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Abstract

Financial authorities (as the Joint Forum and the Board of Governors of the Federal Reserve System) define as "double leverage" the circumstance in which the parent company of a banking group of firms is issuing debt and uses the proceeds for buying equity of subsidiaries. The paper discusses this type of intra-firm financing. We predict that, by double leveraging the parent moral hazard gets more acute, and ultimately leads to higher risk-taking. This risk-incentive might not be counterbalanced by consolidated capital requirements. Empirical results on United States Bank Holding Companies (BHCs) confirm this view. BHCs might want to exploit double leverage techniques in order to arbitrage their capital, with potential consequences on risk. This has got important implications on the financial stability of large banking groups.

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

JEL Classification: G21, G32

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1. Introduction

In the financial industry firms are frequently organized as groups, where a parent company is related to several subsidiary firms.[1] During the last decades, the extension and the complexity of banking groups have grown very rapidly. De Nicolo´ et al. (2004) provide evidence of an increasing trend in consolidation, internationalization, and conglomeration, which tends to accentuate the risk profile of financial firms and can ultimately bring systemic risk.

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 in which the parent firm funds the subsidiaries with equity. As soon as the parent firm is issuing debt in order to invest the proceeds into subsidiaries´ equity, this produces some "double leverage" to the group. 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. We ask whether this type of intra-firm funding has got an ultimate implication on the risk undertaken by the group.

In order to answer this question we provide a simple example where we study how the risk-taking of two hypothesized BHCs varies with their degree of double leverage. We select the items on their balance sheets in a way that they have the same group-wide capital assessment, as well as the same consolidated leverage ratio. Under certain circumstances, the two BHCs might also have the same risk-weighted capital requirement. We show that, inside the BHC where we observe a higher degree of double leverage the parent shareholders might have also higher incentives to undertake riskier projects. The use of double leverage techniques is measured by the so-called "double leverage ratio," defined as the ratio between the equity held in subsidiaries over

[1] The paper does not consider issues concerning the specific organizational structure which the group can assume. There are four types of group structure which are typically distinguished: the integrated model, the parent-subsidiary model, the holding company model and the horizontal group (Dierick (2004)).

the stand-alone equity capital of the parent company (see the Unite States Office of the Comptroller of the Currency, 2009).

Our working hypothesis is that, all else equal, those parent firms which acquire huge participations into subsidiaries by double leveraging do also exhibit higher levels of risk. This happens despite the group is subject to some consolidated capital requirements.

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 holding company stock returns. Regression results reveal that this proxy for risk-taking is positively related to the double leverage ratio. These results are robust to the inclusion of other important aspects driving the BHCs 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 in our results. 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). The employed quantitative methods allow detecting some causality in the inspected relationship. This supports our idea that the risk of banking groups is importantly affected by the funding relationship existing among the interconnected firms.[2]

The paper offers new knowledge on the flows of equity inside banking groups. We establish an increasing relationship between intra-firm equity financing and risk-taking. This has important consequences on the stability of the financial system. Our view is that, by double leveraging financial groups can arbitrage part of their regulatory capital. We argue that, as soon as capital requirements are computed on the base of consolidated balance sheets, they might not calibrate well the type of risk-incentive which this paper has discussed. Regulators and, more generally, policy makers should seriously take into account this result. In the final part of the paper we mention some recent proposals for imposing stronger capital standards on banking groups. The type of dynamics pointed out by this paper might help to evaluate the effectiveness of those proposals.

[2] The model of Freixas, Lóránth, and Morrison (2007) implies different risk-incentives between group structures and stand-alone firms.

So far, the resort from firms on double leverage has been raised much more often by financial authorities rather than academics. 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"). The Joint Forum affirms that, situations of "excessive leverage" inside financial conglomerates can give rise to "double gearing," occurring 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").[3]

The main concern is the ultimate effect that this type of intra-firm financing can have on the assessment of the group-wide capital. In that circumstance "measures of *solo* capital are likely to overstate the external capital of the group (…) [while] 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").[4] For this reason, it is recommended to give evidence in the group-wide capital assessment on the equity participations existing across the group firms.[5]

[3] 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. On the main issues concerning financial conglomerates we send to Herring and Carmassi (2010) and Yoo (2010). Besides the two mentioned in the text, we also mention the United States Office of Thrift Supervision, which denotes "double leverage" as a situation in which "the same capital is used simultaneously as a buffer against risk in two or more legal entities" (Holding Company Handbook (2009))

[4] An example on how double leverage might affect the capital assessment of the group entities can be found in the Joint Forum, 1999, Supplement to the Capital Adequacy Principles Paper.

[5] "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"). "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").

Whenever firms consolidate their balance sheets, accountancy procedures should avoid that capital is double counted.[6]

With this paper we extend with a more academic discussion the views of financial authorities. Our results offer quantitative evidence supporting the opinions from Dierick (2004) and Yoo (2010), who say that significant degrees of double leverage reflect arbitraging of regulatory capital.[7] We are also consistent to Lumpkin (2010), who claims that the "risk" of double gearing is one of the risks carried by financial groups.[8]

As already emphasized, our researched question cannot get important hints from the previous academic papers. There are some relatively old articles which mention issues of double gearing, but do not discuss them in an extensive way. These include Holland (1975), Karna and Graddy (1984), Pozdena (1986), and Wall (1987).

In the next section we develop a simple example which gets some hints from Bebchuk and Spamann (2010). Bebchuk and Spamann (2010) argue that the generic moral hazard[9] problem of equity inside banks might become more severe as soon as firms are organized as bank holding companies rather than as stand-alone firms. The reason is that the holding company has got an additional layer of debt financing which it can use in order to finance the equity capital of the subsidiaries. As soon as those subsidiaries suffer some losses, the equity value of the holding company reduces, leverage raises, and equityholders might want to risk more.

In more general terms, the topic of our paper can be related to the literature on the activities of banking groups. The intra-firm funding belongs to the so-called internal capital market. The features of the internal capital markets of multinational banks have been treated by, among oth-

[6] The Basel Capital Accord applies the regulatory capital standard on groups of firms on the base of consolidated balance sheets items. In general, for subsidiaries not included in the consolidated items of the parent company holds the principle that capital investments into those entities have 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).

[7] The term "capital arbitrage" is meant as in Yoo (2010). Thus, financial groups capitalize on the misalignment between their actual risks taken and the sectoral regulatory requirements that they need to comply with. Kuritzkes, Schuermann, and Weiner (2003) claim that, one limitation of the silo approach for capital regulation of financial conglomerates is the increased potential for regulatory arbitrage.

[8] Fukao (2003) notes how the double leverage inside the Japanese financial industry generates poor quality capital and ultimately raises systemic risk.

[9] The moral hazard problem of equity was introduced by Jensen and Meckling (1976).

ers, Houston, James, and Markus (1997), Houston and James (1998), Campello (2002), De Haas and Van Lelyveld (2010), and Cetorelli and Goldberg (2012).[10]

We focus on the case in which the parent firm uses external debt for investing into the subsidiaries. Papers on the leverage choices of business groups include Bianco and Nicodano (2006), Verschueren and Deloof (2006), Manos, Murinde, and Green (2007), Luciano and Wihlborg (2013), and Luciano and Nicodano (2014). None of these papers though, relate explicitly the usage of debt to the funding of subsidiaries. Closer to this point is De Jong et al. (2011). 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 hence receiving huge dividends from them.

The funding choices of subsidiaries have been studied by Chowdhry and Nanda (1994), Chowdhry and Coval (1998), and Gopalan, Nanda, and Seru (2007).[11] These latter papers look at non-financial firms. To our knowledge there is no paper which studies the funding of subsidiaries inside financial conglomerates.

