.060)	(0.053)	(0.069)
MKBK (t-1)	-0.007***	-0.009***	-0.006***	-0.008***	-0.007***	-0.008***
	(0.001)	(0.002)	(0.001)	(0.002)	(0.001)	(0.002)
RISKBASED CAP (t-1)	-0.094***		0.305**	-0.128***	-0.140***	-0.177***
	(0.021)		(0.139)	(0.030)	(0.021)	(0.028)
CAP (t-1)		-0.199***				
		(0.054)				
LOANS_DEPOSITS (t-1)			0.000			
			(0.005)			
NONBANK SUBS (t)			0.006			
			(0.013)			
DEPOSITORY SUBS (t)			-0.314*			

			(0.171)			
NONINTEREST INCOME (t-1)			-0.149*			
			(0.077)			
*DLR(t-1)*RISKBASED CAP (t-1)*			-0.004***			
			(0.002)			
*DLR(t-1)*CRISIS_DUMMY*			0.042**			
			(0.017)			
EQUITY IN BANKING SUBS (t-1)				0.028***		
				(0.007)		
EQUITY IN NON-BANKING SUBS (t-1)				0.035**		
				(0.014)		
EQUITYINSUBS_TA (t-1)					-0.010	
					(0.006)	
EQUITYINSUBS_TINV (t-1)						0.005
						(010)
Constant	1.852*	3.587*	-3.310	1.972	6.426***	4.687***
	(1.125)	(1.353)	(2.283)	(1.828)	(1.293)	(1.771)
Quarter Dummies	Yes	Yes	Yes	Yes	Yes	Yes
N	20348	14880	17014	11306	20419	11253
R^2	0.296	0.327	0.312	0.301	0.293	0.295

	Panel B: *stdev* (Panel Analysis)					
	(1)	(2)	(3)	(4)	(5)	(6)
DLR	0.043***	0.014***	0.103***			
	(0.008)	(0.011)	(0.030)			
SIZE	-0.671*	-0.590	-0.916	-0.952*	-0.468	-1.286**
	(0.383)	(0.525)	(0.569)	(0.495)	(0.336)	(0.591)
MKBK	-0.013***	-0.021***	-0.014***	-0.019***	-0.013***	-0.019***
	(0.002)	(0.003)	(0.002)	(0.003)	(0.002)	(0.003)
RISKBASED CAP	-0.111***		0.362*	-0.150***	-0.176***	-0.209***
	(0.033)		(0.205)	(0.051)	(0.037)	(0.052)
CAP		-0.530***				
		(0.099)				
LOANS_DEPOSITS			-0.020*			
			(0.011)			
NONBANK SUBS			0.016			
			(0.043)			
DEPOSITORY SUBS			-			
NONINTEREST INCOME			0.071			
			(0.128)			
*DLR*RISKBASED CAP*			0.043***			

			(0.008)			
*DLR*CRISIS_DUMMY*			-0.671*			
			(0.383)			
EQUITY IN BANKING SUBS				0.041***		
				(0.009)		
EQUITY IN NON-BANKING SUBS				0.006		
				(0.017)		
EQUITYINSUBS_TA					-0.014	
					(0.009)	
EQUITYINSUBS_TINV						-0.009
						(0.020)
Constant	12.500***	17.572***	13.586*	18.865***	17.908***	28.104***
	(4.389)	(5.818)	(7.152)	(5.654)	(4.301)	(6.681)
Quarter Dummies	Yes	Yes	Yes	Yes	Yes	Yes
BHC Dummies	Yes	Yes	Yes	Yes	Yes	Yes
N	20630	15157	17345	11357	20702	11303
R^2 *(Overall)*	0.176	0.200	0.171	0.178	0.185	0.149

Table 9: Granger-Causality Tests from DLR to *stdev*

	H_0: *DLR* does not Granger cause *stdev*
F (Average)	2.669
P-val (Average)	0.425
N	548
P-val ≤ 10% (N of BHCs)	113
P-val ≤ 5% (N of BHCs)	78
P-val ≤ 1% (N of BHCs)	36

