Are board characteristics relevant for banking efficiency? Evidence from the US

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Abstract

Purpose – *This paper aims to examine whether board-related characteristics matter for cost efficiency in banking sector.*

Design/methodology/approach – *This study uses a sample of publicly traded US commercial banks and savings institutions to estimate a relationship between cost efficiency measured by stochastic frontier analysis and a set of board-related characteristics for the period 2007-2013.*

Findings – *An inverted U-shape relation is found between board size and efficiency. Thus, there is a trade-off between costs and benefits of larger boards. Optimal board size is higher for banks with more complex operations. This study also observed an inverted U-shape relation between board independence and cost efficiency. The banks where the Chairman also executes the CEO responsibility show lower efficiency. However, a higher proportion of independent board members in banks with unitary leadership structure may mitigate the conflict of interest and lower efficiency stemming from CEO duality.*

Research limitations/implications – *This study's evidence supports the Basel Committee on Banking Supervision emphasis on advising a board composition that provides for a sufficient degree of director independence.*

Practical Implications – *The results are relevant for banks and their external and internal stakeholders. Banks may adjust their current board characteristics to increase the board effectiveness. Externally, potential investors can evaluate the quality of corporate governance of banks before making investment decisions. The empirical findings can also be useful for regulators imposing corporate governance codes in banking.*

Originality/value – *To the best of the authors' knowledge, this is the first paper to provide empirical evidence on the impact of board characteristics on bank efficiency for a wide panel of US banks. Additionally, a comprehensive set of board-related variables is used.*

Keywords *Corporate governance, Board of directors, Banking efficiency, Stochastic frontier analysis*

Paper type *Research paper*

1. Introduction

The recent decade has witnessed increased attention of stakeholders and regulatory bodies to the corporate governance practices, fostered by the publication of Organisation for Economic Co-operation and Development (OECD) corporate governance principles (2004) and Sarbanes–Oxley Act (2002), which were in turn triggered by scandals in Enron, Worldcom and Parmalat. These events undermined investor confidence and thus created obstacles to transferring capital to its best use. One of the solutions to this issue is corporate governance. As mentioned by Tanna *et al.* (2011), OECD considers governance as an important element of the economic efficiency. Basel Committee on Banking Supervision (BCBS, 2006; BCBS, 2014) echoes this statement:

> Enhancements to the framework and mechanisms for corporate governance should be driven by such benefits as improved operational efficiency, greater access to funding at a lower cost, and an improved reputation (p. 21).

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Meanwhile, despite a significant body of research in non-financial sectors, very few papers address governance issues in financial industry in general and in banking in particular, although the key aspects of corporate governance apply to banking industry (de Andrés and Vallelado, 2008). Furthermore, the topic remains relevant and sparks continuous interest from regulators, as evidenced by regular updates published by the Basel Committee, including the most recent consultative document (BCBS, 2014).

There is even scarcer evidence on the link between performance and corporate governance in banking, although the BCBS document emphasizes that sound corporate governance should contribute to it: "a bank's board of directors and senior management are primarily responsible and accountable for the performance of the bank" (BCBS, 2006, p. 19, par. 57). Moreover, the performance is typically measured by financial ratios (return on equity [ROE] and cost-to-income ratio are quite common) which are restrictive because they combine both output and input efficiencies (Pi and Timme, 1993). Financial ratios do not control for input prices and output mix (Halkos and Salamouris, 2004). Moreover, the efficiency of banks measured by accounting ratios, such as ROE or return on assets (ROA), is unstable and is, therefore, challenged as being suitable to determine productive efficiency of banks (Maudos *et al.*, 2002). Efficiency derived from production frontier techniques helps overcome this drawback because "frontier analysis provides an overall, objectively determined, numerical efficiency value and ranking of firms" (Berger and Humphrey, 1997). Consequently, this property makes the scores estimated by frontier techniques particularly useful for policy recommendations (Berger and Humphrey, 1997). Such an approach is therefore relevant for our study because one of the motivations is to verify the guidelines set out in BCBS (2014) with respect to board attributes. Nevertheless, frontier estimation procedures are employed in very rare studies on corporate governance in banking.

The recent bibliometric analysis (Lampe and Hilgers, 2015) has put in evidence that the two most important and widely adopted and diffused methods of efficiency and performance measurement are stochastic frontier analysis (SFA) and data envelopment analysis (DEA). Both methods allow for benchmarking because they estimate the efficiency of each organization relative to a best-performing peer. Whereas Berger and Humphrey (1997) point out that it is impossible to identify a dominant approach between the two because of the uncertainty regarding the true efficiency; Lampe and Hilgers (2015) identify that one of the most influential application areas in banking is SFA.

SFA is a stochastic model in which inefficiency can be distinguished from noise, as opposed to the deterministic DEA, where all deviations from the frontier are considered as inefficiency, thus making it quite sensitive to outliers and measurement errors. The first advantage of the SFA can therefore be considered in its ability to disentangle a random error term and controllable inefficiency. This assumption seems to be more consistent with empirical data (Pi and Timme, 1993).

The second advantage of SFA, in its Battese and Coelli (1995) specification, is that it allows a simultaneous estimation of the parameters of the efficiency frontier and the coefficients of inefficiency model. This procedure is assumed to be superior to a two-step approach due to a higher reliability of estimated efficiency (Lozano-Vivas and Pasiouras, 2010; Battese and Coelli, 1995; Greene, 1993; Lensink and Meesters, 2014; Wang and Schmidt, 2002)[1].

