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Internal capital markets and bank holding company efficiency

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Abstract

Bank Holding Companies and in particular their internal capital markets have been widely discussed in recent financial literature. The financial crisis especially brought regulatory intervention in financial markets into question. Empirical evidence suggests that bank holding companies have clear preferences for double leverage, which are not based on unambiguous and explicit economic foundations. In this article, we analyze the effects of equity, debt and double leverage on the efficiency of bank holding companies. We show that Bank Holding Company efficiency is negatively affected by equity financing from parents to subsidiaries and this effect is even more pronounced in case of double leveraging. Our findings indicate that further measures from regulators are necessary in order to prevent inefficient financing via double leverage, which may be used to circumvent regulatory capital requirements.

KEYWORDS

bank holding companies, double leverage, parent, subsidiary

JEL CLASSIFICATION

G21; G32

1 | INTRODUCTION

Bank Holding Companies (BHCs) are characterized by an internal capital market which enables the inter-related entities to exchange funds. An internal capital market allows a parent company to finance subsidiaries via equity or debt from internal and external sources. The situation of double leverage arises when a parent firm raises external debt in order to acquire stocks of subsidiaries. Financing via double leverage can directly be detected if a BHC has less equity capital than the sum of banks that it owns. In this case, some of the BHC's debt will have been down-streamed to the bank as equity. Following Pozdena (1986), it can be shown that there is no clear advantage to any type of financing, that is, BHCs should be indifferent to both leverage and double leverage. Nevertheless, empirical evidence suggests that the latter is favored.

In this article, we show that this behavior is ambiguous, as it goes along with a reduction in the overall efficiency of BHCs. As a first step, we analyze the efficiency of BHCs using multi directional efficiency analysis (MEA). As a second step we conduct an empirical analysis to investigate possible sources of inefficiency within BHCs to answer the question of whether the different sources of financing provide benefits for the firm or destroy firm value. This study is among the first to link two strands of research. The first is related to the efficiency of banks and BHCs, whereas the second focuses on the analysis of parent subsidiary claim holdings and a discussion of double leverage effects in the context of recent banking regulations.

Efficiency is often interpreted as a measure of diversification benefits or losses, given a specified set of input and output parameters. However, these specifications vary according to the different techniques used for measuring efficiency. In the literature, technical efficiency and cost or profit efficiency are distinguished from each other, and are derived from different financial-efficiency ratios, data envelopment analysis, or multi-directional efficiency analysis (MEA). Efficiency measures provided by stochastic frontier or data envelopment analysis can be limited as the outcome is mainly the overall improvement potential. The use of multi-directional efficiency instead, allows for the analysis of the improvement potential for each of the factors included in the analysis separately, which leads to a more precise distinction between the relative efficiency of BHCs. Since we are interested in the overall improvement potential of both input and output variables, we therefore use a MEA model of mixed orientation. For further discussion on the different pros and cons of the various efficiency measures, see Asmild et al. (2003) or Asmild and Matthews (2012).

Demsetz and Strahan (1997) were the first to show that large BHCs are better diversified than smaller ones. They explain their results through lower capital ratios and larger commercial and industrial loan portfolios. This is also confirmed by Berger and Mester (1997) who use a number of efficiency measures based on parametric and non-parametric methods to analyze the efficiency of BHCs. Vander Vennet (2002) analyzes the cost and profit efficiency of conglomerates and universal banks in Europe. He finds that conglomerates show higher revenue efficiency than firms without stakes in a non-financial companies. Moreover, universal banks show a higher cost and profit efficiency than their specialized competitors.

Using a sample of Canadian banks D'Souza and Lai (2003) show that an optimal level of diversification cannot be reached because of agency problems and regulatory constraints. They measure the "efficiency of financial institutions using a portfolio-allocation approach," so that the inefficiency follows a deviation from the efficient frontier. In addition, Casu and Molyneux (2003) investigate whether there has been an improvement in efficiency across European banking markets since the establishment of an internal capital market. They use DEA efficiency analysis in combination with a Tobit regression model and find that there is a small improvement in efficiency levels.

Acharya et al. (2006) analyze the relationship between bank return and risk, and the degree of internal bank diversification. They focus on the question of how bank returns vary with the level of diversification at different levels of risk and whether this relationship is linear or non-linear for a number of Italian bank holdings between 1993 and 1999.

Elyasiani and Wang (2012) focuses on the effects of the Gramm-Leach-Bliley Act, which enabled the creation of financial holding companies, a subgroup of BHCs. He investigates whether diversification within the holding is associated with an improvement in productive efficiency which should translate into cost-reductions or increases in value.

Asmild and Matthews (2012) point out that former efficiency studies only focus on the level of efficiency and propose the use of multi-directional efficiency analysis (MEA) in order to investigate the potential for improvement. They apply this methodology to stock banks and state-owned banks in China in order to analyze whether there are systematic differences in terms of efficiency and improvement potential between these two types of banks. For our efficiency analysis, we mainly draw on the last two articles. We identify the important input and output factors following Elyasiani and Wang (2012).

The second strand of literature deals with intra-firm claim holdings within the framework of large business groups, something which is still not very well understood. The existence of an internal capital market is one feature which distinguishes business groups from stand-alone firms. Seminal research on internal capital markets deals with non-financial corporations, and the first empirical evidence is from Lamont (1997), who shows that adverse shocks suffered by one segment can spread to other divisions. Subsequent results from Scharfstein (1998) and Scharfstein and Stein (2000) suggest that internal capital markets may lead to inefficient investment, indicating that conglomerates misuse capital.

A number of studies, as for example, Stein (1997), Houston et al. (1997) or Shin and Stulz (1998), investigate the capital allocation mechanism within an internal capital market and document its function to allocate scarce capital to subsidiaries.

Stein (1997) analyzes the rationale behind the creation of internal capital markets and investigate their optimal size under credit constraints. Houston et al. (1997) examine internal capital markets of banks, which are used in order to allocate scarce resources among their subsidiaries. They document a clear relationship between loan growth of the subsidiary and the cash flow of the holding company as compared to the bank's own cash flow or capital.[1] The paper investigates further whether diversification is unsuccessful because of firms' internal capital markets failing to efficiently allocate corporate resources to firm divisions. Internal capital markets could fail because each division is treated as a stand-alone firm that relies mostly on its own cashflow to finance its projects. Shin and Stulz (1998) show that there are internal capital markets within chaebols which allow the reduction of financing constraints at the expense of the firms' efficiency. Meyer et al. (1992) and Scharfstein (1998) provide further evidence that internal capital markets do not allocate resources efficiently by favoring a distribution toward the weakest division.

Dahl et al. (2002) "analyze investment and financing decisions for a broad sample of affiliated and independent banks during the 1994–1998 period." They show that affiliated banks benefit from net equity flows from the parent firm to the subsidiary which implies an increasing role of affiliated banks in aggregate lending. A similar line of reasoning is found in De Haas and Van Lelyveld (2010) who show that subsidiaries grow substantially faster if there is an internal capital market that assists the parental support.