Table 10: Analysis on the BHCs with Double Leverage Ratio above 100%

Panel A: Output from the Wilcoxon rank-sum test. The two sub-samples are distinguished according the variable *DLR_DUMMY*. Panel B: Pooled OLS regression of *stdev* on BHC characteristics and quarter dummies (not reported) for 1990q1-2014q1 on the two-sub-samples distinguished by *DLR_DUMMY*. Panel C: Model with endogenous treatment effects for *stdev*. Column (1) estimates the model with maximum likelihood Maddala (1983); robust standard errors are clustered at the BHC level and reported in parentheses. Column (2) estimates the model using a two-step procedure Maddala (1983); standard errors are estimated asymptotically and are reported in parentheses. * p < 0.10, ** p < 0.05, *** p <0.01

Panel A

Variable	*DLR* ≤ 100% (a)	*DLR* > 100% (b)	Significance of Difference |a-b|	Prob {*x*(a) ≤ *x*(b)}
DLR	94.223%	123.022%	***	100.00%
stdev	5.773%	7.572%	***	58.30%
SIZE	10.857	11.159	***	55.00%
MKBK	157.711	148.742	***	44.80%
RISKBASED CAP	17.190%	13.382%	***	25.80%

	Panel B: *stdev* (Pooled OLS)	
	DLR ≤ 100	*DLR* > 100
stdev (t-1)	0.269***	0.335***
	(0.025)	(0.026)
DLR (t-1)	0.003	0.032***
	(0.008)	(0.011)
SIZE (t-1)	0.220***	0.104*
	(0.079)	(0.057)
MKBK (t-1)	-0.004**	-0.007**
	(0.002)	(0.002)
RISKBASED CAP (t-1)	-0.075***	-0.181***
	(0.016)	(0.052)
Constant	3.481**	4.253**
	(1.554)	(2.128)
Quarter Dummies	Yes	Yes
N	9302	10759
R^2	0.223	0.370

Chow Test for Structural Change

H_0: Regression Coefficients are not stable at *DLR*=100%

F(6, 19957)	16.31
P-Val	0.000

	Panel C: *stdev* (Model with Endogenous Treatment Effects)	
	Maximum Likelihood	Two-Step
DLR_DUMMY	2.195***	3.133***
	(0.468)	(0.823)
SIZE	0.009	-0.071
	(0.080)	(0.076)
MKBK	-0.009***	-0.008***
	(0.002)	(0.001)
RISKBASED CAP	-0.099***	-0.063*
	(0.024)	(0.034)
Constant	6.496***	6.296***
	(1.168)	(0.546)
Quarter Dummies	Yes	Yes
N	20619	20619
Wald Test(χ^2)	11.730***	
λ		-1.429***
		(0.498)

Table 11: Propensity Score Matching

Panel A: Quality of the *n-to-n* matching exercise. The matching is done with replacement and caliper equal to 0.00001. The second column of the panel reports the mean values of each variable for treated and control group, before and after the matching. The t-test in the third column tests whether the means are equal in the two samples. The fourth column computes the standardised percentage bias, as the difference of the sample means in the treated and control sub-samples as a percentage of the square root of the average of the sample variances in the treated and control groups (see Rosenbaum and Rubin (1985)). Panel B: Features of the matching and estimates of treatment effects. Figure 1: Histogram of the propensity score by treatment status. Figure 2: *stdev* as a function of propensity scores by treatment status. Panel C: Pooled OLS regression of *stdev* on the matched sample. Robust standard errors are clustered at the BHC level and are reported in parentheses. * p < 0.10, ** p < 0.05, *** p <0.01