The paper is organized as follows. Section 2 addresses the research question of the paper. We formulate our testable hypothesis on the relationship occurring between the risk-taking of banking groups of firms and double leverage. This prediction is supported by a simple example where we show how one can assess the presence of some double leverage by the inspection of the firms´ balance sheets, and how it can impact risk. Section 3 is the empirical analysis of the paper. Data are from the United States banking industry, and regard a large sample of BHCs during the period 1990-2014. Several econometric techniques are implemented in order to test the working hypothesis. Section 4 does addition empirical tests. These are important checks which make the interpretations of the estimated outcomes more robust. In particular, the task is to offer stronger support to claims on causality. In Section 5 we discuss our main empirical pattern in relation to the formulated prediction. The discussion emphasizes how our results can be exploited for policy purposes. Section 6 concludes the paper.

[10] 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).

[11] In addition to those papers, we also mention Aggarwal and Kyaw (2008) who 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.

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

2.1 A Simple Numerical Example

The current section has got the following tasks. First, we show how the balance sheets of the group entities would change when parent firms finance their subsidiaries by double leveraging. We consider the simple case of a group with two only entities and no frictions involved. We show how intra-firm funding based on double leverage might impact the group-wide capital assessment. We further show how the rules for the consolidation of balances sheets deal with this issue.[12] Second, with this example we want to stress the importance of our research question. The view point of regulators is that opportunities for double leveraging bring risk to the firm. With the following figures we show that, inside the BHC with highest double leverage the parent shareholders can gain larger benefits from the risky strategy undertaken by the subsidiary. We show that, while differences in the degree of double leverage would correspond to different risk incentives, we might not have different capital assessments for the two firms. The hints we get from this example lead us in stating the working hypothesis of this paper, which is tested in the succeeding section.

The framework of the example is the following. We consider two different Bank Holding Companies (BHCs) denoted with subscript A and B, respectively. The two groups are constituted by two only entities: the Holding Company (HC) and the unique subsidiary firm (S).[13] We consider two periods of time; for simplicity discount rates and taxes are set to zero. Investors are risk-neutral. The example develops in two parts. First we show that the balance sheet items of

[12] 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 should address the concern about double leveraging.

[13] For the legal definition of a "Bank Holding Company" and the related "Subsidiary" see the 12 United States Code Sections 1841-48 (so-called Bank Holding Company Act of 1956). The paper focuses on the parent-subsidiary relationship and we do not discuss the presence of branches. In general, branches of banks are fully owned by their parents and represent their operations. They are not separate legal entities, while subsidiaries, in general, are separate legal entities which are owned or controlled directly or indirectly by the holding company. We use the terms "parent firm" and "holding company" interchangeably.

the two BHCs can be chosen in a way that the two firms have the same capital assessment and consolidated leverage ratio, while having different degree of double leverage, as measured by the so-called double leverage ratio. Second, we demonstrate that, inside the BHC where we compute the highest double leverage ratio, shareholders are better off if the subsidiary is undertaking a risky strategy.[14]

2.2 Two BHCs: Same Capital, Different "Double Leverage"

HC_A acquires the "targeted" S_A.[15] Before the deal HC_A and S_A have got balance sheets as follows:

Holding Company (HC_A)			
Assets		**Liabilities**	
Loans	150	Equity	40
		Debt	110
Total	150	Total	150

Subsidiary (S_A)			
Assets		**Liabilities**	
Loans	100	Equity	50
		Debt	50
Total	100	Total	100

HC_A acquires the full control of S_A by issuing debt.[16] Afterwards, the consolidated balance sheet of the group looks as follows:[17]

[14] Our example is closely related to the example in Bebchuk and Spamann (2010). Bebchuk and Spamann (2010) 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. Our example integrates the example of Bebchuk and Spamann (2010) further showing that, the risk incentive for the holding company shareholders is proportional to its double leverage ratio.

[15] When HC buys more than 50% of the outstanding common stock of S the purchasing company HC has legal "control" over the acquired company. For the definition of control see the Bank Holding Company Act of 1956.

[16] The simple example abstracts from issues which might affect transactions, as taxes or discount rates. We consider two only points in time: the moment in which the holding company and the subsidiary are both in place and the holding company has not invested into the subsidiary yet, and the period immediately after the acquisition. For simplicity, between the two periods there is no further change in the balance sheet composition of the firms. In particular, the holding company is not rising in capital.

[17] 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, 2009, "Holding Company Handbook."

Consolidated Balance Sheet of Bank Holding Company A ($HC_A + S_A$)			
Assets		**Liabilities**	
Loans	150+100	Equity	40 ~~+ 50~~
~~BV participation in S~~	~~50~~	Debt	110+50+50
Total	250	Total	250

Note that, on the consolidated asset side of the balance sheet the participation into S_A offsets with the equity value of S_A on the liability side, and the consolidated entity relies on the holding company capital. The equity-asset ratio for BHC_A results to be equal to 16% (=40/250).

We employ the items from the balance sheets above in order to compute the so-called double leverage ratio. This equals to the stake of the subsidiary´s equity held by the parent company divided by the parent company own equity capital.[18] When the double leverage ratio is higher than one it means that the parent has acquired the subsidiary in a larger measure than its *solo* capital. This implies that the deal has been funded with some debt issuance. The double leverage ratio for BHC_A is DLR = 125% (=50/40).

The capital adequacy of BHC_A is evaluated as follows. We assess the group-wide capital as follows.[19] 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_A has to subtract from its equity capital the investment in S_A. The group-wide capital is the sum of the capital surplus/deficit computed for both firms. The Table below shows the calculations:

[18] We are consistent with the definition of double leverage ratio provided by the Office of Thrift Supervision, now part of the Office of the Comptroller of the Currency, 2009, "Holding Company Handbook." Some empirical papers employ slight different measures for the group 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. In the more recent paper of Krainer and Lopez (2009) the double leverage ratio is computed as we do in this example.

[19] For the group-wide capital assessment we follow the instructions from the Office of Thrift Supervision (2009, "Holding Company Handbook") and from the Joint Forum (1999, "Capital Adequacy Principles Paper"). In particular, among the several methods which institutions can use with discretion in order to assess capital, the example follows the so-called full accounting consolidation method.

	HC_A	**S_A**	**Group-Wide Total**
Equity Capital	40	50	90
Deduct Investment in S_A	-50	0	-50
Capital Required (10%*Assets)	-15	-10	-25
Capital Surplus / Deficit (-)	-25	40	15

On a stand-alone basis HC_A has got a capital surplus of 25. Nonetheless, the investment into S_A brings down its effective capital position. The overall capital for BHC_A is a surplus of 15.

Let´s now consider a second different group. BHC_B is constituted by HC_B and S_B, which have the following balance sheets:

Holding Company B (HC_B)			
Assets		**Liabilities**	
Loans	140	Equity	30
		Debt	110
Total	140	Total	140

Subsidiary B (S_B)			
Assets		**Liabilities**	
Loans	110	Equity	50
		Debt	60
Total	110	Total	110

HC_B acquires the fraction *x* of S_B using debt proceeds. Assuming that *x* equals to 80%, the consolidated balance sheet of the group would be the following:

Consolidated Balance Sheet of Bank Holding Company B (HC_B + S_B)			
Assets		**Liabilities**	
Loans	140+110	Equity	30+~~0.8*(50)~~
~~BV participation in S~~	~~0.8*50~~	Minority Interests	0.2*(50)
		Debt	110+0.8*(50)+60
Total	250	Total	250

Note that, HC_B has to register a minority interest on its liability side.[20] The consolidated equity-asset ratio equals to 16% (=(30+10)/250)).[21] HC_B holds a participation of 40 with respect to its own capital of 30, hence the group has double leverage ratio slightly above 133%. The capital adequacy of BHC_B is summarized in the following Table:

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

Comparing the capital assessments of the two BHCs we note that the group-wide capital for BHC_B is the same as in BHC_A. The consolidated leverage measure based on book values is also the same. We could further assume that the two BHCs have got the same risk weighted assets. In that case, if the capital of the firms is all qualified for regulatory purposes, then the capital ratio we just computed would be close to the regulatory standard. In terms of double leverage instead, the two firms are different. BHC_B is carrying higher double leverage on its structure,

[20] In this case HC_B 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)).