Demirgüç-Kunt and Huizinga (2010) show that banking strategies that make prominent use of non-deposit funding are very risky. Berger et al. (2010) find that diversification in deposits (besides diversification in assets) reduces profits and cost efficiency of Chinese banks.

Also Mukherjee and Pana (2018) analyze the impact of internal capital markets on the strength of the subsidiaries. They “find that smaller bank subsidiaries with lower capital and earnings received more capital than other subsidiaries, which supports…the argument that the distribution of capital was done in accordance with regulatory requirements that mandate bank holding companies to act as a source of strength for their subsidiaries.” Mukherjee and Pana (2018) show results that corroborate the argument that BHCs act as a source of strength for their subsidiaries. This is also confirmed more recently by Avramidis et al. (2020). They show that the existence of an internal capital market leads to a reduction in the default probability of the subsidiaries.

This paper contributes to the literature in several ways. First of all, we extend the view of Elyasiani and Wang (2012) by extending the dataset and using multi-criteria efficiency analysis instead of simple Malmquist indices. Second, to the best of our knowledge, this is the first article to establish a relationship between the efficiency of BHCs and the intra-firm funding of equity between parent and subsidiaries. Therefore, we contribute to the previous research by drawing attention on the reciprocal ownership of equity capital inside banking corporations, which is an aspect of utmost importance for policy-makers, as it relates to the core of financial regulation.

In this context, recent articles raise concerns that intra-firm financing can create per- verse incentives for management, which affect capital positions and implies a high risk potential for banks. For example, Bressan (2016, 2017a) finds that US Bank Holding Companies become financially more unstable as parent firms invest in the securities issued by their subsidiaries. According to Bressan (2017b), “financial authorities have frequently raised concerns about the issue of double leverage because this type of intra-firm financing appears to allow for both the arbitrage of capital and the assumption of risk.” Third, we are the first to directly link the level of a BHC’s efficiency to the source of financing considered. More specifically, we analyze the effects of double leverage on the level of efficiency.

Looking at the evidence, we expect to find that the financing between parent and subsidiaries could be a possible source of inefficiency for BHCs. We analyze a sample of US Bank Holding Companies over the period 2003–2010. The results of the efficiency analysis indicate that changes in BHC efficiency over time are captured reasonably well, that is, BHCs do not move from being least to fully efficient over a short period of time. Only a few BHCs are always fully efficient and the variation in efficiency stays within one to three percentile changes for most BHCs. Furthermore, we find that for the time horizon under consideration, BHCs become on average relatively less efficient over time, with a few exceptions.

Moreover, we find a negative relationship between the efficiency of BHCs and the parent holding shares of subsidiaries’ equity. This effect is even more pronounced in the case of financing via double leverage, that is, when the parent acquires subsidiaries’ equity through external debt. We further find that double leverage significantly increases the consolidated leverage while reducing the efficiency at the same time.

The rest of the paper is organized as follows. Section 2 describes the methods applied in our empirical analysis, and presents the data used. Section 3 contains the results of the analysis, whereas Section 4 draws together the main findings and presents our conclusions.

2 | METHODS AND DATA

As a first step, we analyze the relative efficiencies of the BHCs using multi-directional efficiency analysis (MEA). Then, we run a set of regressions to explain the BHCs’ efficiency using internal capital market measures, double leverage and a number of control variables.

2.1 | MEA specification—General model, input, and output factors

BHCs diversify their risk across their three main areas of business: banking, securities and insurance. However, due to the introduction of recent banking regulations, double leverage became prominent again due to business optimization to satisfy capital adequacy guidelines. A double leveraging strategy is successful for the firm, if there is a significant effect on the risk of the BHC, which, as a consequence, turns into an efficiency loss. Using this line of reasoning, we investigate the relationship between financing and efficiency in general, and double leverage and efficiency in particular.

Multi-directional efficiency analysis is a non-parametric method to determine the relative efficiency of different decision-making units (DMUs) through a set of input and output variables. Thus, it is related more generally to efficiency analysis using linear programming techniques, such as data envelopment analysis (DEA), which allows a direct comparison of firms based on their relative efficiency.[2] DEA can be applied to output orientation, input orientation, or input-output orientation, that is, the maximization of output or minimization of input, or both. MEA was first introduced by Bogetoft and Hougaard (1999) and further developed by Tone (2001) and Asmild et al. (2003). As compared to DEA, it is possible to determine the improvement potential for each input and output factor separately and derive the relative efficiency of DMUs based on the overall improvement potential in an input-output orientation.

Let N be the number of BHCs in each period $t = 1,\ldots, T$. Let $\mathrm{DMU_j}$ with $j \in \mathbb{N}$ at time t produce outputs $y^t_{r,j}$ with $r = 1,\ldots,$ m using inputs $x^t_{i,j}$ with $i = 1,\ldots, n$. A certain $\mathrm{DMU_j}$ under analysis is designated as $\mathrm{DMU_o}$ with $o = 1,\ldots, N$ with the production plan $\left(x^t_o, y^t_o\right)$. The maximum improvement potential is determined by the distance between the current production plan and an unreachable ideal reference point at each t, which represents the ideal production plan $\left(x^{t*}_o, y^{t*}_o\right)$ comprised of different optimal reference values for each input variable given by.

$$\begin{aligned}
&\text{minimize} && d^t_{i,o} && \\
&\text{subject to} && \sum_{j=1}^{N} \lambda_j x^t_{i,j} \le d^t_{i,o}, && \\
& && \sum_{j=1}^{N} \lambda_j x^t_{-i,j} \le x^t_{-i,o}, && -i = 1, \ldots, i-1, i+1, \ldots, n, \\
& && \sum_{j=1}^{N} \lambda_j y^t_{r,j} \ge y^t_{r,o}, && r = 1, \ldots, m, \\
& && \lambda_j \ge 0, && j = 1, \ldots, N,
\end{aligned} \tag{1}$$

and each output variable given by

$$\begin{aligned}
&\text{maximize} && \delta^t_{r,o} && \\
&\text{subject to} && \sum_{j=1}^{N} \lambda_j x^t_{i,j} \le x^t_{i,o}, && i = 1, \ldots, n, \\
& && \sum_{j=1}^{N} \lambda_j y^t_{r,j} \ge \delta^t_{r,o}, && \\
& && \sum_{j=1}^{N} \lambda_j y^t_{-r,j} \ge y^t_{-r,o}, && -r = 1, \ldots, r-1, r+1, \ldots, m, \\
& && \lambda_j \ge 0, && j = 1, \ldots, N.
\end{aligned} \tag{2}$$

Even though the ideal reference point normally lies outside the production set due to technological constraints, the realizable improvement potential for each DMU can be found by projecting the actual production plan onto the efficient frontier ($\lambda*$, $\beta*$) in the direction of the ideal production plan. The efficient frontier constitutes the set of realizable input and output values given the technological frontier derived from the set of DMUs under analysis. The distance to the efficient frontier represents the level of the overall inefficiency of the DMU with respect to all the input and output variables, which is given by the following:

$$\begin{aligned}
&\text{maximize} && \beta^t_o && \\
&\text{subject to} && \sum_{j=1}^{N} \lambda_j x^t_{i,j} \le x^t_{i,o} - \beta^t_o (x^t_{i,o} - d^{t*}_{i,o}), && i = 1, \ldots, n, \\
& && \sum_{j=1}^{N} \lambda_j y^t_{r,j} \ge y^t_{r,o} + \beta^t_o (\delta^{t*}_{r,o} - y^t_{r,o}), && r = 1, \ldots, m, \\
& && \lambda_j \ge 0, && j = 1, \ldots, N.
\end{aligned} \tag{3}$$

A value of 0 implies that no further improvement is possible, that is, this DMU is situated on the efficient frontier and, thus, implies a (Farrell) efficiency level F of 1.