Panel A

Variable	Before/After Matching	Mean: Treated	Mean: Control	t-test	Bias (%)
SIZE	Before	12.374	11.512	35.73***	55.6
	After	11.848	11.794	1.14	3.5
MKBK	Before	148.380	161.020	-11.13***	-17.2
	After	151.760	151.190	0.22	0.8
RISKBASED CAP	Before	13.524	15.639	-40.37***	-60.1
	After	13.996	13.920	0.82	2.2
CAP	Before	8.762	9.870	-38.06***	-57.8
	After	9.129	9.119	0.18	0.5
LOANS_DEPOSITS	Before	87.636	82.224	21.78***	33.2
	After	85.631	86.197	-1.02	-3.5
NONBANK SUBS	Before	4.238	1.416	23.86***	38.1
	After	1.947	1.862	0.49	1.1
DEPOSITORY SUBS	Before	1.251	1.146	12.50***	19.5
	After	1.152	1.138	0.83	2.6
NONINTEREST INCOME	Before	1.295	1.186	7.10***	10.9
	After	1.217	1.183	0.98	3.4
		Mean			
Bias (%)	Before	36.541			
	After	2.199			

Panel B

	On Support	Off Support	Total
Untreated	1466	6082	7548
Treated	1520	8277	9797
Total	2986	14359	17345
	Mean	Min	Max
Propensity Score	0.574	0.001	0.978
	Estimate		
ATT	0.453		
ATE	0.478		

Figure 1

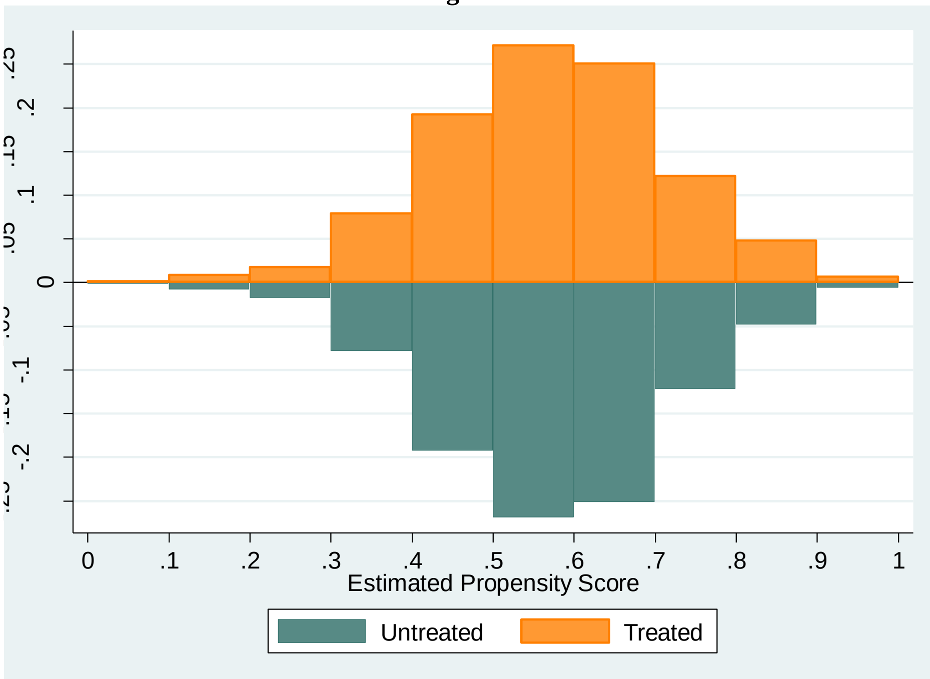
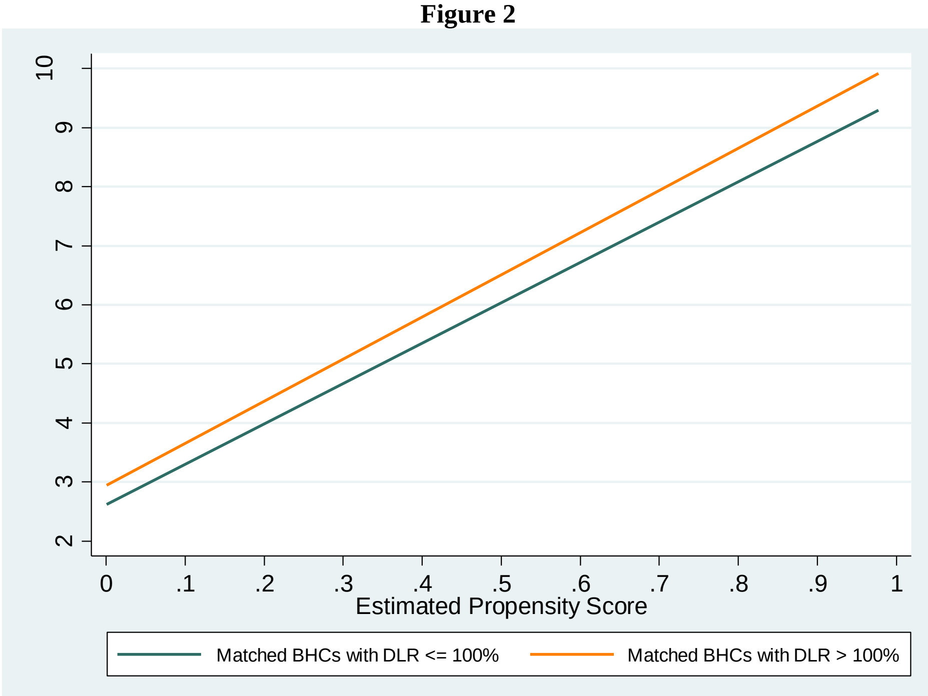