[21] In our example 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).

and HC_B is more largely exposed to the subsidiary.[22] The task of the succeeding part of the example is to show how this exposure might affect the risk-taking of the two parent companies.

2.3 Two BHCs: Different "Double Leverage," Different Risk Incentives

We assume that in both groups the subsidiary adopts a value neutral strategy which produces with equal probability a loss or a gain of $x\pi$. Remember that x is the stake of HC_B owned in S_B. In general, the participation into the subsidiary is an asset for the holding company, thereby the activities run by the subsidiary affect the value for the holding company shareholders.[23] The second and third columns of the table below report the expected value for equityholders inside both HCs. The worth of their claim depends on whether S plays or not the risky strategy, and on the entity of the loss/gain π as compared to the equity value of the holding company. In the last column of the table the quantity delta is the difference in expected value terms between the holding company equity when S is playing the risky strategy, and the same equity when no risk is taken by S. In other terms, delta measures the advantage for the holding company shareholders that the risk-taking of the group is higher.

	Expected Value of HC Equity if:				**Delta (b-a)**	
	S does not play the Risky Strategy (a)		**S plays the Risky Strategy (b)**			
	HC_A	HC_B	HC_A	HC_B	HC_A	HC_B
$0.8\pi < 30$	40	30	$0.5*(40 + 0.8\pi) + 0.5*(40 - 0.8\pi) = 40$	$0.5*(30 + 0.8\pi) + 0.5*(30 - 0.8\pi) = 30$	0	0
$30 \leq 0.8\pi < 40$	40	30	$0.5*(40 + 0.8\pi) + 0.5*(40 - 0.8\pi) = 40$	$0.5*(30 + 0.8\pi) + 0.5*(0) = 15 + 0.4\pi$	0	$0.4\pi - 15$
$0.8\pi \geq 40$	40	30	$0.5*(40 + 0.8\pi) + 0.5*(0) = 20 + 0.4\pi$	$0.5*(30 + 0.8\pi) + 0.5*(0) = 15 + 0.4\pi$	$0.4\pi - 20$	$0.4\pi - 15$

Note: Equity $HC_A = 40$; Equity $HC_B = 30$; Holdings of HC_B into $S_B = 0.8$; π = gain/loss

[22] In both cases we choose values in a way that in the two BHCs the *DLR* is above 100%. This means that the two holding companies are investing into their subsidiaries in a larger measure than their stand-alone capital.

[23] In the example we concentrate only on the benefits for shareholders and do not consider benefits for executive managers.

In the first row the gain/loss π is lower than the equity of HC_B. Given that HC_B is lower than HC_A, inside both groups the loss would be entirely absorbed by the holding company equity. Based on the expected value of their claim, shareholders would not have an advantage that the subsidiary does the risky activity, since the computed delta is in both cases zero. The third row is the extreme case in which the gain/loss overcomes the equity of HC_A. If S is losing π, the equityholders of both firms are wiped out, and part of the loss has to be borne by creditors. The strategy of S brings a positive expected benefit, which is larger for HC_B.[24] The second row represents the intermediate situation in which the loss π triggers the distress inside HC_B, where shareholders are wiped out, while HC_A has got enough capital to absorb the same loss. In this case only inside HC_B the shareholders get a positive delta.

Between the two groups, BHC_B is the firm where we observed the highest degree of double leverage. We have showed that, under certain circumstances, BHC_B might be more encouraged to undertake risk. Recall that, we chose the items of the two balance sheets in a way that they produced the same capital assessment. The task was to point out that, despite the two organizations would be equally assessed on their capital adequacy, the consolidated capital available to BHC_B might be more frequently insufficient for covering losses once that the subsidiary decides to carry the risky project.

2.4 Discussion on the Numerical Example and Empirical Prediction

We discuss the way in which our simple example motivates our research question summarizing the main insights we get from it. We finally formulate the prediction which we test in the empirical part of the paper.

We choose the items on the balance sheets of the two BHCs in a way to point out how the group capital assessment might not reveal potential frictions originating from double leverage on risk. There might be several issues which our example does not take into account exhaustively. Note that the analysis is not developed under the framework of Modigliani and Miller (1958). This might be left to future research, and effort could be spent in order to offer a better modeling for the dynamics which our figures have represented in a very stylized way. Despite of this, we think the example offers the following main insights.

[24] In the last row π is larger or equal than 50. Delta for the equityholders of HC_A is at minimum zero (0.4*50-20=0), while delta for the equityholders of HC_B is at minimum five (0.4*50-15=5).

As the holding company acquires a certain stake in the equity of the subsidiary, it adds an asset to its investment portfolio. If the subsidiary is successful in the risky strategy, the holding company shareholders gain on that asset. At the same time, they suffer a shortfall if the subsidiary is losing on the strategy. In our example we assumed that the holding company is liable in the limit of the exposure towards the subsidiary.[25]

The opportunistic behavior of the holding company might depend on how the firm finances the subsidiary. When the firm invests debt proceeds and at the same time maintains a relatively low stand-alone capital, the moral hazard might get more acute, because shareholders can get larger upsides from the risky activity of the subsidiary.[26] In other terms, we argue that, intra-firm funding of equity producing double leverage can encourage firms to undertake higher levels of risk.

By construction the two BHCs have got the same capital assessment and, under certain conditions, also the same consolidated regulatory capital ratio. Despite of this, the example shows that there are some states in which a certain loss triggers the distress of BHC_B while it is fully absorbed by the capital buffer of BHC_A.[27]

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[25] 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 finds its expressions in the confidential directions issued by the controlling shareholders and with which the directors spontaneously comply.

[26] The outcome would be different in the opposite case in which the holding company raises equity on its own and acquires equity in the subsidiary in the correspondent measure. For example, let´s consider the deal inside BHC_A. HC_A issues equity by 50 and buys all the stocks of S_A. In that case there is no funding of the subsidiary through double leverage, since the holding company is not raising debt on its own. The loss π can be at maximum 50, and we can show that, for all the values between 0 and 50, the delta for shareholders would be always zero, since the capital of the holding company would be 90 (the initial 40 plus the 50 issued for acquiring the subsidiary). In the opposite case we represent in the example instead, the holding company raises the additional 50 by debt. The same loss of 50 is now providing shareholders with a delta equal to five.

[27] As we have remarked, this example is constructed *ad hoc*. We would though exclude that the result we get from the example is an immediate consequence of the fact that, BHC_A fully controls the subsidiary, while in BHC_B the subsidiary in partially owned by the holding company. Let´s construct a third group BHC_C. HC_C has got equity and debt equal to 40 and 100, respectively. S_C has got equity and debt equal to 45 and 65, respectively. In this case HC_C fully acquires S_C by issuing debt. BHC_C have equity-asset ratio equal to 16% (=40/250), and *DLR* equal to 112.5% = (45/40). HC_C has same capital of HC_A. If we compare the risk incentive between the two firms as we did in text, we see that, delta of owners is the same in both cases: zero as long as $\pi \leq 40$, and then turns positive for $\pi > 40$. Inside both BHC_A and BHC_C the subsidiary is fully controlled. We find more plausible that risk-taking incentives would be higher inside HC_A, for the following reason. Losses of $\pi \in (45, 50)$ would be absorbed by the capital of S_A, while the equity of S_C will completely vanish. Consider for example a loss of 47. S_A covers the loss with its

Our expectation on the relationship occurring among double leverage, risk, and banking capital is the following:

A holding company increasingly investing into the equity of its subsidiaries as compared to its own equity capital (thus, having higher "double leverage") might be incentivized to undertake more risk. All else equal, this risk incentive might not be entirely offset by the holding company capital requirement.