2.2 | Regression analysis

Once the relative efficiencies for a set of BHCs has been derived, a series of Tobit and Probit regression analyses are conducted to investigate the effect of parent-subsidiary financing on BHC efficiency.

We define the variables EiS and $N\,EiS$, which denote the amount of equity and non-equity claims held across the subsidiaries (as a percentage of the total consolidated assets). Equity claims include stocks, goodwill, and other intangible assets, whereas non-equity claims are loans, advances, notes, bonds, debentures, and other receivables. The funding of subsidiaries' equity may lead to instances of double leverage (see Bressan (2017b)). In order to analyze the direct effects of double leverage on BHC efficiency, we use the so-called "double leverage ratio" as given by the following formula:

$$DLR_{i,t} = \frac{\sum_{s=1}^{S} EiS_{s,t}}{E_{BHC_{i,t}}} \tag{4}$$

If the sum of equity held by the subsidiaries s in period t is significantly larger than the equity acquired by the parent firm i, denoted by E_{BHCi}, we deduce that the company is double leveraged.

Based on the efficiency scores resulting from the MEA ($F_{i,t}$), we run the following set of Tobit regressions to explain BHC efficiency using the source of parent-subsidiary financing.

$$F_{i,t} = \alpha_0 + \beta_0 DLR_{i,t} + \lambda_0 \text{Controls}_{i,t} + \gamma_{0,t} + \varepsilon_{i,t} \tag{5}$$

$$F_{i,t} = \alpha_1 + \beta_1 EiS_{i,t} + \lambda_1 \text{Controls}_{i,t} + \gamma_{1,t} + \varepsilon_{i,t} \tag{6}$$

$$F_{i,t} = \alpha_2 + \beta_2 NEiS_{i,t} + \lambda_2 \text{Controls}_{i,t} + \gamma_{2,t} + \varepsilon_{i,t} \tag{7}$$

The control variables are the same for all regressions, and include the logarithm of total assets ($SIZE$), the return on average assets (ROA), the ratio of interest income to assets (II), the ratio of tangible equity to tangible assets (TE), and the complement to one of the risk-based capital ratios (LEV). We also include $TARP$ as the amount of equity received by a BHC under the Troubled Asset Relief Program (TARP) in percentage of the total consolidated assets as a robustness check.[3]

2.3 | Data

The dataset comes from SNL Financial LC and includes all firms available in the database at the time, which are classified as a US "Bank Holding Company."[4] We use quarterly observations for the time period 2003–2010. We utilize information from consolidated as well from unconsolidated (i.e., parent-only) filings. As we assess double leverage using the ultimate parent-only disclosure about its participation in subsidiaries, we use the reporting forms FR Y9-C and FR Y9-LP filed by the BHCs with the Federal Reserve System.[5] We only include BHC observations in the sample for which the amount of equity participation within subsidiaries required to compute DLR as well as all input and output variables for the multi-directional efficiency analysis are available. Thus, the final sample consists of 230 BHCs, which amounts to 6,442 observations in total.

The choice of input and output variables for the efficiency analysis follows Elyasiani and Wang (2012) and Mester (1993). Descriptive statistics for these variables are given in Table 1. We consider total deposits, total assets, and labor costs, computed as the ratio of total expenses for salaries over the total number of employees, as input variables, whereas the output variables are given by total securities, net income, and total loans.

Descriptive statistics for the regression variables are reported in Table 2. It can be observed that parent firms hold equity claims in their subsidiaries in larger measure than non-equity claims, as EiS and $N\,EiS$ are 10% and 0.3% respectively. The average DLR in Table 2 is 110%. We can therefore conclude that the issue of double leverage is substantial in our sample.

TABLE 1 Descriptive statistics of MEA input and output variables

Variable	Mean	Median	Vol	Min	Max
Input					
Total deposits	15,702	1,239	72,655	102	797,578
Total assets	30,052	1,638	160,918	136	1,935,336
Labor costs	68	64	23	-238	391
Output					
Total securities	5,691	424	28,095	9	361,956
Net income	58	3	457	-13,109	5,859
Total loans	18,864	1,436	89,963	94	1,024,966

Notes: This table shows the descriptive statistics for the MEA input and output variables. Total deposits, total assets, total securities, net income and total loans are given in $000. Labor costs are measured by the ratio of compensation and benefits to employees over the average full-time-equivalent employees. Compensation and benefits include salaries, wages, bonuses, commissions, changes in reserve for future stock-option expenses, and other employee benefit costs, also related to employment or retirement benefits, whether paid or deferred, recognized during the period. If the company does not report the average full-time equivalent employees for the period, this is calculated by SNL Financial LC. All variables are calculated on the basis of the information available in the reporting forms FR Y9-C and FR Y9-LP filed by the BHCs of the sample to the Federal Reserve System.

TABLE 2 Descriptive statistics of regression variables

Variable	Mean	Median	Vol	Min	Max
DLR	110.2657	109.4552	24.0889	34.4247	902.2524
EiS	10.0410	9.7760	2.2641	0.9092	36.5774
NEiS	0.3407	0.0000	1.0913	−0.0002	11.8744
SIZE	14.6934	14.3090	1.6661	11.8230	21.3836
ROA	0.7598	1.0000	1.1762	−6.4500	2.2900
INTEREST INCOME (II)	5.3512	5.2800	0.9719	1.4300	9.6400
TANGIBLE EQUITY (TE)	7.7461	7.5000	2.1633	−1.2600	31.7500
LEVERAGE (LEV)	13.7686	13.0900	3.1675	0.9000	51.3600
TARP	3.3862	3.1165	1.7411	0.7414	27.3891

Notes: This table shows the descriptive statistics of the regression variables. *DLR* denotes the double leverage ratio as computed in Equation 4, where *EiS* and *N EiS* represent the amount of equity and non-equity claims held by the parent company across all subsidiaries in a percentage of the total consolidated assets. Equity claims include stocks, goodwill, and other intangible assets, whereas non-equity claims include loans, advances, notes, bonds, debentures, and other receivables. *SIZE* is the logarithm of total assets; *ROA* is the return-on-assets computed as the ratio of net income to total assets in percentage terms; *I* is the ratio of interest income to total assets in percentage terms; *TE* is the ratio of tangible equity to tangible assets in percentage terms; *LEV* is the complement to 100 of the risk-based capital ratio as computed in accordance with the requirements established by the Basel II Capital Accord. *TARP* is the amount of equity received by a BHC under the Troubled Asset Relief Program (TARP) in percentage of the total consolidated assets. All variables are calculated on the basis of the information available in the reporting forms FR Y9-C and FR Y9-LP filed by the BHCs of the sample to the Federal Reserve System.