Several factors are likely responsible for a relative lack of empirical evidence on corporate governance practices in banks. First, the banking sector is more heavily regulated compared to others, with government authorities reducing the flexibility of managerial decisions. Therefore, the role of corporate governance has been consistently downplayed as regulation has been considered a substitute, at least a partial one, of internal monitoring mechanisms (Booth *et al.*, 2002). The interaction between corporate governance, regulation and bank risk taking is thoroughly discussed by Laeven and Levine (2009). Second, peculiar features of the banking business model, in particular high leverage, make

the agency problem much more complex than in other sectors. The traditional role of corporate governance, including that of board of directors, is seen as aligning managers' incentives with shareholders' interests. However, the stakeholder base in banking is wider and more important: depositors and creditors have substantial claims on banking assets. Likewise, government and society as a whole depend on the financial stability. For the former reason, it seems essential to take into account measures that reflect not only the shareholder wealth but also encompass the interests of other stakeholders.

In the aftermath of the 2007 financial crisis, the confidence of clients and investors in the financial sector continued to plummet. The survey conducted by Ernst & Young revealed that in 2010, 55 per cent of respondents decreased their trust in banks in the USA[2]. In this respect, the financial turmoil was responsible for shaping similar perceptions as the wave of corporate scandals in 2000s; however, they reflected on the entire sector rather than on large corporations. The regulatory response was somehow different. The banking sector was primarily affected by a series of reforms, including Dodd–Frank Act in the USA and MiFID in Europe, which established new procedures for trading certain financial products, but did not specifically address internal and external governance mechanisms. In the myriad of regulatory changes, BCBS (2010) document on enhancing principles of corporate governance in banking was like a drop in the ocean, unlikely to produce drastic effects. But these efforts likely contributed to restoring consumer confidence in the financial industry. In 2014, Ernst & Young global survey reported that 78 per cent of respondents increased or maintained their trust in banks[3]. The main reason for this, shared by 60 per cent of consumers, was financial stability. This makes the case of analyzing performance measures other than traditional profitability ratios in the context of corporate governance even more appealing.

The main contribution of this paper is the following. To the best of our knowledge, this is the first paper to provide empirical evidence on the impact of board characteristics on bank efficiency for a wide panel of US banks and by using the techniques that overcome some of the econometric issues of previous studies (ordinary least squares [OLS] where the DEA scores are used as a dependent variable in the second stage). Our period covers a few years when the G-SIB regulation was adopted, with tighter capital regulation applied to systemically important banks. Additionally, we use a comprehensive set of board-related variables, including those that were largely ignored in prior studies, such as the number of board changes and meeting frequency. We also take into account bank size and complexity when exploring the relationship between board size and efficiency.

We find an inverted U-shaped relationship between board size and efficiency. Thus, banks should strike a balance between advantages and costs of adding new directors to a board. Our findings also indicate that bank efficiency is positively related to the fraction of independent directors on the board, up to a level of approximately 86 per cent. Thus, efficient boards should be complemented by insiders for better decision-making and strategy elaboration. In line with corporate governance codes, banks where the Chairman also executes the CEO responsibility show lower efficiency. However, this effect is mitigated by a higher percentage of independent directors on board.

The rest of the paper is organized as follows. Section 2 reviews existing evidence on the research question and develops a set of hypotheses. Section 3 describes data and methodology. Section 4 analyses the empirical findings. Section 5 sets out the directions for further research. Section 6 concludes.

2. The impact of corporate governance practices on performance and efficiency

Until recently, the financial services industry was not put under particular constraints in terms of corporate governance. Apart from the general principles required by the Sarbanes–Oxley Act and New York Stock Exchange (NYSE) and NASDAQ listing requirements from all publicly traded companies, regardless of the sector, and greater

oversight of executive compensation stipulated by the 2010 Dodd–Frank Act, there were no specific rules guiding bank governance. BCBS (2014) is one of the first official documents to address this issue. In addition to discussing extensively peculiar features of banking operations, in particular risk-taking inherent in financial operations, it adopts a differentiated approach to banks of various size and complexity, rather than allowing for a "one-size-fits-all" framework. For instance, it requires an audit and risk committee for systemically important banks, while for others, they remain highly advised or recommended.

Despite these requirements and some guidance, various aspects of corporate governance, including board-related attributes, are managed at the discretion of banks. In this regard, it is of utmost importance to identify whether some of these decisions are relevant for enhancing efficiency.

2.1 Previous evidence

Theoretical background on whether and how corporate governance mechanisms matter for company performance through monitoring and advising managers provides mixed signals.

There exists some evidence on how corporate governance indicators influence SFA or DEA efficiency of financial and non-financial firms. Su and He (2011) find a U-shape relation between ownership concentration and efficiency scores as measured by SFA and DEA techniques for a sample of Chinese manufacturing firms. They also report that firms with more independent boards are more efficient. For the banking sector, Berger *et al.* (2005) estimate the relevance of governance indicators, in particular the type of ownership, for Argentine bank performance measures, including SFA cost and profit efficiency. When analyzing the performance of 23 investment banks, Mamatzakis and Bermpei (2015) found that banks with smaller boards and unitary leadership structure are more efficient. Their measures of performance include financial ratios along with SFA profit efficiency. In the study on the Ghanaian banking industry, Bokpin (2013) finds that larger boards contribute to higher profit efficiency, but slightly worsen cost efficiency, as measured by SFA techniques.

In the remainder of this section, we will discuss specific indicators related to the board of directors' characteristics.