The remaining part of the paper is addressed to test empirically this view, and to discuss the policy implications of our results. We conclude this ection with an aside comment regarding the terminology used so far in our article. Financial institutions talk about a "double" counting of leverage. Nonetheless, the figures of the example do never show a duplication of leverage ratios or debt values. The term "double leverage" is to our view relatively inaccurate. It would be more appropriate to say that the parent firm can use "additional" leverage.[28] Namely, the parent can add debt to its capital structure for funding subsidiaries, besides using debt issuances for investments outside the group network. This remains a suggestion, and in the rest of the paper we continue to use the term "double leverage" with the same meaning as in the previous sections.

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

3.1 Sample and Data

The data for this study are obtained from SNL Financial LC. We use information on balance sheet and income statement of firms classified as "Bank Holding Company" (BHC) headquartered in the United States. The frequency of observation is quarterly and our sample spans from

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capital and shareholders on the board remain with value of 3. Inside HC_C instead, equityholders are wiped out, creditors have to bear part of the loss and the firm experiences distress. We might think that the risky strategy offering the payoff $\pi = 47$ could be more attractive to HC_A rather than to HC_C, where owners would place a lower probability of undertaking that action. To conclude, the case presented in this footnote wanted to show that the implications on risk-taking from intra-firm funding do not derive only from the ownership fraction held by the holding company into the subsidiary.

[28] Bebchuk and Spamann (2010) refer to an "additional layer of debt financing" available to bank holding companies. In their discussion they do not mention any regulatory debate around "double leverage," although we find that Bebchuk and Spamann (2010) can give some important hints for understanding double leverage effects inside groups and their implications on risk-taking.

1990q1 till 2014q1. The data provided by SNL Financial LC are collected from the banks filing of the reporting forms FR Y9C, FR Y9LP, and FR Y9SP to the Federal Reserve System.[29]

From the same source we obtain the monthly stock prices for the quoted BHCs. 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.

The results we present exclude those organizations where the holding company is a saving and loan firm, which are the 7.7% of the BHCs covered by SNL Financial LC. We checked that, including those institutions does not change the quality of the results. BHCs with only one quarter of observation are excluded as well, and the final sample counts a total number of 465,115 bank-quarter observations. Around the 97% of the firms are stock corporations, while the rest are mutual holding companies. The 83% of stock corporations are fully privately held firms.

3.2 Risk-Taking

The task is to explore whether the double leverage of a BHC is affecting the risk undertaken by the same firm. The idea is to measure whether cross-sectional differences in the double leverage ratio and other balance sheet and income statement variables are related to risk-taking.

We identify the BHC total risk with the equity market volatility, as in papers from Galloway, Lee and Roden (1997), Lee (2002), and Stiroh (2006). Thus, we measure risk through the standard deviation of the parent firm stock returns (*stdev*).[30] The average *stdev* on the whole sample is 6.7%. Table 2 reports the average *stdev* across years. We note a sharp increase in the average

[29] 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 nonbanking 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 FR Y-9SP is the Parent Company Only Financial Statements for Small Bank Holding Companies. The panel consists of all domestic BHCs with consolidated assets of less than $500 million and with only one subsidiary bank and multibank holding companies with consolidated assets of less than $500 million, without debt outstanding to the general public and not engaged in certain nonbanking activities. For the definition of Bank Holding Company (BHC) we send to the Bank Holding Company Act of 1956.

[30] Other studies test multiple measures of banks´ risk-taking. The equity volatility is often included among these measures by 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 employing the standard deviation of the bank stock returns as a proxy for risk-taking are 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 a stock returns, rather than the volatility of book or regulatory capital.

risk during 2008, and we believe this a consequence of the turmoil experienced in the United States financial market. Till 2012, *stdev* stays always above the mean annual value.

One limitation in the empirical approach of our analysis is the following. We want to identify double leverage effects on risk-taking. Nonetheless, we cannot observe the optimal amount of risk-taking, and the excessive risk-taking behaviour is inherently unobservable. Some measurement error can be spoiling proxies for risk-taking, and there are no good instruments for this errors-in-variables problem (Kim (2013)). Despite of this, we are consistent with some of the previous empirical banking literature which has often approximated risk with the standard deviation of equity. In order to make the interpretation of our results more robust, we also include a subsection where we test effects on an alternative measure for risk-taking.

3.3 "Double Leverage Ratio"

We introduced the "double leverage ratio" in the previous section, where we cited the definition provided by financial authorities on this measure. This number has been computed for the two BHCs of the example. We now calculate the double leverage ratio for the BHCs of our dataset, and the variable *DLR* is equal to the total aggregated investment of the holding company into the equity of subsidiaries divided by the equity capital of the holding company.[31] A high *DLR* denotes the circumstance in which the holding company acquires significant stakes in the equity of subsidiaries by remaining relatively low capitalized.[32]

On average, our BHCs have *DLR* of 108.5%.[33] The years of the recent crisis do not seem having induced large changes in *DLR*, since the average values during the turmoil are not strikingly different with respect to the annual values before and after the turmoil.

We want to see how the relationship between risk and double leverage reveals in the data in unconditional terms. 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

[31] 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 in the subsidiaries. Furthermore, *DLR* cannot be informative on the entire capital structure of the subsidiary.

[32] Wall and Peterson (1988) claim that the double leverage ratio is an inverse function of the BHC strength.

[33] We have scarce quantitative evidence on measures for double leverage. 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%.

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

In our regressions we include a set of control variables which reflect the characteristics of the firm which we deem to be important determinants of risk-taking. The Appendix defines those variables, while Table 1 summarizes their 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 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*). If *MKB* is high, the firm could make higher profits if it continues with the current business, and it might want to avoid those risky strategies which could bring instability.[34] Finally, the size of the organization (*SIZE*) might attenuate risk, so that larger banks can diversify and reduce the variance of their revenues.[35]

The variables presented so far characterise our baseline model for risk-taking. In a separate regression model we test the effect of the following additional covariates. First, we include an 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. We take care for the business model of the firm, normalizing the amount of loans by deposits (*LOANS_DEPOSITS*). The complexity of the organization might matter for explaining risky attitudes. A BHC with

[34] 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. For a more extended discussion on banks charter value and its interaction with risk-control regulation, we send to Galloway, Lee and Roden (1997).

[35] Lee (2002) is interested in the effect on risk-taking from insider ownership. The control set of his regression for the standard deviation of stock returns includes the variables *CAP*, *MKB*, and *SIZE* as defined in our paper. We add to our empirical specifications some other features of our firms which might affect their risk-taking.

numerous subsidiaries might have more opportunities to diversify risk.[36] We count the number of non-bank subsidiaries (*NONBANK SUBS*), and the number of depository subsidiaries (*DEPOSITORY SUBS*).[37] 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.[38] Finally, we take into consideration the fact that our sample includes the crisis of 2007-2009, and want to be sure that the pattern observed in the data is not referable only to the period of the recent turmoil. For this purpose we include the interaction term between *DLR* and a dummy variable assuming value one during the crisis period, which we let go from 2008q2 till 2009q4.[39]

3.5 Empirical Models for Risk-Taking

We estimate regression models which relate the risk-taking of our BHCs to their degree of double leverage and to 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, and we think that the inclusion of *DLR* is a novel and interesting feature of our empirical framework.

Table 4 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

[36] For an overview on the main motives for conglomeration we send, among many, to Dierick (2004). One of the most supported explanations 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 some evidence more closely related to conglomerates in the financial industry we send to Laeven and Levine (2007) and Schmid and Walter (2009).

[37] Depository institutions are banks or savings associations (12 United States Code Section 3201). The average number of depository subsidiaries is almost one, and it is by only a small amount lower than the average number of non-depository subsidiaries. Modern large BHCs tend to have one or few affiliated banks, while more numerous non-bank affiliates.