3 | RESULTS

First, we describe the results of the MEA analysis. Second, the regression results are described, allowing us to explore the relationship between efficiency and the source of financing from the perspective of a BHC.

3.1 | BHC efficiency

Since the efficiency analysis is conducted on a quarterly basis, the results of the efficiency analysis comprises a time series of efficiency scores for each BHC. Figure 1 shows the distribution of average efficiency scores for each BHC over the total sample period. The average efficiency score in the sample is between 0.70 and 0.75, which accounts for roughly 55% of all BHCs. Around 10% of BHCs are, on average, fully efficient, with 27% of BHCs exhibiting mean MEA scores between 0.8 and 0.95. Only approximately 5% of firms have an average efficiency score of under 0.70.

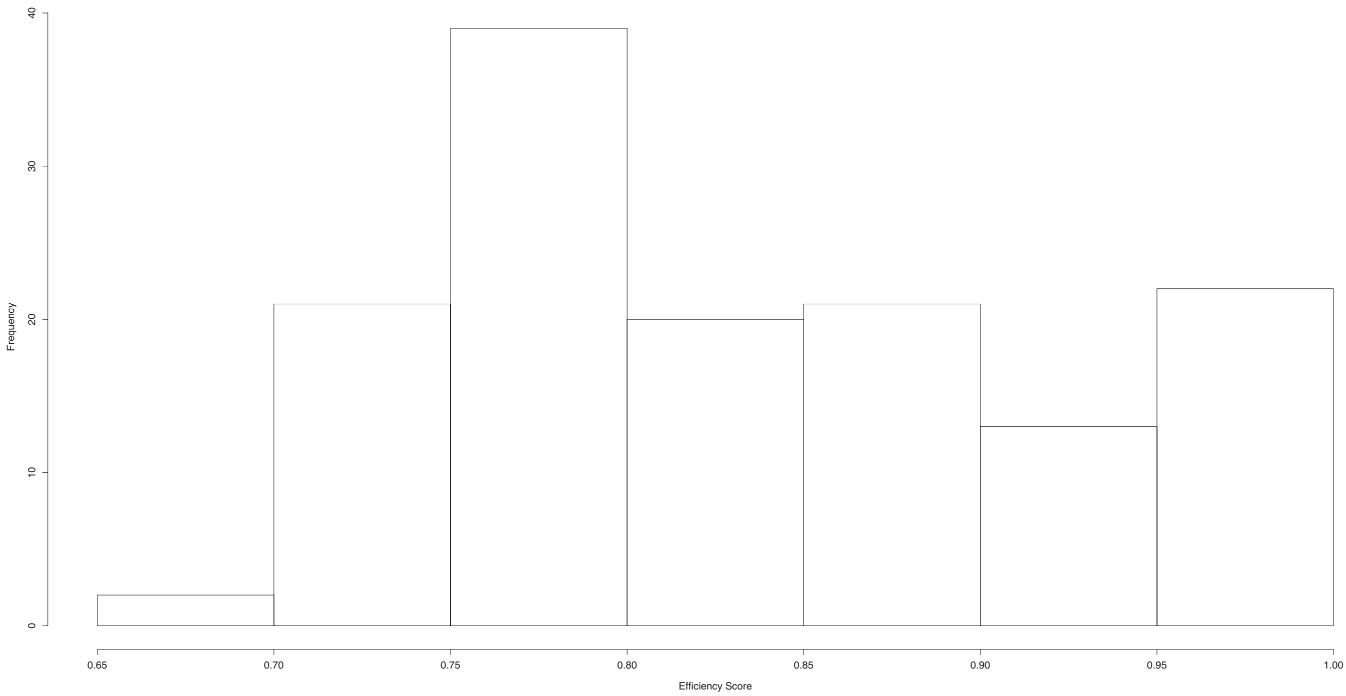

FIGURE 1 Distribution of average BHC efficiency scores over the total sample period. Notes: This figure shows the distribution of quarterly efficiency scores estimated using multi-directional efficiency analysis. For each BHC the relative efficiency in comparison to all other BHCs in the sample is evaluated quarterly from 2003 to 2010

In order to understand the consistency of the efficiency measurement over time, we group the periodic MEA scores into percentiles and track the percentile changes over time. We compute the cumulative percentile changes to map the path a particular BHC has traversed in order to understand how far the BHC has departed from its starting evaluation. This provides insights into the robustness of the multi-directional efficiency analysis over time. Table 3 shows descriptive statistics for the distribution of the sum of total percentile changes across all BHCs. We observe that roughly 43% of BHCs are in the same efficiency percentile at the end of the observation period as at the beginning. Roughly 11% have moved down one percentile, whereas 17% have moved down two or more percentiles. About 27% have moved up at most 3 percentiles, with less than 1% of BHCs ending up four percentiles higher than their starting percentile. Columns 3 to 7 show that periodic efficiency scores do not experience much variation between periods, especially for BHCs belonging to the center of the distribution of percentile changes. BHCs belonging to the tails of the distribution display higher volatility as well as higher maximum and minimum periodic percentile changes, and higher total absolute percentile changes. This implies that roughly one third of BHCs in the sample experience more frequent and higher efficiency changes over time.

Table 4 highlights the mean results of the input and output factors of the MEA for BHCs grouped into two panels. Panel A shows the MEA score with input and output variables divided into four groups according to the level of efficiency, which range from the lowest efficiency score in the sample given by 0.4 to the highest efficiency score given by 1. In panel B we also sort BHCs according to efficiency scores, but we split the sample into four groups with the same number of observations in each group. If only one input and one output was considered, a clear interpretation would be possible, that is, a firm B with a higher output than firm A would be classified as more efficient than firm A, given the same input for both. However, since we refer to several inputs and outputs, and production plan changes can happen on multiple dimensions, such a clear interpretation is not possible. Panel A shows that 27% of firms' observations exhibit full efficiency, whereas most observations lie between 0.6 and below 0.8, which is in line with Figure 1.

3.2 | Regression results

Table 5 displays the estimates for equations in 5–7. The three regressions differ only in the variable measuring the claim-holdings of the parent within the subsidiary. We separate the investment of the parent into equity versus non-equity of subsidiaries, captured by the variables *EiS*, *N EiS,* and *DLR* defined in section (2.3).

The first two columns reveal that efficiency decreases with the parent stake in subsidiariess' equity. The negative impact of double leverage (*DLR*) is slightly stronger than the negative impact of the parent's equity holings in the subsidiaries (*EiS*). This means that the use of double leverage exerts a more pronounced negative effect on BHCs' efficiency. This is in line with the findings in Bressan (2017b).