2.1.1 Board size. It may be argued that larger boards may contribute to higher efficiency through additional expertise in exercising monitoring and advising functions. As pointed out by Upadhyay and Sriram (2011), larger boards have greater resources to perform their managerial oversight role. Larger boards may be more adequate for solving more complex problems, which likely explains why banks have, on average, more directors on board compared to non-financial firms (Adams and Mehran, 2003)[4]. Various theories that challenge this statement have been put forth. They include free-riding problem (Jensen, 1993) and corresponding meeting attendance issues; groupthink (Janis, 1983) which translates into the pressure to find a unanimous decision and potential fear to disagree with the majority; coordination issues; and increased time to build a consensus.

Empirical evidence on the relationship between board size and performance of financial institutions is mixed. Some studies document that board size is irrelevant for performance. Erkens *et al.* (2012) find a non-significant relationship between board size and bank stock returns for US large bank-holding companies for 2007-2008. By using efficiency analysis tools, Hardwick *et al.* (2011) find no linear or quadratic relationship between board size and profit efficiency of UK life insurance companies. However, there is a larger body of research that reports either a positive (Adams and Mehran, 2012; Aebi *et al.*, 2012; Beltratti and Stulz, 2012) or an inverted U-shape relationship (de Andrés and Vallelado, 2008; Grove *et al.*, 2011).

2.1.2 Board independence. It has been argued that a higher proportion of outside directors provides the board with better opportunities to monitor managers and, hence, contributes

to aligning managers' and shareholders' interests. Moreover, outside directors may have additional insights into issues the company encounters. On the other hand, outside directors may have less in-depth knowledge about the firm's operations, especially if they are complex, and lower access to information. The latter may be because of managers being reluctant to provide confidential data to outside professionals as some of them may be engaged in competing companies. Empirical studies on non-financial firms document that better performance is linked to director independence (Byrd and Hickman, 1992). These results are less convincing for the financial sector. In examining the percentage of outside directors in US banks prior to 1990, Pi and Timme (1993) report that it is not relevant for bank performance as measured by ROA and cost efficiency. Similar conclusion is drawn by Fernandes and Fich (2016) and Aebi *et al.* (2012) who analyze the 2007-2008 credit crunch and a larger sample of US banks and do not find a significant relationship between the percentage of independent directors and bank performance measured by buy-and-hold returns or ROE, in the former case. Adams and Mehran (2012) document a non-significant relationship between the fraction of outside directors and Tobin's Q for 35 US bank-holding companies over 1964-1995.

Another strand of literature reports a negative relationship between board independence and performance (Erkens *et al.*, 2012; Beltratti and Stulz, 2012; Wang *et al.*, 2012). Wang *et al.* (2012) use modified DEA to measure performance. Minton *et al.* (2012) find that independent directors with financial expertise were more prone to take on higher risks, which resulted in a decrease in bank value during the 2007-2008 crisis. However, all of the aforementioned studies focus on a short time period referring to the recent financial crisis. They explain a negative relation between lower bank performance during the crisis and board independence by higher risks taken by outside directors before the crisis. On the other hand, according to Yeh *et al.* (2011), banks with higher fraction of independent directors on board committees (audit and risk) delivered better performance over 2005-2008, as measured by stock returns and accounting measures (ROE and ROA). Finally, the non-linear relationship between board independence and bank performance measured by Tobin's Q and accounting indicators has been found by de Andrés and Vallelado (2008).

2.1.3 Chief executive officer duality. There exist two opposing theories on whether it is more beneficial for a company to have the same person in the role of CEO and Chairman of the board. According to the agency theory, separating the two roles is essential for aligning managers' interests with those of shareholders and avoiding entrenchment. Pi and Timme (1993) provide support to this proposition by showing that banks with dual leadership structure report higher ROA and are more cost efficient.

Stewardship theory, on the other hand, argues that agency costs are insignificant and company insiders are in a better position to monitor the firm's operations (Donaldson and Davis, 1991). Brickley *et al.* (1997) show in their empirical study that separating the roles of the CEO and the Chairman has a negative potential net benefit. Finkelstein and D'Aveni (1994) analyze how companies strike the trade-off between strengths and weaknesses of CEO duality.

2.1.4 Frequency of board meetings. According to the agency theory, more frequent board meetings may contribute to more active monitoring, reduction of agency costs and hence better performance. This may be achieved through more frequent exchange of ideas among board members, and therefore higher efficiency of the control and enhanced advisory role of the board (Maati and Maati-Sauvez, 2012). This argument was empirically confirmed by Vafeas (1999) who highlights the importance of the number of board meetings as a board characteristic and reports improved operating performance for a sample of 307 non-financial firms after periods of abnormal board activity. Grove *et al.* (2011) finds similar results for US banks before the 2007 financial crisis with regards to the impact of board meeting frequency on risk-adjusted performance (alpha from the market model). It should however be noted that there is only a limited body of research exploring

the board meeting frequency in banking and the evidence is scant and mixed. Contrary to Grove *et al.* (2011), de Andrés and Vallelado (2008) do not find any significant relationship between the number of board meetings and bank value.

2.1.5 Gender diversity. The issue of providing men and women with equal opportunities in the workplace has recently been in the centre of political debate and academic research. Several countries, including Finland, France, Germany, Italy, Norway and Spain, have adopted quotas for the minimum female representation in the boardroom. The USA do not impose fixed quotas on listed companies; however, companies have to disclose whether diversity (including gender diversity) is a consideration and, if so, how it is implemented. Because there is no long record for significant female representation on board, empirical evidence on the link between fraction of female directors and financial performance (efficiency) is scarce. Several theories explain the expected relationship between the two variables. Resource-dependent theory (Pfeffer and Salancik, 1978; Hillman, 2010) argues that boards provide companies with access to external resources. Moreover, diverse board members warrant the availability of different resources, thus making the case for diversity appealing and predicting a positive relationship between degree of diversity and performance through the reduction in the cost of funding. According to the human capital theory (elaborated in the seminal work of Becker (1964) and further developed by Tjersen *et al.* (2009)), human capital represents the sum of skills and experience of employees of the firm. To the extent that diverse employees accumulate different skills, diversity may be beneficial for performance. Agency theory stipulates better monitoring and control in the case of diverse boards because directors are less likely to be beholden to managers (Carter *et al.*, 2010). Finally, social psychological theory puts forward opposing views by emphasizing cohesion issues within diverse groups (Westphal and Milton, 2000).