[38] See for instance DeYoung and Roland (2001) and Stiroh and Rumble (2006).

[39] 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 prefer omitting to report these latter results for not overloading the set of outputs.

we relate the ex-ante risk-taking incentive to the ex-post risk-taking.[40] This type of regression model 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.[41]

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 4-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.[42]

3.6 Empirical Results

Across the outputs of Table 4 the estimated sign on *DLR* in the models for *stdev* 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 4-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. We sustain that this outcome is in line with the prediction we formulated at the end of Section 2.

In the OLS specification of Table 4-Panel A the first lag of the dependent variable is highly and significantly positive, with the highest estimated coefficient among the regressors. 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.[43]

[40] This is similar to Galloway, Lee, and Roden (1997).

[41] OLS specifications are tested in several papers examining 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.

[42] Empirical studies on banking risk-taking which implement 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).

[43] "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 standard deviation though, we would cautious in making any claim on a second stylized fact of "clustering" behavior in the stand-

Concerning the remaining set of covariates, we note that, BHCs smaller in size and with high continuation value would be less induced to risk.[44] In Panel B-column (3) 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.[45]

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 endowed by lot of capital would display less variability in their equity, even if they are rising in the degree of double leverage.

3.7 Granger Causality Test

The timing in the events we assumed in the example of Section 2 is the following. In period (*t*) HC buys equity issued by S and determines *DLR*. Between (*t*) and (*t+1*) S undertakes a risky project. We showed how the quantity delta for shareholders was changing according to the payoff from the project. We might think that the measure for risk-taking computed at (*t+1*) is affected by the risky project undertaken the period earlier. Namely, we could admit that there is a lag-led relationship between the level of *DLR* and the succeeding risk-taking. If this idea holds, it might be meaningful to perform a Granger causality test (Granger (1969)). This can be a first attempt for pinning down problems of endogeneity which our specifications might suffer from. Testing for Granger causality we are asking whether we are better in predicting *stdev* using also the history of *DLR*, instead than using only its own past history.

Through a reiterative procedure, we calculate the Granger causality test for each BHC of the sample. The output is reported in Table 5. For the 14% of the firms we reject the null hypothe-

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ard 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).

[44] 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.

[45] 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).

sis 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 decision on risk.

3.8 Discussion on the Way in which "Double Leverage" Affects the Measure for Risk-Taking

So far we measured the BHC risk-taking through the volatility of the parent firm stock returns. As already pointed out, measuring risk-taking may involve problems of measurement error. Still, the volatility of stock returns remains one of the most largely diffused proxies for risk-taking among banking studies.[46] We think there are several reasons which drive *stdev* to positively correlate to *DLR*.[47,48]

We claimed that, the shareholders of parent firms are benefitted by the risky projects undertaken by the participated subsidiaries. Those projects are likely to make the subsidiaries´ revenues more variable, and this will transfer on the consolidated income statement for the group, which combines the earnings of both parent and subsidiaries. If the stock of the holding company reflects fundamentals, then we should register a higher variability in the parent equity.

Another aspect to be appreciated is the following. Operations of double leveraging do imply some "dividend upstream." Typically, the holding company receives some dividends from the invested subsidiary, and uses such dividends in order to pay back the debt which was initially issued for the acquisition of the subsidiary stock.[49] The dividend amount is not specified on the underlying equity claim, differently than the payment of the debt interest. Dividends highly depend on the capability of the firm in generating significant earnings, and the resulting dividend

[46] We send to the literature mentioned in Section 3.

[47] We verified the year of establishment of our BHCs. For the sample during 2014q1, around the 47% of the firms has been established before or during the year 1990, which is the starting time of our sample. In this way we check that we are not looking at a large group of young firms, where the choices on risk might differ with respect to the same choices at later stages.

[48] Kahn and Winton (2004) describe how financial institutions assume often a "bipartite" structure, where safer assets are separated from the riskier loans which are instead managed by separated subsidiaries.

[49] Explicit claims on the dividend "upstream" can be found in two already cited documents from United States financial authorities. The first is the "Bank Holding Company Supervision Manual," 2012, from the Board of Governors of the Federal Reserve System, Division of Banking Supervision and Regulation (Section 4010.1 and Section 4060.9); the second is the "Holding Companies Handbook," 2009, from the Office of the Comptroller of the Currency, formerly The Office of Thrift Supervision (Section 720.1). A further citation on the dividend "upstream" is in Pozdena (1986).

flow is often volatile. Dividends declaration might also be restricted by regulation.[50] With these comments we might understand that the subsidiary dividend cannot be sufficient for the parent to regularly service the debt obligation, and it might look for higher risk-return profile projects.[51]

In turn, the dividend "upstream" would create some pressure on the subsidiary, as well. In order to pay regular dividends to the parent, the firm might choose to pursue riskier and more profitable strategies, which ultimately make the consolidated revenues more variable.[52]

We have clarified the reasons why we find plausible that, raising in double leverage the stock returns of the parent firm become more dispersed. Nonetheless, in order to make the discussion of the paper more robust, in Section 4.3 we test the impact from *DLR* on another diffused proxy for the BHC risk, namely the z-score.

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

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

The United States supervisor asserts that, a group of firms 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"). Indeed, 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, at least part of that acquisition has been done by using debt proceeds.

We refer to BHCs with *DLR* above 100% as "double levered" firms. We 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 in the remaining cases.[53] Table 6-Panel A shows results from the univariate Wilcoxon test on the two sub-samples. BHCs with *DLR* above 100% have higher

[50] Limitations to banking dividends are imposed by Sections 5199(b) (12 United States Code 60) and 5204 (12 United States Code 56) of the United States Revised Statutes.

[51] Wall and Peterson (1988) say that "the danger in using double leverage is that the BHC parent becomes more dependent on its subsidiaries´ dividend to service its debt." The idea is that mismatching among the holding company cash flows might introduce some instability to the firm.

[52] The Office of the Comptroller of the Currency formerly The Office of Thrift Supervision (2009, "Holding Companies Handbook") affirms that, "[double leverage circumstances] 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." Nicodano and Regis (2014) say that the presence of Intercorporate Dividend Taxation (IDT) results in a double taxation to the ultimate shareholders, and study the effects from IDT on complex organizations´ leverage and financial stability.

[53] In Section 2 we have mentioned papers employing various measures for double leverage. None of those papers discusses whether these measures present cross-sectional differences.

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 4-Panel A. The results are displayed in Table 6-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 last 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 should identify 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

The approach followed so far might not be properly dealing with some residual endogeneity in the outcomes. We detect a significant correlation between *stdev* and *DLR*, although we cannot exclude that our regressions suffer from problems 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 the dummy variable from the previous sub-section (*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 $[0,0,\sigma_\epsilon,1,\sigma]$.[54] Under this assumption, Table 6-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.[55] In 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 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 a certain 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). Once that treated and control units are

[54] 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.

[55] In other terms, ATE is the average difference of the potential risk from double leverage and the potential risk from absence of double leverage. It is also called "average causal effect."

matched, 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.[56] Table 7-Panel A tests the success of the matching on the covariates. The matching reduces the difference in the mean values of the exogenous variables considerably. 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.[57] Figure 1 confirms that 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. 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.[58]

Finally, we perform the same type of regression of Table 4-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 seems to encourage BHCs to assume higher risk.

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[56] The caliper equals to 0.00001. The low value of the caliper reduces significantly the subsample of matched observations, although 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).

[57] 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 (see Rosenbaum and Rubin (1985)).

[58] In the model of Table 6 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 of the potential risk from double leverage and the potential risk from absence of double leverage 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.

3.9.4 Regression Discontinuity Design

Our approach is now the one 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.[59] 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.[60]

Table 8 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 ap-

[59] 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).