Figure 2



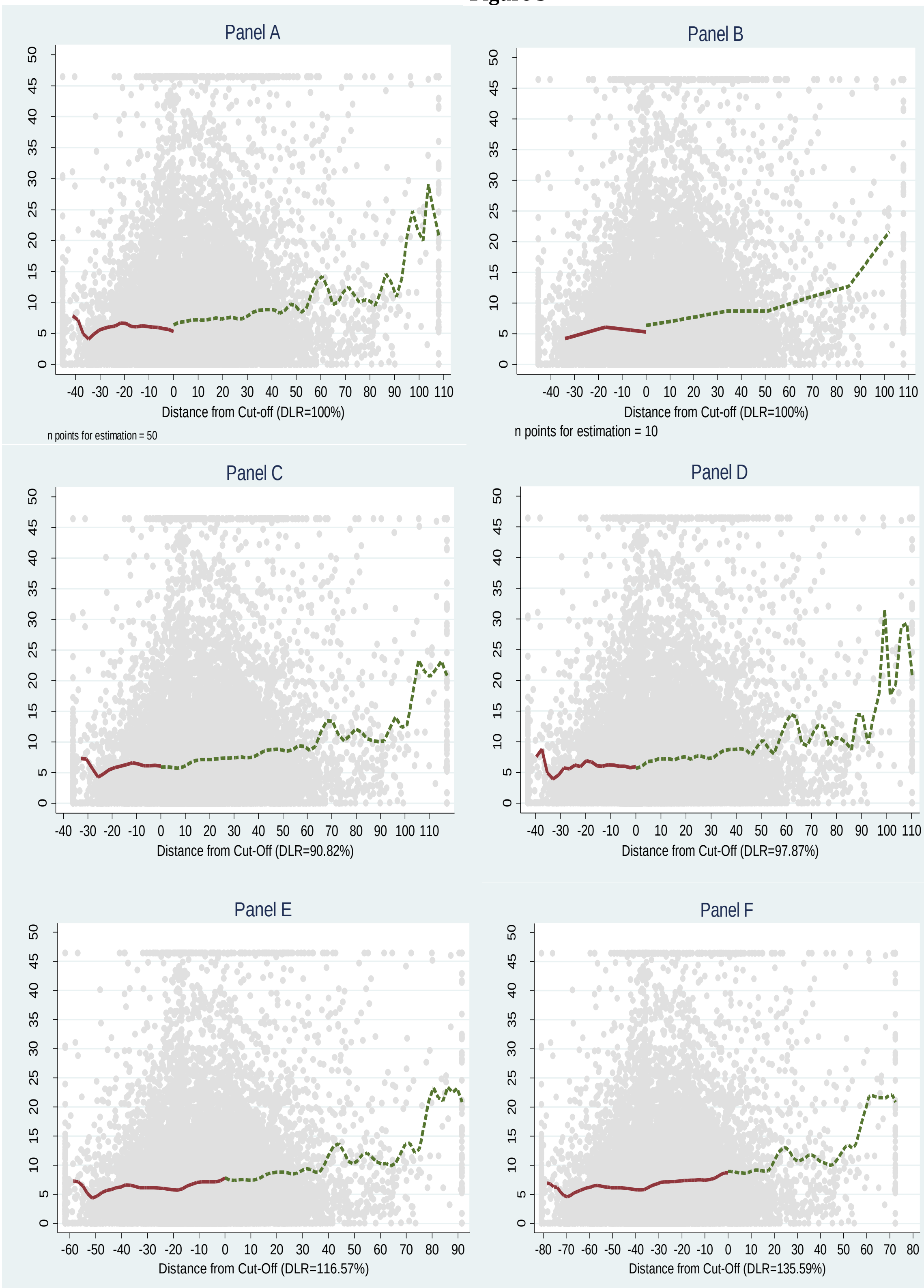
	Panel C: *stdev* (Pooled OLS on Matched Sample)	
	(1)	(2)
stdev (t-1)	0.299***	0.296***
	0.032	0.032
DLR_DUMMY (t-1)	0.567**	
	(0.253)	
DLR (t-1)		0.029***
		(0.009)
SIZE (t-1)	0.407***	0.454***
	(0.140)	(0.141)
MKBK (t-1)	-0.008***	-0.008***
	(0.003)	(0.003)
RISKBASED CAP (t-1)	-0.138**	-0.114**
	(0.058)	(0.057)
LOANS_DEPOSITS	0.003	0.004
	0.009	0.009
NONBANK SUBS	0.033	0.026
	0.031	0.031
DEPOSITORY SUBS	-0.641***	-0.673***
	0.242	0.245
NONINTEREST INCOME	-0.118	-0.102
	0.167	0.167
Constant	1.519	-2.064
	(1.756)	(2.140)
Quarter Dummies	Yes	Yes
N	2911	2911
R^2	0.290	0.293