TABLE 3 MEA results: Distribution of percentile changes over time

$\sum \Delta P(Fi,t)$	#	μ	σ	Min	Max	$\sum \Delta \lvert P(Fi,t) \rvert$
-3	12	−0.10	1.14	−3.17	2.58	19.00
-2	28	−0.06	0.80	−2.25	1.68	12.64
-1	25	−0.03	0.68	−1.68	1.60	10.76
0	101	0.00	0.69	−1.68	1.72	10.77
1	38	0.03	0.69	−1.61	1.63	11.42
2	11	0.06	1.02	−2.18	2.36	17.82
3	12	0.10	0.93	−2.08	2.58	14.50
4	3	0.13	1.03	−2.33	3.00	14.00

Notes: This table shows the MEA results with regards to the percentile changes over time. MEA scores are grouped into percentiles P (Fi,t) and quarterly percentile changes are observed over time, that is, the MEA score of a particular BHC moves up/down one or more percentiles from quarter $t-1$ to t. Column 1 shows the sum of total percentile changes over the whole observation period grouped from the most negative to most positive total percentile change observed. Column 2 reports the number of BHCs belonging to each group defined under Column 1. All values shown in Columns 3 to 6 are means for each group of the distribution. Columns 3 and 4 report the mean periodic percentile change and volatility. Columns 5 and 6 indicate the minimum and maximum percentile change over the whole observation period. Column 7 displays the sum of absolute percentile changes of the average BHC in each group. It shows that BHCs belonging to the tails of the distribution switch percentiles more often compared to other BHCs.

TABLE 4 MEA results: Mean results for input and output variables

	MEA score	Total deposits	Total assets	Labor costs	Total loans	Total securities	Net income	# Obs
Panel A								
MEA Range								
1	1	4,0165,005	81,490,391	68	50,354,889	15,767,333	165,286	1,715
[0.8, 1)	0.81	1,278,982	1,833,940	56	1,556,436	590,272	5,523	139
[0.6, 0.8)	0.72	4,759,643	6,786,578	69	5,430,536	1,642,988	11,051	4,536
[0.4, 0.6)	0.55	201,986,230	438,520,528	110	198,404,134	40,182,362	763,923	52
Panel B								
MEA Quartile								
Q I	1	35,843,590	75,962,032	68	43,783,722	15,095,820	143,777	1,610
Q II	0.79	9,403,293	14,308,199	63	12,826,830	2,583,829	41,688	1,610
Q III	0.73	3,427,470	4,784,942	68	4,062,272	1,148,339	10,669	1,610
Q IV	0.68	14,136,527	25,160,727	76	14,790,110	3,940,472	36,169	1,612

Notes: This table shows the mean values for inputs and outputs for the MEA results. In the top half of the table the BHCs are grouped according to MEA score levels. The bottom half shows the values for BHCs grouped into quartiles. Total deposits, total assets, total securities, net income and total loans are in $000. Labor costs are measured by the ratio of compensation and benefits to employees over the average full-time-equivalent employees. Compensation and benefits include salaries, wages, bonuses, commissions, changes in reserve for future stock-option expenses, and other employee benefit costs, also related to employment or retirement benefits, whether paid or deferred, recognized during the period. If the company does not report the average full-time equivalent employees for the period, this is calculated by SNL Financial LC. All variables are calculated on the basis of the information available in the reporting forms FR Y9-C and FR Y9-LP filed by the BHCs of the sample to the Federal Reserve System. The column # Obs indicates the number of observations across all BHCs which belong to the MEA Range or MEA Quartile.

TABLE 5 Results of Tobit Regressions 2003:Q1 - 2010:Q4

Variable	(1)	(2)	(3)
DLR	−0.033** (0.015)		
EiS		−0.019*** (0.001)	
NEiS			0.011*** (0.003)
SIZE	0.013*** (0.002)	0.021*** (0.002)	0.010*** (0.002)
ROA	0.025*** (0.002)	0.026*** (0.002)	0.026*** (0.002)
II	0.042*** (0.004)	0.046*** (0.004)	0.039*** (0.004)
TE	−0.004** (0.002)	0.004** (0.002)	−0.002 (0.002)
LEV	−0.012*** (0.001)	−0.014*** (0.001)	−0.012*** (0.001)
Observations	6,408	6,408	6,408

Note: This table shows the results of the Tobit regressions investigating the effect on efficiency of parent-subsidiary claim-holdings for the total observation period. *DLR* denotes the double leverage ratio computed as in Equation 4, where *EiS* and *N EiS* represent the amount of equity and non-equity claims held by the parent company across all subsidiaries as a percentage of the total consolidated assets. Equity claims include stocks, goodwill, and other intangible assets, whereas non-equity claims include loans, advances, notes, bonds, debentures, and other receivables. *SI Z E* is the logarithm of total assets; *ROA* is the return-on-assets computed as the ratio of net income to total assets in percentage terms; *I I* is the ratio of interest income to total assets in percentage terms; *T E* is the ratio of tangible equity to tangible assets in percentage terms; *LEV* is the complement to 100 of the risk-based capital ratio as computed in accordance with the requirements established by the Basel II Capital Accord. All variables are calculated on the basis of the information available in the reporting forms FR Y9-C and FR Y9-LP filed by the BHCs of the sample to the Federal Reserve System. Robust standard errors are reported in parentheses.

*$p < .10$,

**$p < .05$,

***$p < .01$.

In contrast to this, the third column shows that efficiency improves when the parent holds debt issued by subsidiaries. Concerning the control variables included in the regressions, we notice that efficiency increases with size, profitability, and interest income, whereas it declines with double leverage.

Tables 6 and 7 show the results of our baseline Tobit regressions for restricted samples before and after 2008:Q4 to check the robustness of our results with respect to the financial crisis. Overall, we do not observe considerable changes in the sign, level, or statistical significance of the coefficients for the regression variables in the model.

TABLE 6 Results of tobit regressions 2003:Q1 - 2008:Q3

Variable	(1)	(2)	(3)
DLR	−0.118*** (0.021)		
EiS		−0.019*** (0.001)	
NEiS			0.007** (0.002)
SIZE	0.010*** (0.021)	0.019*** (0.002)	0.010*** (0.002)
ROA	0.032*** (0.004)	0.032*** (0.005)	0.034*** (0.005)
II	0.038*** (0.004)	0.043*** (0.003)	0.034*** (0.004)
TE	−0.007*** (0.003)	0.005** (0.002)	0.000 (0.002)
LEV	−0.013*** (0.001)	−0.015*** (0.001)	−0.013*** (0.002)
Observations	4,431	4,431	4,431

Note: This table shows the results of the Tobit regressions investigating the effect on efficiency from parent-subsidiary claim-holdings for a restricted observation period from 2003:Q1 to 2008:Q3. *DLR* denotes the double leverage ratio computed as in Equation 4, where *EiS* and *N EiS* represent the amount of equity and non-equity claims held by the parent company across all subsidiaries as a percentage of the total consolidated assets. Equity claims include stocks, goodwill, and other intangible assets, whereas non-equity claims include loans, advances, notes, bonds, debentures, and other receivables. *SI Z E* is the logarithm of total assets; *ROA* is the return-on-assets computed as the ratio of net income to total assets in percentage terms; *I I* is the ratio of interest income to total assets in percentage terms; *T E* is the ratio of tangible equity to tangible assets in percentage terms; *LEV* is the complement to 100 of the risk-based capital ratio as computed in accordance with the requirements established by the Basel II Capital Accord. All variables are calculated on the basis of the information available in the reporting forms FR Y9-C and FR Y9-LP filed by the BHCs of the sample to the Federal Reserve System. Robust standard errors are reported in parentheses.