[60] According to this strategy, the analysis limits to observations that lie within the close vicinity of the cut-off point (the bandwidth). We follow Imbens and Kalyanaraman (2009) and the optimal bandwidth is the one that minimizes the mean squared error. On those observations within one bandwidth on either side of the threshold we estimate a kernel-weighted local regression using a triangle kernel.

proaches and overcomes the cut-off.[61] This trend is though discontinuous, and we note a jump in *stdev* corresponding on the 100% limit, which identifies an "excessive" double leverage.

Using the same approach, we further test whether there is a discontinuity corresponding to other percentiles in the distribution of *DLR*. On those 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, these latter 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. Furthers Tests

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

We test whether the risk-taking of the parent company varies depending on whether the firm invests into subsidiaries belonging to the banking industry rather than into subsidiaries operating in other industries.

The variable *EQUITY IN BANKING SUBS* in 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 firms not in the banking sector. In general, non-banking subsidiaries do not offer both lending and depository services. Typically, they instead offer non-bank products and services, such as insurance and investment advice, and do not provide Federal Deposit Insurance Corporation insured banking products.[62] 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.[63] From the regression results in the two Panels of Table 4-

[61] 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 variables capturing the "severity" of the double leverage problem is on the x-axis.

[62] 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.

[63] Note that, the values of *EQUITY IN BANKING SUBS*, and *EQUITY IN NON-BANKING SUBS* which we report in Table 3 do not sum to *DLR*, because not all our BHCs have participations in the equity of both banking and non-

column (4), we see a higher statistical significance on the coefficient of *EQUITY IN BANKING SUBS*.[64]

We can relate this outcome to the moral hazard problem of equity. If subsidiaries are not performing well, the holding company shareholders can shift part of their risk towards the subsidiary debtholders. If losses are huge, also the debtholders of the holding company can be asked to bear losses. In the case that subsidiaries are banking firms and their creditors are mostly insured depositors, equityholders might expect that they will rely on the protection from the insurance fund and will be less reactive to actions taken by the property. In these terms we might justify the observed pattern where the risk attitude of the parent shareholders seems to be amplified by investing into banking rather than non-banking firms.

4.2 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 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 4-columns (5/6) do not estimate an important effect on the two variables we just constructed. Only when we use *DLR* as regressor we observe that *stdev* reacts in a significant way.

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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 almost 4%, and the proportion is calculated with respect to the parent equity capital.

[64] Brewer, Fortier, and Pavel (1988) review those papers which question on the impact of non-banking subsidiaries on risk-taking. Among others, non-bank subsidiaries are found to be risk-moderating rather than risk-accentuating in the papers from Wall (1987), and Brewer (1989). Meinster and Johnson (1979) note that diversification into non-bank activities whose cash flows are not correlated with the cash flows from banking activities, may ultimately reduce the volatility of the overall firm cash inflow. 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, this latter thanks to reputation effects or market power. On the other side, various papers sustain the opposite view that non-banking activities promote risky behaviours. These papers include De Young and Roland (2001), Stiroh and Rumble (2006), and Bebchuk and Spamann (2010). In a previous article Holland (1975) affirms that a source of instability brought by the development of BHCs is the riskier quality of assets that some non-bank affiliates might bring into the organization.

The test performed in this sub-section is important for the remark on what *DLR* can capture, and why the other two variables do not sort relevant effects. *DLR* tells how far the parent equity can respond in front of losses suffered from the subsidiary.[65] *DLR* can be seen as a rough measure for the sharing of capital between the two firms. *DLR* should inform 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. The other two tested measures are not measures *vis-à-vis* the parent capital, and this might explain why they lack of explanatory power.

4.3 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.[66] The parent company would find convenient to use debt proceeds for its own projects, but also for the acquisition of larger ownership into the subsidiaries. Our expectation is that, due to the increase in the tax rate, the parent reshuffles its capital structure and gives a larger weight to debt, in order to benefit from the enlarged tax shield, and, at the same time, so to save on the group-wide capital requirement thanks to the double leveraging.

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 9-Panel A).[67] 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.

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

[65] 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)).

[66] 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.

[67] We consider the same changes in taxation examined by Schandlbauer (2014). Our Table 9-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.

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.[68] We work on the matched sample rather than on the entire sample in order to reduce the presence of confounding effects.[69] 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 9-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.[70]

We also check whether the same tax changes sort an effect in the variation of the variable *EQUITYINSUBS_TA*, which weights the participation of the parent into the subsidiaries over the parent total assets. Consistently with the finding from the previous sub-section, in Table 9-Panel B there is no important effect from *Tax Increase* on *ΔEQUITYINSUBS_TA*.

The reason why *DLR* is more sensitive to the tax change than *ΔEQUITYINSUBS_TA* is motivated with the following example. Suppose that, after the tax change, the parent decides to issue

[68] 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.
[69] 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.
[70] 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*.

some debt, while the equity share of the balance sheet remains fixed.[71] If all the newly issued debt goes to finance some new projects of the parent, than after the tax change we should observe no variation in the double leverage ratio, given that, both the participation in the subsidiary and the parent capital remain the same as before the tax change. On the other side, the expansion in assets decreases the weight of the participation over assets, and *EQUITYINSUBS_TA* would be lower. Differently happens when the newly issued debt is used for acquiring larger ownership into the subsidiaries. In that case, given that the parent capital stays constant, *ΔDLR* would be positive. We would also have changes in *EQUITYINSUBS_TA*, although *ΔEQUITYINSUBS_TA* would be higher than zero only when the fraction of the debt issuance devoted to the purchase of the subsidiaries equity is above a certain threshold.

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 *NONBANK SUBS*, *DEPOSITORY SUBS*, and *DLR*, where *DLR* is instrumented by *Tax Increase*.[72] 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 subsection the IV approach uses the continuous version of *DLR*.

Table 9-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.[73] The second stage regression estimates positive and significant coefficients on both *DLR* and *SIZE*. Diagnostic checks verify that *DLR* is endogeneous and that it is not a weak instrument in the equation of risk.[74] To conclude, in this sub-section we have discovered that tax changes have important im-

[71] Effectively, there might be some reduction in the parent capital with consequent increments in *DLR* if the parent firm, for instance, pays cash dividends or has got to cover some losses. We assume that none of these events happens between the point in time in which the tax changes, and the succeeding time, namely when we compute the variation in the firm capital structure.

[72] Note that, on the right hand side of the equation, we excluded *MKB* and *RISKBASED CAP* which we rather had in the OLS specification of Table 4-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*.

[73] 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.

[74] In the *C*-test (or, "GMM distance" test) the null hypothesis is that the specified endogenous regressors can actually be treated as exogenous (see Baum, Schaffer, and Stillman (2007)). In this case we are largely rejecting the exog-

plications on risk-taking via the effect they have on the double leverage of our BHCs. These outputs integrate the previous results, offering a stronger support for the claims on causality in the inspected relationship.

4.4 Alternative Measure for Risk-Taking

We test the effect from *DLR* on an alternative proxy for the BHC risk, namely the z-score.[75] The z-score is computed as the return on assets plus the capital asset ratio, further divided by the 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 9. We discover a negative and significant relationship between *DLR* and *zscore*,[76] suggesting that situations of double gearing make the distress of groups more probable.

5. Discussion and Implication of the Empirical Outputs

eneity 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.

[75] 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.

[76] As done by Boyd and Graham (1988) we remark what follows. 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.

We now briefly sum up the main results from the empirical analysis and discuss how these outputs can contribute to the debate around some recent proposals advanced by financial authorities on the regulation of banking capital.