Empirically, however, neither of the theories has received convincing support in the banking sector. In the fragmented research on the topic, Carter *et al.* (2010) do not find a significant relationship between the fraction of female directors and ethnic minorities on the board and financial performance of US banks as measured by ROA and Tobin's Q. In a similar vein, Pathan and Faff (2013) report the irrelevance of gender diversity for several accounting and market measures of bank performance.

Overall, the existing research suggests that there is no consensus in the literature with regards to the relevance and the role of different corporate governance mechanisms in the financial services industry.

2.2 A set of testable hypotheses

As extensively reported in the existing literature, various governance mechanisms are often chosen simultaneously; therefore, in our empirical specifications, we include groups of board-related variables rather than considering a limited number of them in isolation to limit the possibility of capturing spurious correlations. We select variables that reflect such aspects of governance as the efficiency of and motivation for oversight, board independence and competence.

Larger board size facilitates monitoring the alignment of interest. However, there is a trade-off between diversity and coordination. Lipton and Lorsch (1992) recommend a number of board members between seven and eight. However, for the banking industry, board size is significantly larger than that of manufacturing firms (Adams and Mehran, 2003).

Nevertheless, the absolute board size does not necessarily reflect the coherence with banking operations. Indeed, Yermack (1996) and Coles *et al.* (2008) argue that complexity can be an important determinant of optimal board size. Coles *et al.* (2008) find, for a sample of 35 US BHC, that the advantages of larger boards outweigh their costs for more complex banks (as measured by the impact of the board size on performance). This leads us to test a relative rather than an absolute measure of the board size:

H1. There is an inverted U-shaped relationship between the normalized board size and cost efficiency: Boards which are too small or too large are likely to negatively impact banking efficiency[5].

We perform normalization by dividing the board size by the number of employees. Alternative specifications are also considered. The first one suggests applying the BCBS approach to measuring the complexity of banking operations, in line with the indicator-based approach for identifying global systemically important banks (G-SIB). In accordance with this approach, complexity is a function of Level 3 assets, notional amounts of over-the-counter (OTC) derivatives and value of held-for-trading and available-for-sale securities, with each indicator being equally weighted. The second proxy is the percentage of non-interest income in total income which measures the banks' involvement in non-traditional banking activities:

H2. There is an inverted U-shaped relationship between the board independence and banking efficiency.

Our assumption is that the percentage of independent directors impacts efficiency; however, the directional sign is unclear. Opposing theoretical grounds have been developed in the literature. According to the agency theory, a conflict of interest exists between managers and shareholders; hence, a higher percentage of independent directors positively affects efficiency or performance. On the other hand, under the stewardship theory, there are no agency costs; therefore, insiders may make better decisions for the firm performance because they have more intimate knowledge of internal operations and strategy, and therefore a higher percentage of independent directors may negatively impact efficiency.

Another issue is related to the definition of independence. All banks report the number and percentage of independent directors on board, but the definition is specific to each bank. To ensure comparability, we use the percentage of non-executive directors on board to proxy independence. This is consistent with Coles *et al*. (2008) and Adams and Mehran (2003) who consider non-insiders, i.e. directors not working for the bank, in measuring independence. As a robustness check, we perform estimations with the proportion of independent directors, with independence determined by each bank based on common listing requirements. However, this measure can be biased, as noted by Adams and Mehran (2003), because of the fact that in many cases, directors are also customers of the bank, but these relationships are typically not disclosed.

Another indicator of independence is CEO duality which is a dummy variable equal to 1 if the same person assumes the responsibilities of both CEO and the Chairman of the Board, and 0 otherwise. Corporate governance codes along with the guidelines of BCBS (2014) claim for the separation between the two roles to lessen the conflict of interests between shareholders and managers. The concentration of power in the hands of one person may dilute the monitoring role and reduce bank efficiency:

H3. There is an inverse relationship between CEO duality and the banking efficiency.

On the other hand, in banks with unitary board structure where CEO is the Chairman of the board, a possible conflict of interest may be lessened by a significant proportion of independent directors on the board:

H4. There is a positive relationship between the interaction variable (CEO duality × Board independence) and banking efficiency.

Following some previous studies (Jizi *et al*., 2014; Hardwick *et al*., 2011), we explore the impact of interaction terms on efficiency. The rationale is to examine the theoretical argument that more than one governance mechanism may serve the same purpose. In particular, we interact CEO duality with the relative number of independent directors to test whether the concentration of power in the hands of CEO who is also the Chairman may be mitigated by a sufficient degree of independence of the remaining board members:

H5. There is an inverted U-shaped relationship between board duration and the banking efficiency.

H6. There is an inverted relationship between the number of board changes and the banking efficiency.

Fernandes and Fich (2016) show that outside directors with greater board tenure in their banks were more efficient during the 2007-2008 financial crisis. Very low duration and frequent changes in the board structure may be harmful for bank performance because board members are likely to have lower commitment and fewer opportunities to get insights into strategy and vision. On the other hand, very long duration may lead to a decrease in board independence and entrenchment:

H7. The frequency of board meetings is positively related to the banking efficiency.