*$p < .10$,

**$p < .05$,

***$p < .01$.

TABLE 7 Results of tobit regressions 2008:Q4 - 2010:Q4

Variable	(1)	(2)	(3)
DLR	−0.015* (0.007)		
EiS		−0.016*** (0.002)	
NEiS			0.025*** (0.006)
SIZE	0.015*** (0.003)	0.022*** (0.003)	0.007* (0.004)
ROA	0.021*** (0.002)	0.021*** (0.002)	0.021*** (0.002)
II	0.036*** (0.006)	0.040*** (0.006)	0.036*** (0.006)
TE	−0.006** (0.003)	0.002 (0.003)	−0.004 (0.003)
LEV	−0.008*** (0.002)	−0.011*** (0.002)	−0.007*** (0.002)
Observations	1,977	1,977	1,977

Note: This table shows the results of the Tobit regressions investigating the effect on efficiency from parent-subsidiary claim-holdings for a restricted observation period from 2008:Q4 to 2010:Q4. *DLR* denotes the double leverage ratio computed as in Equation 4, where *EiS* and *N EiS* represent the amount of equity and non-equity claims held by the parent company across all subsidiaries as a percentage of the total consolidated assets. Equity claims include stocks, goodwill, and other intangible assets, whereas non-equity claims include loans, advances, notes, bonds, debentures, and other receivables. *SI Z E* is the logarithm of total assets; *ROA* is the return-on-assets computed as the ratio of net income to total assets in percentage terms; *I I* is the ratio of interest income to total assets in percentage terms; *T E* is the ratio of tangible equity to tangible assets in percentage terms; *LEV* is the complement to 100 of the risk-based capital ratio as computed in accordance with the requirements established by the Basel II Capital Accord. All variables are calculated on the basis of the information available in the reporting forms FR Y9-C and FR Y9-LP filed by the BHCs of the sample to the Federal Reserve System. Robust standard errors are reported in parentheses.

*$p < .10$,

**$p < .05$,

***$p < .01$.

Harris et al. (2013) find that banks who received TARP funds exhibit significantly decreased efficiency. In order to investigate whether TARP has any significant impact on our previous findings, we add the control variable *T ARP* to the baseline specification as a robustness check by accounting for the amount of TARP equity received normalized by total assets. We use a reduced sample period starting form 2008:Q4 when TARP was initiated, The results of this exercise can be found in Table 8. For the time period and efficiency measure considered, we can confirm the negative impact of TARP equity on a BHC's efficiency.[6] Our previous findings are confirmed for *EiS* and *N EiS*. We find that, for the observation period considered, the effect of *DLR* on BHC efficiency becomes statistically insignificant, when including *T ARP* as a control variable. It seems that BHC financing via double leverage was not relevant at that time, when cheap government capital was available. This can also be observed in Figure 2, which shows a decrease in *DLR* activity around the initiation of TARP and shortly afterwards. We still observe highly significant coefficients for *EiS* and *N EiS*.

We further find that the coefficient of the control variable *LEV* becomes significantly positive, when TARP is added, whereas our earlier findings report a significantly negative coefficient. A negative sign of *LEV* implies that efficiency increases with bank capitalization.[7] After the initiation of TARP we now observe that BHC's with higher level of risk-weighted assets (i.e., higher *LEV*) improved in efficiency. It seems that BHC's, whose banks received TARP, were able to partially offset the TARP-induced efficiency loss due to positive effects of increased lending activity, as banks were encouraged to convert TARP funds into loan originations at that time of economic downturn (Black and Hazelwood, 2013)

In order to verify if and to what extent, the parent's exposure to subsidiaries' equity can harm BHC efficiency, we use the information in the parent-only filings. We divide the parent holdings into banking *EiBS* versus non-banking subsidiaries *EiN BS*, as normalized by the parent stand-alone assets. The results of this exercise are shown in Table 9. The negative and significant signs of the coefficients reinforce the validity of our main conclusion. BHCs become less efficient as parent firms hold a large ownership stake in their subsidiaries. This holds for both banking and non-banking subsidiaries, although the effect seems to be more pronounced in non-banking subsidiaries. The latter outcome is interesting and leads to the follow-up question of whether the effect could also be observed inside financial conglomerates, which may include banking, insurance, and security-service companies. We leave this task to future research.

In order to separate the fully efficient companies from the less efficient ones clearly, we recode the efficiency scores as a binary variable which takes the value of one (zero) if the BHC efficiency score is one (below one). This variable enters a Probit model, where the set of covariates remains the same as in the previous equations. The results are shown in Table 10 and are in line with Table 5 and confirm all the previous findings with an even.

stronger magnitude of the coefficients.

TABLE 8 Results of Tobit Regressions including TARP 2008:Q4 - 2010:Q4

Variable	(1)	(2)	(3)
DLR	0.009 (0.028)		
EiS		−0.012*** (0.002)	
NEiS			0.015*** (0.006)
SIZE	0.034*** (0.004)	0.038*** (0.004)	0.029*** (0.004)
ROA	0.019*** (0.002)	0.019*** (0.002)	0.019*** (0.002)
II	0.045*** (0.007)	0.048*** (0.007)	0.045*** (0.007)
TE	0.001 (0.004)	0.004 (0.004)	0.001 (0.004)
LEV	0.006** (0.003)	0.004 (0.003)	0.006** (0.003)
TARP	−1.427* (0.740)	−1.350* (0.714)	−1.214* (0.705)
Observations	1,215	1,215	1,215

Note: This table shows the results of the Tobit regressions investigating the effect on efficiency from parent-subsidiary claim-holdings for a restricted observation period starting from the initiation of the Troubled Asset Relief Program (TARP) in 2008:Q4. *DLR* denotes the double leverage ratio computed as in Equation 4, where *EiS* and *N EiS* represent the amount of equity and non-equity claims held by the parent company across all subsidiaries as a percentage of the total consolidated assets. Equity claims include stocks, goodwill, and other intangible assets, whereas non-equity claims include loans, advances, notes, bonds, debentures, and other receivables. *SI Z E* is the logarithm of total assets; *ROA* is the return-on-assets computed as the ratio of net income to total assets in percentage terms; *I I* is the ratio of interest income to total assets in percentage terms; *T E* is the ratio of tangible equity to tangible assets in percentage terms; *LEV* is the complement to 100 of the risk-based capital ratio as computed in accordance with the requirements established by the Basel II Capital Accord. *T ARP* is the amount of equity received by a BHC under the Troubled Asset Relief Program (TARP) in percentage of the total consolidated assets. All variables are calculated on the basis of the information available in the reporting forms FR Y9-C and FR Y9-LP filed by the BHCs of the sample to the Federal Reserve System. Robust standard errors are reported in parentheses.