By implementing several different econometric methods, we get evidence suggesting that parent firms are incentivized to undertake higher levels of risk when the group double leverage is higher. The positive impact from *DLR* on *stdev* is observed while controlling for the firm regulatory capital. We retain that our results confirm the expectation formulated in Section 2.[77]

We now want to discuss in more detail the policy implications of our results. Our estimates suggest that the capital available to BHCs may not entirely absorb the perverse effect on risk-taking originated by double leverage techniques.[78] Our view is that this type of intra-firm funding can give firms opportunities to partially arbitrage their regulatory capital, in accordance to the opinions of Dierick (2004) and Yoo (2010).

The system of risk-based capital requirements developed under the Basel accords might have some pitfalls in capturing the effects proved by this paper. This opinion is close to Jackson (2005), who claims that the system of consolidated capital requirements under Basel II is not capturing subtle issues related to the risk of financial conglomerates. Elliot (2010) says that, the current enforcement powers of regulators over BHCs are weaker as compared to the same powers over single banks.

Supervisors should more carefully consider whether intra-firm funding relationships can end up in making complex institutions more fragile. The United States Office of Thrift Supervision (2009) sustains that the over-reliance of a group on double leverage should trigger more supervision on the institution. Van Lelyveld and Schilder (2003) argue that the existence of double leverage reflects some "regulatory inconsistency," and needs to be regulated. Our paper offers quantitative evidence to these latter views.

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[77] Our results would be consistent with the opinion of some older papers, claiming that, when the parent firm finances the subsidiaries with equity, this exacerbates a sort of "risk of affiliation" (Black, Miller, and Posner (1978) and Karna and Graddy (1984)). Karna and Graddy (1984) argue that the success of a double leverage strategy will "depend on whether double leverage has an independent effect on the risk structure of consolidated banks." Later on, the Unite States supervisor affirms a similar view and state that double leverage might reinforce the "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).

[78] "(…) The bank capital is put at risk due to the increased exposure of the organization, 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).

Ultimately, our outcomes can help in evaluating some recent interventions in the context of banking capital. Basel III would complement the risk-based capital requirements by a simpler non-risk based leverage ratio intended mainly to avoid destabilising deleveraging effects on the financial system.[79] United States Agencies have proposed to strengthen the leverage requirements for United States banking organizations (so-called 2013 rule) 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.[80] The main reason is that the actions taken by banking groups have important consequences on financial stability.[81]

The discussion we dealt in the paper can be useful in appreciating this rule. If BHCs are restricted in their debt levels they might also be less tempted to exploit double leveraging, and this would have the ultimate effect of limiting the overall risk of the group. The new rule could induce also changes in the asset composition of the subsidiaries, since parent companies might decide to move some assets to the non-bank subsidiaries, although those transfers would be limited by the leverage requirement set at the BHC level.

Finally, we mention a recent intervention in the framework of 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 wonder whether European banks could arbitrage the new rule introduced from the Federal Reserve by double leveraging. A European holding company might issue debt and inject capital into the United States subsidiary, so that the foreign entity would then be com-

[79] The general rule establishes a minimum tier 1 leverage ratio requirement of 4% applicable to all insured depository institutions and depository institution holding companies. In July 2013 the Fed proposed to impose covered BHCs to have a minimum leverage ratio of 5%, while the insured depository institutions of covered BHCs had to meet a 6% leverage ratio. See http://www.federalreserve.gov/newsevents/press/bcreg/20130709a.htm.

[80] According to the proposal covered BHCs will be imposed a supplementary leverage ratio of 5% (minimum 3% + 2% buffer), while insured depository institutions will be subject to a minimum 6% of leverage ratio. See http://www.federalreserve.gov/newsevents/press/bcreg/20130709a.htm

[81] "Maintenance of a strong base of capital at the largest, most systemically important institutions is particularly important because capital shortfalls at these institutions can contribute to systemic distress and can have material adverse economic effects" (FDIC Chairman Martin J. Gruenberg, 9 July 2013, https://www.fdic.gov/news/news/press/2013/pr13060.html)

pliant with the new standards. The United States and the European regulator (as well as regulators from other countries) should be concerned by this phenomenon. Evidently, further research is needed in order to support regulators in the set-up of efficient rules for multinational groups.

6. Conclusion

Working on a large sample of BHCs from the United States during the last more than 20 years, we showed that the risk-taking of BHCs is significantly increasing in their degree of double leverage. The standard deviation of the holding company stock returns approximates risk-taking, and is put into relation to the so-called "double leverage ratio." A high degree of "double leverage" identifies the circumstance in which the parent company holds large stakes of subsidiaries´ equity, while maintaining a relatively low *solo* capital. Overall, the discussion and the empirics from this article suggest that the risk-taking of banking groups might depend on the way in which parent companies are financing their subsidiaries; more specifically we show that BHCs are encouraged to risk when the intra-firm funding produces some double leverage.

The estimated pattern is significant while we control for the consolidated regulatory capital of our firms. Our view is that consolidated capital requirements might not fully offset the implications from double leverage on risk, and we cannot exclude that by double leveraging BHCs can circumvent regulatory capital standards.

Our evidence supports the Office of Thrift Supervision (2009) when it argues that the over-reliance of a group on double leverage should trigger more supervision on the same institution. The most important suggestion for policy making hinted by our research is that, the capital rules applied on financial groups should be designed in a way to more narrowly incorporate potential effects on the firm stability originated by intra-firm funding. Despite capital rules are applied on a consolidated basis, cross participations among related entities might create some distortions which can ultimately accentuate the risk profiles of firms. This is line with the view of Van Lelyveld and Schilder (2003), who state that the "regulatory inconsistency" reflected by double leverage opportunities needs to be regulated.

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 effec-

tive 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.[82]

Our discussion can be further related to the claims of some relatively older articles. We have pointed out that intra-firm financing of equity can generate frictions which can be seen as the reflection of some "affiliation" risk (Black, Miller, and Posner (1978), and Karna and Graddy (1984)), or "interdependence" risk (Board of Governors of the Federal Reserve System (1992)).

We have also noted that the term employed by financial authorities might become slightly misleading. Instead than emphasizing a "duplication" of leverage which is not straightforward to note, we rather suggest referring to an additional (or, second) level of leverage available to business groups as compared to single operating entities.

In order to draw attention on the potential effects stemming from double leverage we use a very simple representation of the balance sheets of two BHCs. We choose the items on the balance sheets of the two firms *ad hoc*. A more sophisticated modeling could offer a deeper understanding on the way in which intra-firm funding would interact with risk-taking. This is left for future research.

To conclude, the topic uncovered by this paper is important for the impact that the distress of large banking institutions has got on systemic risk. A strong base of capital at the largest, systemically important institutions is needed for preventing adverse economic consequences. Any regulatory proposals advanced for making the capital regulation of banking group more effective should take into considerations the issues pointed out by this paper.

[82] 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.

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Appendix: 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 1: 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 2: BHC Risk, Double Leverage Ratio and Risk-Based Capital by Years during 1990-2014

Year	*stdev* (%)	*DLR* (%)	*RISKBASED CAP* (%)
	(N of Observations)	(N of Observations)	(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 3: 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 4: 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 5: 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 6: 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 7: 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		t-test	Bias (%)
		Treated	Control		
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