Table 12: Regression Discontinuity

The Table reports the output from analyses based on regression discontinuity (RD) designs. The outcome variable is *stdev*, while the assignment (or, treatment) variable is *DLR*. Discontinuity is tested for the cut-off values in *DLR* reported in first column. The second column contains the bandwidth, where the optimal bandwidth is the one that minimizes the minimum squared error, as in Imbens and Kalyanaraman (2009). The remaining columns reports results from the local Wald estimation. Estimation is done using local triangle kernel regressions. Figure 3: *stdev* as a function of the distance in *DLR* from the cut-off. In Panel A and B the cut-off is 100%; in Panel A the local regressions are computed in 50 points, while in Panel B the local regressions are computed in 10 points. In Panels C-F the cut-offs are the values corresponding to the 10^{th}, 25^{th}, 75^{th}, and 90^{th} percentile of the distribution of *DLR*, respectively. The local regressions are computed in 50 points.

Cut-off in *DLR*	Bandwidth	Wald Estimator	Standard Error	P-value
100%	Optimal = 3.943	1.038	0.257	0.000
100%	50% of Optimal = 1.971	0.946	0.312	0.000
100%	200% of Optimal = 7.886	1.104	0.211	0.000
90.82%	Optimal = 5.100	-0.157	0.399	0.694
97.87%	Optimal = 2.693	-0.306	0.294	0.297
116.57%	Optimal = 5.176	0.044	0.504	0.931
135.58%	Optimal = 6.422	0.228	1.014	0.822

Figure 3



Panel A
Distance from Cut-off (DLR=100%)
n points for estimation = 50
Panel B
Distance from Cut-off (DLR=100%)
n points for estimation = 10
Panel C
Distance from Cut-Off (DLR=90.82%)
Panel D
Distance from Cut-Off (DLR=97.87%)
Panel E
Distance from Cut-Off (DLR=116.57%)
Panel F
Distance from Cut-Off (DLR=135.59%)