H8. The frequency of audit committee meetings is positively related to banking efficiency.

The number of board meetings can be considered as a proxy for the efficient functioning of the board. On the one hand, meetings allow directors to obtain additional firm-specific information (Adams and Ferreira, 2007). This might enhance the monitoring and advisory roles of the boards because of better-informed decisions. On the other hand, de Andrés and Vallelado (2008) point out that meetings provide directors with an opportunity to exchange ideas and elaborate a more comprehensive strategy. These arguments suggest that higher number of board meetings per year might result in a closer control over managers and more timely decisions under changing market conditions. We therefore predict a positive relationship between the frequency of board meeting and banking efficiency.

We have also decided to consider separately the frequency of audit committee meetings for the following reasons. Because of higher complexity of banking operations, audit committees may provide more specialized and relevant advice. Moreover, until recently, audit committees in smaller banks also fulfilled risk monitoring functions. For efficiency estimation purposes, such decisions influence several parameters, including loan amounts, other earnings assets and short-term borrowings. Finally, in conformance with NYSE listing requirements, all the members of audit committee should be independent. Consequently, more frequent meetings of audit committees may lead to more efficient monitoring. Considering the aforementioned factors, we expect a positive relationship between the frequency of audit committees and banking efficiency.

3. Data and methodology

3.1 Sample selection

Our sample consists of publicly traded US commercial banks (SIC codes 6021, 6022 and 6029) and savings institutions (SIC codes 6035 and 6036). Both financial and corporate governance indicators have been taken from Bloomberg which compiles the information from various sources including annual reports, proxy statements, news and company websites. Initially, we have selected a period from 2005 to 2013 to conduct our study. However, the number of observations for corporate governance indicators for 2005 and 2006 is very low (three and four, respectively, for most indicators). Interestingly, the number of governance disclosures increases dramatically in 2007, perhaps as a response to BCBS (2006) document. We have therefore opted to focus on the period from 2007 to 2013. This results in an unbalanced panel of 1,181 to 1,1256 bank-year observations, depending on the model specification.

Because all the banks (US publicly traded national banks) in our sample are under the control of the same regulators, the Federal Reserve and the SEC, and operate in the same institutional setting, we do not need to factor in the potential effect of regulation and institutional framework in our analysis.

3.2 Estimation of bank efficiency

In the rare studies linking efficiency with bank governance, the DEA technique is applied due mostly to a small sample size[6]. In such studies, the analysis is performed in two steps: in the first step, efficiency scores are derived with optimization methods. In the second step, these scores are regressed against a set of exogenous variables which are potentially related to efficiency. However, as emphasized by Simar and Wilson (2007 and 2011), this two-step approach presents some econometric issues. First, efficiency scores are left-bounded by zero (for absolutely inefficient decision-making units) and right-bounded by 1 (absolutely efficient decision-making units); therefore, the OLS technique applied in some studies is not appropriate. Moreover, even if the boundary-related issues are solved by transforming scores or using Tobit estimation, the description of the data-generating process is not provided, which renders unclear the regression estimation results. Second, a more serious problem arises from the serial correlation of DEA efficiency scores because changes in some observations on the efficiency frontier will alter efficiencies for other observations. As a result, standard inference techniques become invalid. Simar and Wilson (2007) suggest using bootstrapping or double bootstrapping to address this problem. To the best of our knowledge, this has not been implemented in the existing bank governance literature. Finally, a two-step estimation leads to biased efficiency scores because of the misspecification of the first-stage model, and this bias has shown to be severe (Wang and Schmidt, 2002).

We use a multi-product translog stochastic frontier specification suggested by Battese and Coelli (1995) and augmented by Lozano-Vivas and Pasiouras (2010) to take account of non-traditional banking activities:

$$\begin{aligned} ln\left(\frac{TC}{W_3}\right) = {} & \beta_0 + \beta_1 ln(Q_1) + \beta_2 ln(Q_2) + \beta_3 ln(Q_3) + \beta_4 ln\left(\frac{W_1}{W_3}\right) + \beta_5 ln\left(\frac{W_2}{W_3}\right) \\ & + \beta_6 \frac{1}{2}(\ln(Q_1))^2 + \beta_7 ln(Q_1) ln(Q_2) + \beta_8 ln(Q_1) ln(Q_3) + \beta_9 \frac{1}{2}(ln(Q_2))^2 \\ & + \beta_{10} ln(Q_2) ln(Q_3) + \beta_{11} \frac{1}{2}(ln(Q_3))^2 + \beta_{12} \frac{1}{2}\left(ln\left(\frac{W_1}{W_3}\right)\right)^2 + \beta_{13} ln\left(\frac{W_1}{W_3}\right) ln\left(\frac{W_2}{W_3}\right) \\ & + \beta_{14} \frac{1}{2}\left(ln\left(\frac{W_2}{W_3}\right)\right)^2 + \beta_{15} ln(Q_1) ln\left(\frac{W_1}{W_3}\right) + \beta_{16} ln(Q_1) ln\left(\frac{W_2}{W_3}\right) + \beta_{17} ln(Q_2) ln\left(\frac{W_1}{W_3}\right) \\ & + \beta_{18} ln(Q_2) ln\left(\frac{W_2}{W_3}\right) + \beta_{19} ln(Q_3) ln\left(\frac{W_1}{W_3}\right) + \beta_{20} ln(Q_3) ln\left(\frac{W_2}{W_3}\right) + \beta_{21} T + \beta_{22} \frac{1}{2} T^2 \\ & + \beta_{23} ln(Q_1) T + \beta_{24} ln(Q_2) T + \beta_{25} ln(Q_3) T + \beta_{26} ln\left(\frac{W_1}{W_3}\right) T + \beta_{27} ln\left(\frac{W_2}{W_3}\right) T \\ & + \beta_{28} ln(EQUITY) + \sum \beta_i SIC_i + u_{i,t} + v_{i,t}, \end{aligned} \tag{1}$$