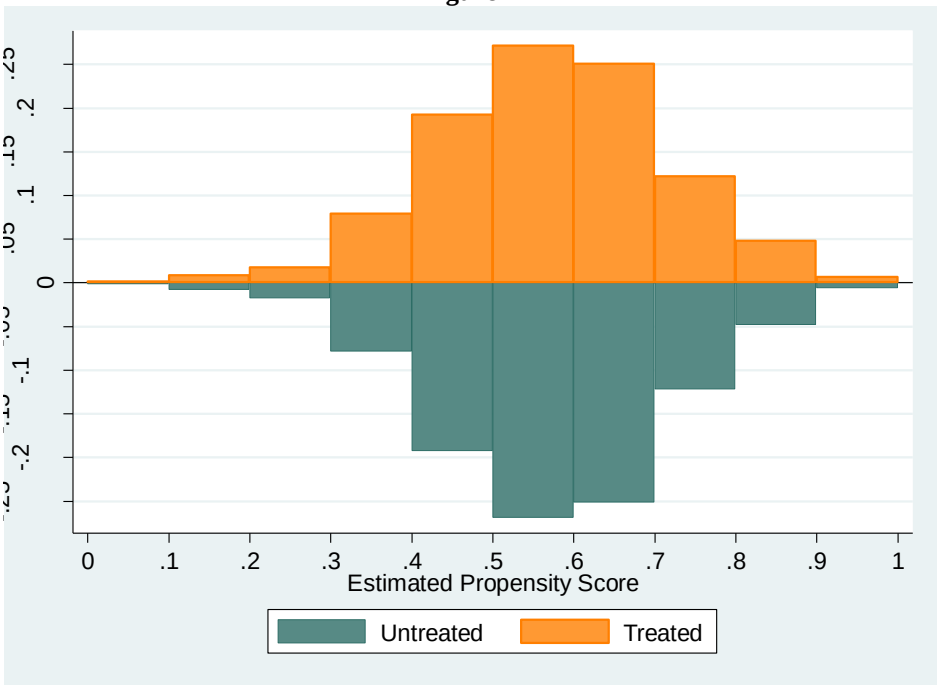
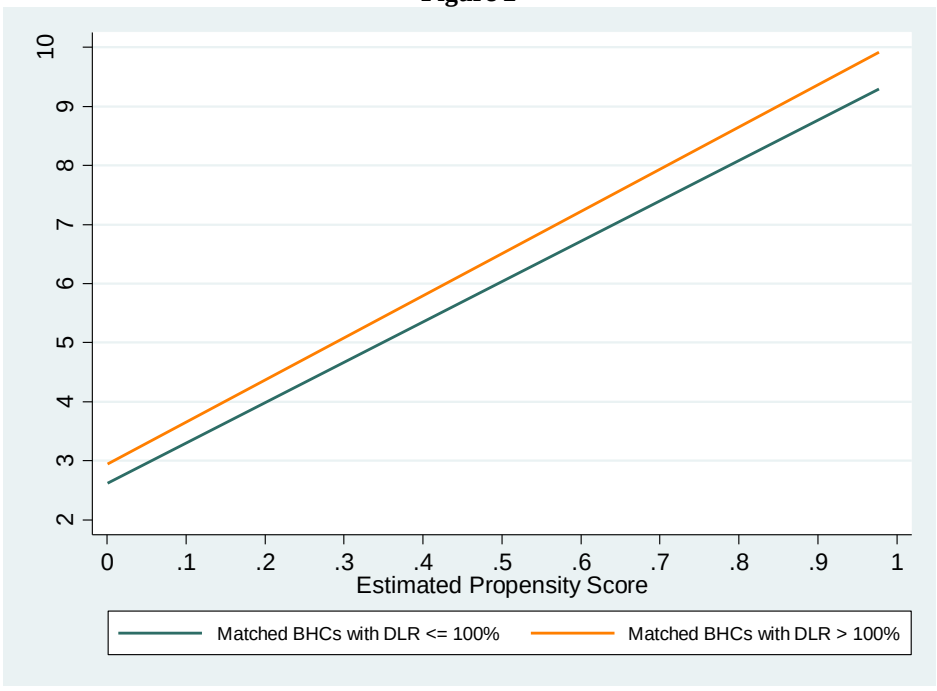


Figure 2



	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 8: 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 2: *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

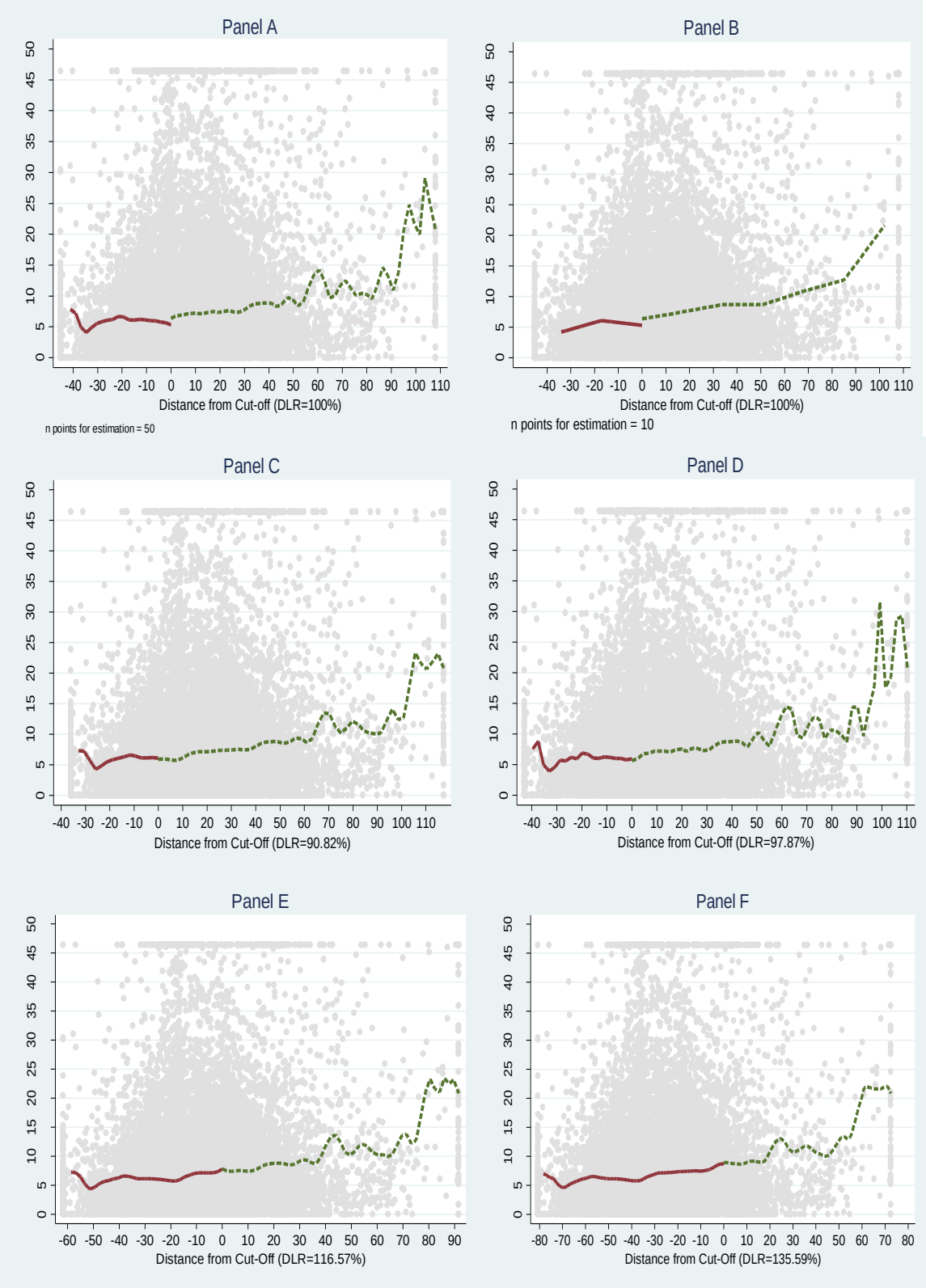

Panel A
Distance from Cut-off (DLR=100%)
n points for estimation = 50
Panel B
Distance from Cut-off (DLR=100%)
n points for estimation = 10
Panel C
Distance from Cut-Off (DLR=90.82%)
Panel D
Distance from Cut-Off (DLR=97.87%)
Panel E
Distance from Cut-Off (DLR=116.57%)
Panel F
Distance from Cut-Off (DLR=135.59%)

Table 8: 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

Table 9: 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 7-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