Table 13: Effect of Tax Increases on the Double Leverage

Panel A: Increases in the corporate tax rates of United States countries during 2000-2011. The Panel resembles Table 1 of Schandlbauer (2014). Panel B: Pooled OLS regression of *ΔDLR* and *ΔEQUITYINSUBS_TA* during 2000-2011 on the matched sample. *Tax Increase* is an indicator variable assuming value one if a tax rate increase occurred in a certain country and quarter, while is zero in the other cases. The treated units are the BHCs incorporated in countries experiencing a tax increase during the quarter, and are identified by *Tax Increase* equal to one. The matched control units are determined by propensity score matching. Each treated unit is matched with five control units, without replacement, and on the base on the same BHC characteristics used for the matching exercise of Table 11-Panel A. Panel C: Two-Stage Least Square Regression for *stdev*. *DLR* is instrumented by *Tax Increase*. The critical values for the Cragg-Donald Wald *F* Statistic are taken by Stock and Yogo (2005). Robust standard errors are clustered at the BHC level and are reported in parentheses. * p < 0.10, ** p < 0.05, *** p <0.01

Panel A		
State	Year of Enactment	Type of Tax Change
AL	2001	Income Tax Increase
NH	2001	Income Tax Increase
TN	2002	Income Tax Increase
MD	2008	Income Tax Increase
OR	2009	Income Tax Increase
IL	2011	Income Tax Increase
AR	2003	Introduction of Surcharge Tax
CT	2003	Introduction of Surcharge Tax
CT	2004	Increase of Surcharge Tax
NJ	2006	Introduction of Surcharge Tax
MI	2008	Introduction of Tax on Net Capital
CT	2009	Introduction of Surcharge Tax
NC	2009	Introduction of Surcharge Tax

Panel B				
	ΔDLR	*ΔDLR*	*ΔEQUITYINSUBS_TA*	*ΔEQUITYINSUBS_TA*
Tax Increase (t)	0.855*		-0.050	
	(0.464)		(0.823)	
Tax Increase (t-1)		1.019**		-0.082
		(0.519)		(0.268)
Constant	-0.424	-0.424	1.677**	1.677**
	(0.451)	(0.451)	(0.825)	(0.825)
Quarter Dummies	Yes	Yes	Yes	Yes
N	1361	1361	1360	1360
R^2	0.085	0.085	0.084	0.084

Panel C		
	First Stage	Second Stage
	DLR	*stdev*
DLR		0.809**
		(0.381)
SIZE	-0.096	0.545*
	(0.403)	(0.314)
DEPOSITORY SUBS	0.771	-1.168
	(1.742)	(1.403)
NONBANK SUBS	0.227***	-0.200*
	(0.080)	(0.105)
Constant	106.693***	-84.268**
	(4.562)	(40.421)
Instrument:		
Tax Increase	4.694*	
	(2.400)	
N	22410	22410
F Statistic	9.15***	1.96*
Angrist-Pischke *F* Statistic	3.83*	
C Test		19.986***
Cragg-Donald Wald *F* Statistic		22.4
Critical Values for Cragg-Donald Wald F Statistic	10% max size distortion	16.38
	15% max size distortion	8.96
	20% max size distortion	6.66
	25% max size distortion	5.53

Table 14: The Effect of the Double Leverage Ratio on BHCs Risk – *zscore* as Alternative Measure for Risk

The Table reports the output from the pooled OLS regression of zscore on BHC characteristics and year dummies (not reported) for 1990-2014. The initial quarterly variables are now employed in their average value across year. Robust standard errors are clustered at the BHC level and are reported in parentheses. * p < 0.10, ** p < 0.05, *** p <0.01

	zscore (Pooled OLS on Annual Averages)
DLR	-0.723***
	(0.138)
SIZE	2.129
	(1.731)
MKBK	0.282***
	(0.055)
RISKBASED CAP	1.158
	(1.320)
Constant	137.428***
	(38.030)
Year Dummies	Yes
N	14012
R^2	0.099