Q_1, Q_2, Q_3 are outputs (loans, other earning assets and off-balance sheet commitments [or non-interest income], respectively). W_1, W_2, W_3 are the costs of inputs (cost of borrowed funds, cost of fixed assets and cost of labour, respectively). TC, total costs are defined as the sum of interest expense and non-interest expense. T stands for the trend. $v_{i,t}$ is a two-sided normal disturbance term. SIC_i are SIC dummies controlling for subsector-specific fixed effects. $u_{i,t}$ is an inefficiency term which is assumed half-normally distributed. The cost efficiency score is defined by $CE_{i,t} = exp(-u_{i,t})$, $CE_{i,t} \in [0;1]$, where $CE_{i,t} = 1$ indicates that input consumption cannot be reduced to achieve a given level of output.

The estimated model for the inefficiency terms $u_{i,t}$ can be formally stated as follows (the estimation is done simultaneously with the previous model):

$$u_{i,t} = \alpha_0 + \alpha_1 INF_t + \alpha_2 GDPGR_t + \alpha_3 ln(EQUITY_{i,t}) + \sum \alpha_i CG_{i,t} \tag{2}$$

INF and *GDPGR* denote inflation and GDP growth, respectively, and define the macroeconomic conditions susceptible to affect the bank efficiency. *ln*(*EQUITY*) allows controlling for the risk-taking behaviour. Finally, different corporate governance indicators specified in Section 2 are denoted by CG_i.

Our basic specification of equation (1) accounts for temporal effects by including a linear and quadratic trend reflecting potential technological changes. We also test an alternative way to control for time effects by replacing trend variables and interaction variables with trend by year dummies. The results remain robust and are presented in the Tables AII-AIV.

4. Results

4.1 Basic results

Table I presents the main descriptive statistics. As indicated, there is a clear decreasing trend in the average cost of borrowed funds which declined from 3.19 per cent in 2007 to 0.64 per cent in 2013, which can be explained by an expansive monetary policy (cut in the Fed rate, quantitative easing) in response to the 2007-2009 global financial crisis. However, there is a larger dispersion of cost of borrowed funds among the sample banks in the second half of the period than in 2007-2009, as evidenced by the range (the difference

Table I Descriptive statistics of SFA inputs

Year	*Stats*	*Loans*	*OEA*	*Non-interest income*	*Cost of borrowed funds*	*Cost of labour*	*Cost of fixed assets*	*Equity*
2007	Mean	6,572.677	2,103.06	149.4162	0.0319262	0.0160041	1.063604	1,028.617
	SD	8,378.787	2,003.394	152.558	0.0090292	0.0062338	0.6886468	1,162.296
	Minimum	310.0285	179.5	5.0174	0.0128757	0.0081047	0.3463898	63.9956
	Maximum	39,087.78	7,361.109	570.552	0.0486975	0.0319602	2.986772	5,323.739
	N	19	19	19	19	19	19	19
2008	Mean	8,375.364	2,907.209	147.0104	0.0261888	0.0147929	1.684136	1,364.575
	SD	26,955.53	9,345.731	416.0464	0.0085381	0.0075884	2.682243	4,142.541
	Minimum	66.2467	64.4696	−6.687	0.0094082	0.0042843	0.4216143	23.2038
	Maximum	179,855	62,938	2754	0.0463028	0.0533847	16.77752	27,648
	N	45	45	45	44	42	42	45
2009	Mean	22,392.43	14,681.76	1,468.981	0.0196615	0.0146884	1.696859	5,171.625
	SD	123,872.3	92,183.71	9,827.481	0.0076009	0.0067682	2.494827	30,265.32
	Minimum	78.8342	18.01099	−4.106	0.0047322	0.0051869	0.1225478	24.4839
	Maximum	944,002	707,782	75,370	0.034273	0.044713	15.96135	231,444
	N	59	59	59	56	54	53	59
2010	Mean	11,893.98	10,677.47	561.2758	0.0152676	0.0148122	1.32081	2,573.288
	SD	77,021.39	93,677.21	4,736.338	0.0072033	0.004242	1.620874	18,507.91
	Minimum	81.5382	16.80099	0.011	0.0030281	0.0021875	0.2886243	14.743
	Maximum	975,498	109,3561	59,664	0.0633083	0.0385882	22.42995	228,248
	N	326	326	325	319	323	322	326
2011	Mean	13,408.99	10,579.26	577.2528	0.0121013	0.0182775	1.348341	2,834.304
	SD	83,162.39	90,058.31	4,403.003	0.0164886	0.0640145	1.65988	19,315.75
	Minimum	1.828	15.65799	−8.163	0.00192	0.0024943	0.1710072	−16.926
	Maximum	939,962	117,9334	49,545	0.3067559	1.250322	20.45036	230,101
	N	377	375	376	363	374	371	377
2012	Mean	14,107.69	11,689.58	581.0897	0.0083436	0.0156214	1.380443	3,141.316
	SD	85,414.03	97,793.02	4,374.144	0.0048874	0.005068	2.376106	21,046.06
	Minimum	81.9716	3.389008	−19.766	0.0013134	0.0031935	0.3282828	27.754
	Maximum	927,232	128,3324	52,121	0.0348799	0.0465686	35.8385	236,956
	N	365	362	364	357	364	360	365
2013	Mean	14,412.9	10,645.71	609.4402	0.0064123	0.0157146	1.242	3,086.361
	SD	85,664.69	92,252.23	4,718.922	0.0040878	0.0050342	1.397515	20,670.43
	Minimum	3.4749	1.7226	−106.647	0.00098	0.003438	0.2494949	30.79
	Maximum	939,595	133,8540	53,287	0.0348666	0.0487402	16.98594	232,685
	N	304	304	304	304	304	304	306
Total	Mean	13,569.48	10,706.72	598.1048	0.0116629	0.0160825	1.346661	2,928.862
	SD	83,187.52	91,325.03	4,768.194	0.0108963	0.0324709	1.86725	19,986.75
	Minimum	1.828	1.7226	−106.647	0.00098	0.0021875	0.1225478	−16.926
	Maximum	975,498	133,8540	75,370	0.3067559	1.250322	35.8385	236,956
	N	1,495	1,490	1,492	1,462	1,480	1,471	1,497