*$p < .10$,

**$p < .05$,

***$p < .01$.

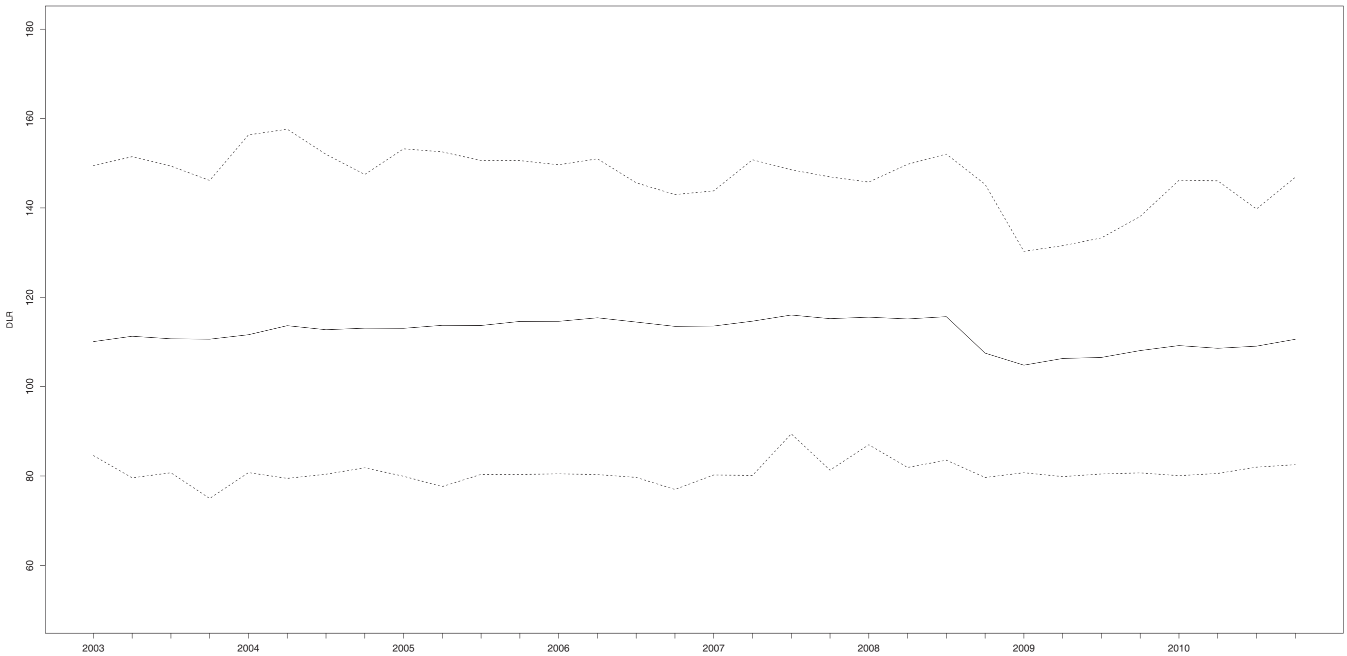

FIGURE 2 DLR Activity over the total sample period. Notes: This figure shows the average quarterly *DLR* activity over all Bank Holding Companies as well as the 95% confidence bands for the observation period 2003 to 2010.

3.3 | Simultaneous system of equations

In line with Zellner (1962), Zellner and Huang (1962), and Zellner (1963), for every BHC *i* at time *t*, we use the following regression model to examine the effects of efficiency and capital structure (*LEV*) within a joint framework:

$$F_{i,t} = \alpha_0 + \beta_0 x_{i,j,t} + \lambda_0 \text{Controls}_{i,t} + \varepsilon_{i,t}) \tag{8a}$$

$$LEV_{i,t} = \alpha_1 + \beta_1 x_{i,j,t} + \varepsilon_{i,t} \tag{8b}$$

$$j = DLR,\ EiS,\ NEiS \tag{8c}$$

TABLE 9 Results of Tobit Regression—Parent holdings of equity issued by banking versus non-banking subsidiaries

Variable	F
EiBS	−0.001*** (0.0001)
EiNBS	−0.003*** (0.0003)
SIZE	0.006*** (0.002)
ROA	0.018*** (0.002)
II	0.030***(0.003)
TE	0.002 (0.002)
LEV	−0.009*** (0.001)
C	1.394*** (0.116)
Observations	6,408

Notes: This table shows the results of the Tobit regression investigating the effect on efficiency *F* from parent-subsidiary equity-holdings for the total observation period separating bank from non-bank subsidiaries. *EiBS* and *EiN BS* represent the amount of equity claims held by the parent company in banking and non-banking subsidiaries as a percentage of the parent stand- alone assets. Equity claims include stocks, goodwill, and other intangible assets, whereas non-equity claims include loans, advances, notes, bonds, debentures, and other receivables. *SI Z E* is the logarithm of total assets; *ROA* is the return-on-assets computed as the ratio of net income to total assets in percentage terms; *I I* is the ratio of interest income to total assets in percentage terms; *T E* is the ratio of tangible equity to tangible assets in percentage terms; *LEV* is the complement to 100 of the risk-based capital ratio as computed in accordance with the requirements established by the Basel II Capital Accord.
All variables are calculated on the basis of the information available in the reporting forms FR Y9-C and FR Y9-LP filed by the BHCs of the sample to the Federal Reserve System. Robust standard errors are reported in parentheses.

*$p < .10$,

**$p < .05$,

***$p < .01$.

TABLE 10 Results of probit regressions

Variables	(1)	(2)	(3)
DLR	−0.915*** (0.144)		
EiS		−0.174*** (0.010)	
NEiS			0.081*** (0.017)
SIZE	0.132*** (0.012)	0.205*** (0.013)	0.104*** (0.015)
ROA	0.162*** (0.028)	0.189*** (0.028)	0.178*** (0.029)
II	0.293*** (0.029)	0.316*** (0.030)	0.237*** (0.029)
TE	−0.063*** (0.015)	0.053*** (0.014)	−0.013 (0.013)
LEV	−0.094*** (0.009)	−0.110*** (0.009)	−0.085*** (0.009)
Observations	6,408	6,408	6,408

Notes: This table shows the results of the Probit regressions investigating the effect on efficiency from parent-subsidiary claim-holdings for the total observation period using a dummy variable which takes the value of 1 if the efficiency score equals to one, and 0 otherwise. *DLR* denotes the double leverage ratio computed as in Equation 4, where *EiS* and *N EiS* represent the amount of equity and non-equity claims held by the parent company across all subsidiaries as a percentage of the total consolidated assets. Equity claims include stocks, goodwill, and other intangible assets, whereas non-equity claims include loans, advances, notes, bonds, debentures, and other receivables. *SI Z E* is the logarithm of total assets; *ROA* is the return-on-assets computed as the ratio of net income to total assets in percentage terms; *I I* is the ratio of interest income to total assets in percentage terms; *T E* is the ratio of tangible equity to tangible assets in percentage terms; *LEV* is the complement to 100 of the risk-based capital ratio as computed in accordance with the requirements established by the Basel II Capital Accord. All variables are calculated on the basis of the information available in the reporting forms FR Y9-C and FR Y9-LP filed by the BHCs of the sample to the Federal Reserve System. Robust standard errors are reported in parentheses.