Notes: The table reports descriptive statistics of financial indicators used as inputs in constructing the translog SFA cost function. OEA stands for other earning assets. Cost of borrowed funds is defined as interest expense divided by customer deposits and short-term funding. Cost of labour is the ratio of personnel expenses to total assets. Cost of fixed assets is calculated by dividing other operating expenses by the net book value of fixed assets

between the maximum and the minimum values) and coefficient of variation. This is likely due to a greater selectivity of external fund providers after the financial crisis and the "flight to quality".

The average balance sheet size has increased between 2007 and 2013. The trend was more pronounced for other earning assets which showed a 12-fold increase, whereas loans expanded by 300 per cent. Coupled with a substantial rise in non-interest income, these statistics suggest a shift in the focus of the banking business model in the low-interest rate environment in a search for higher yields. Therefore, we use the term "non-traditional banking activities" to describe non-interest income and off-balance sheet items to be consistent with Lozano-Vivas and Pasiouras (2010), but we recognize that recently these elements have made an integral part of normal business activities in most banks.

The results of efficiency score estimation are reported in Table II. An average score over the entire estimation period amounts to 0.9104 for the model incorporating non-traditional activities measured by non-interest income, indicating that an average bank could reduce costs by 9.96 per cent for the same amount of outputs. Interestingly, the lowest scores (both in terms of average and minimum values) are observed in the aftermath of the financial crisis, suggesting the stickiness of costs and the difficulty faced by banks in adjusting the costs rapidly in response to falling output. Indeed, in recent years, many

Table II Descriptive statistics for cost efficiency scores

Year	*Stats*	*CE1*	*CE2*	*CE3*
2007	Mean	0.9131	0.9119	0.9208
	SD	0.0412	0.0398	0.0354
	Minimum	0.8350	0.8319	0.8520
	Maximum	0.9740	0.9727	0.9736
2008	Mean	0.9271	0.9241	0.9362
	SD	0.0321	0.0368	0.0252
	Minimum	0.8472	0.7887	0.8725
	Maximum	0.9704	0.9724	0.9745
2009	Mean	0.9238	0.9237	0.9372
	SD	0.0368	0.0349	0.0323
	Minimum	0.8186	0.8224	0.8318
	Maximum	0.9842	0.9848	0.9853
2010	Mean	0.9083	0.9081	0.9139
	SD	0.0622	0.0613	0.0611
	Minimum	0.4891	0.4636	0.4484
	Maximum	0.9799	0.9787	0.9833
2011	Mean	0.9076	0.9073	0.9141
	SD	0.0641	0.0622	0.0606
	Minimum	0.5159	0.5131	0.4992
	Maximum	0.9814	0.9805	0.9849
2012	Mean	0.9112	0.9118	0.9191
	SD	0.0562	0.0528	0.0512
	Minimum	0.4922	0.5743	0.5629
	Maximum	0.9764	0.9754	0.9768
2013	Mean	0.9105	0.9112	0.9159
	SD	0.0541	0.0523	0.0502
	Minimum	0.6606	0.6738	0.6946
	Maximum	0.9813	0.9812	0.9846
Total	Mean	0.9104	0.9105	0.9171
	SD	0.0579	0.0560	0.0548
	Minimum	0.4891	0.4636	0.4484
	Maximum	0.9842	0.9848	0.9853

Notes: The table documents descriptive statistics for efficiency scores by year. CE2 is the cost efficiency from traditional stochastic frontier models with two outputs, loans and other earning assets. CE1 is the cost efficiency account from the model that accounts for non-traditional banking activities by adding non-interest income in the output vector. CE3 is the cost efficiency account from the model that factors in non-traditional banking activities by replacing non-interest income by off-balance sheet commitments in the output vector

financial institutions have announced their intention to reduce the staff; however, this process is typically lengthy. Consequently, the cost of labour cannot be reduced instantly, which is also confirmed by the descriptive statistics reported in Table I, where there is an increasing trend in the cost of labour up to 2011.