*$p < .10$,

**$p < .05$,

***$p < .01$.

TABLE 11 Results of simultaneous systems of equations

Variable	(1) F	(1) LEV	(2) F	(2) LEV	(3) F	(3) LEV
DLR	−0.024*** (0.007)	4.471*** (0.155)				
EiS			−0.013*** (0.001)	−0.488*** (0.016)		
NEiS					0.001*** (0.002)	−0.083** (0.036)
SIZE	0.008*** (0.001)		0.011*** (0.001)	0.005*** (0.001)		
ROA	0.015*** (0.001)		0.015*** (0.001)	0.016*** (0.001)		
II	0.021*** (0.002)		0.026*** (0.002)	0.020*** (0.002)		
LEV	−0.007*** (0.001)		−0.011*** (0.001)	−0.007*** (0.001)		
Observations	6,408	6,408	6,408	6,408	6,408	6,408

Notes: This Table displays the results of simultaneous systems of equations for the total observation period and shows the effect of double leverage and standard leverage on efficiency. *DLR* denotes the double-leverage ratio computed as in Equation 4, where *EiS* and *N EiS* represent the amount of equity and non-equity claims held by the parent company across all subsidiaries as a percentage of the total consolidated assets. Equity claims include stocks, goodwill, and other intangible assets, whereas non-equity claims include loans, advances, notes, bonds, debentures, and other receivables. *SI Z E* is the logarithm of total assets; *ROA* is the return-on-assets computed as the ratio of net income to total assets in percentage terms; *I I* is the ratio of interest income to total assets in percentage terms; *T E* is the ratio of tangible equity to tangible assets in percentage terms; *LEV* is the complement to 100 of the risk-based capital ratio as computed in accordance with the requirements established by the Basel II Capital Accord. All variables are calculated on the basis of the information available in the reporting forms FRY9-C and FR Y9-LP filed by the BHCs of the sample to the Federal Reserve System. Robust standard errors are reported in parentheses.

*$p < .10$,

**$p < .05$,

***$p < .01$.

Through the simultaneous system of equations, we investigate the hypothesis that *DLR* determines both the capital structure and BHC efficiency simultaneously. The results of this analysis are displayed in Table 11.

Column 1 shows that the sign of the coefficient on *DLR* is positive for *LEV*, whereas negative for $F_{i,t}$. Thus, a high degree of double leverage lowers the amount of regulatory capital and efficiency at the same time. Finally, we replace *DLR* with *EiS* and *N EiS* in columns 2 and 3. Similarly to *DLR*, *EiS* also has a negative effect on $F_{i,t}$. This pattern is in line with the argument that BHC efficiency deteriorates as the parent equity holdings in subsidiaries increase. The impact of *DLR* is larger in magnitude. This means that BHC efficiency reduces substantially as the parent participates in subsidiaries with low stand-alone capital (i.e., high *DLR*).

In contrast to *DLR*, the consolidated leverage correlates negatively to *EiS* and *N EiS*. This outcome confirms that *DLR* may reveal critical aspects of the parent holdings of subsidiaries. *DLR* can be seen as an indicator of arbitrage of regulatory capital, as argued, for example, by Dierick (2004) and Yoo (2010), who claim that by double leveraging, financial groups can take on additional risk without increasing their capital proportionally,

thereby circumventing regulatory capital requirements. Our results show clearly that BHCs become more levered with *DLR*. Thus, the capital structure of BHCs becomes more unstable as the parent participates in the subsidiaries without increasing the buffer of *solo* capital that can absorb losses from this participation. The funding of subsidiaries does not necessarily increase leverage, as suggested by the negative effect of *EiS* and *N EiS*. Instead, what may potentially introduce fragility is the funding of subsidiaries not supported by parent capitalization.

4 | CONCLUSION

In this paper, we derive the efficiency of Bank Holding Companies from multi-directional efficiency analysis (MEA). This method allows a consideration of each factors' improvement potential by determining the overall efficiency level. We find that BHCs exhibit, on average, a relative efficiency score of between 0.7 and 0.75, showing a clear improvement potential, with only 10% being fully efficient. We also find that most BHCs stay within three percentiles of their initial efficiency estimates, with almost 60% of BHCs experiencing an overall efficiency percentile change by the end of the observation period, and that higher overall efficiency changes are accompanied by higher periodic volatility, more frequent and higher positive and negative efficiency changes.

Based on these findings, we investigate whether this level of efficiency is directly related to the financing relationship between parent and subsidiary. For this, we run a set of Tobit and Probit regressions to understand the effect of various parent-subsidiary claim holdings on BHC efficiency.

We find that BHC efficiency reduces as long as the parent finances the equity capital of the subsidiaries, whereas efficiency improves when the parent holds non-equity instruments issued by subsidiaries. As long as the internal equity funding gives rise to so-called "double leverage," the estimated impact on efficiency is more severe and negative. This means that double leverage increases the consolidated leverage substantially while reducing efficiency at the same time.

This pattern is of primary interest for policy-makers, since it draws attention to the issue of double leverage, which until now has received only marginal attention in the literature. In this article, we demonstrate that intra-firm ownership of capital may cause friction in large corporations, especially when it leads to double leverage. Therefore, further research is necessary to explain why double leverage is still favored by BHCs even though this source of financing seems to destroy value, and how incentives could be created to overcome this issue.

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ENDNOTES

[1] These findings are also confirmed by Houston and James (1998) who show that BHCs use internal capital markets to reallocate capital among the different subsidiaries.

[2] See Koopmans (1951), Debreu (1951) or Farrell (1957).

[3] The Troubled Asset Relief Program (TARP) was a U.S. economic program designed to ward off the nation's mortgage and financial crisis. Signed on October 3, 2008, by President George W. Bush, TARP allowed the Department of the Treasury to allocate capital into failing banks and other businesses by purchasing assets and equity.

[4] We exclude banks classified as "de novo banks" and "merger targets" from the dataset in order to avoid that BHC efficiency estimates are influenced by M&A activities and changes in governance.

[5] We refer to the form FR Y9-C as our main data source, while the form FR Y9-LP is required specifically to disentangle the ultimate parent holdings into subsidiaries' equity as this information can only be found in the ultimate parent-only filings.

[6] For our regression analysis we also test effects from the amount of TARP equity received normalized by the parent-only assets, and normalized by the parent-only equity. Results do not change significantly and are available upon request.

[7] Recall that *LEV* represents the complement to 100 of the risk-based capital ratio (RBCR) as com- puted in accordance with the requirements established by the Basel II Capital Accord. The risk based capital ratio is a measure that represents the equity buffer of a bank in relation to its risk-weighted assets.

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