Table III reports the strength of linear association between selected financial and governance indicators. Overall, the coefficients of correlation are low. A few observations are still worth mentioning. The correlation between board size and bank size (total assets) is 0.11, suggesting that larger banks tend to have larger boards. This is in line with the results obtained by Tanna *et al.* (2011) for UK banks, although the association is weaker. Interestingly, higher percentage of non-interest income in total income is associated with a larger number of audit committee meetings. Larger boards (and larger banks) tend to have a higher percentage of women on board, although the relation is not strong (0.15). This finding is similar to that obtained by Mateos de Cabo *et al.* (2011) for European banks. Arguably, larger boards are more likely to facilitate free-riding. Adams and Ferreira (2012) find a positive relationship between board size and attendance issues for US bank-holding companies. A weak negative relationship between the number of directors and meeting attendance reported in Table III corroborates this result to some extent. Larger banks have, on average, more diversified income (as measured by a larger percentage of non-interest income in total income) and more complex operations. The percentage of independent directors is negatively associated with attendance rate which can probably be explained by their engagements on other boards and therefore lower availability. There is also a positive association between the percentage of independent directors and the number of board changes. More independent directors are associated with a higher fraction of compensation paid in stock awards and a higher pre-tax income.

Table IV presents the descriptive statistics for macroeconomic and corporate governance indicators over 2007-2013. Given low variability of board-related measures over time, we do not report distribution characteristics on a year-by-year basis. The indicator that exhibits a higher variability is stock compensation, the average level of which drops from 20 per cent of total compensation before 2010 to 13 per cent in 2010 and 2011 and then rises to 17 per cent and 26 per cent in 2012 and 2013, respectively. Our estimation period includes the financial crisis and subsequent recovery, which explain the range of inflation rate and GDP growth rate. An average board in the US banks comprises 11 directors, which is higher than the optimal size for non-financial firms, but in line with the arguments put forth by Adams and Mehran (2003). Approximately 36 per cent of banks in our sample have the dual appointment of the Chairman of the board and the CEO. An average board duration amounts to 2.3 years and varies from 1 year to 4 years.

4.2 Relevance of board characteristics for bank efficiency

Tables V-VII report the estimated relationship between board characteristics and bank *in* efficiency. Tables V and VI document the results for individual corporate governance characteristics, while Table VII shows the effect of including the CEO duality × Non-executive directors' interaction variable.

Overall, we fail to reject *H1*, *H2*, *H3*, *H4* and *H6*. We reject *H5*, *H7* and *H8*.

When measured relative to the bank size (here, proxied by the number of employees), the board size is significant and we find an inverted U-shape relationship between board size and efficiency (or equivalently, a U-shape relationship between board size and inefficiency). In other words, larger boards contribute to a higher efficiency, but if the size exceeds an optimal level, the costs of larger boards (such as coordination issues and herding behaviour) outweigh the benefits. We therefore fail to reject *H1*. We compare board sizes for most efficient and least efficient banks in our sample. We find that, all else equal, for banks with less than 1,000 employees, the board size should not exceed 12-13 directors; for banks with more than 1,000 employees, but less than 10,000 employees, an

Table III Cross-correlation table

Variables	*Total assets*	*Board size*	*Stock compensation*	*Meeting attendance*	*Meetings per year*	*Non-interest income*	*Board duration*	*Non-executive directors*	*Changes per year*	*CEO duality*	*Audit committee meetings*	*Women on board*	*Female executives*
Total assets	1.00												
Board size	0.12 (0.00)	1.00											
Stock compensation	0.23 (0.00)	0.18 (0.00)	1.00										
Meeting attendance	0.05 (0.09)	−0.04 (0.17)	0.04 (0.13)	1.00									
Meetings per year	0.06 (0.02)	−0.11 (0.00)	−0.09 (0.00)	−0.03 (0.19)	1.00								
Non-interest income	0.23 (0.00)	0.15 (0.00)	0.14 (0.00)	0.03 (0.23)	−0.10 (0.00)	1.00							
Board duration	−0.16 (0.00)	−0.15 (0.00)	−0.08 (0.00)	−0.09 (0.00)	0.06 (0.02)	−0.16 (0.00)	1.00						
Non-executive directors	0.12 (0.00)	0.31 (0.00)	0.10 (0.00)	−0.06 (0.02)	−0.01 (0.84)	0.01 (0.66)	−0.06 (0.01)	1.00					
Changes per year	0.21 (0.00)	0.19 (0.00)	0.09 (0.00)	−0.03 (0.30)	0.05 (0.06)	0.05 (0.05)	−0.04 (0.13)	0.10 (0.00)	1.00				
CEO duality	0.06 (0.02)	−0.02 (0.53)	0.06 (0.01)	0.09 (0.00)	−0.14 (0.00)	0.10 (0.00)	−0.11 (0.00)	−0.17 (0.00)	−0.06 (0.02)	1.00			
Audit committee meetings	0.18 (0.00)	0.12 (0.00)	0.12 (0.00)	−0.04 (0.17)	0.11 (0.00)	0.05 (0.05)	−0.14 (0.00)	0.07 (0.01)	0.09 (0.00)	0.02 (0.38)	1.00		
Women on board	0.13 (0.00)	0.15 (0.00)	0.16 (0.00)	0.02 (0.40)	−0.02 (0.50)	0.13 (0.00)	−0.08 (0.00)	0.13 (0.00)	0.03 (0.18)	0.02 (0.45)	0.01 (0.68)	1.00	
Female executives	−0.02 (0.52)	−0.04 (0.12)	−0.01 (0.83)	0.00 (0.91)	−0.01 (0.78)	−0.06 (0.03)	0.08 (0.01)	0.09 (0.00)	−0.01 (0.80)	−0.02 (0.55)	−0.02 (0.58)	0.13 (0.00)	1.00

Notes: Stock compensation is measured as a percentage of total board compensation in the form of shares or stock options; meeting attendance represents the number of meetings attended relative to the total number of meetings; non-interest income is defined as non-interest income divided by total income (the sum of non-interest income and interest income); non-executive directors as a percentage of total number of directors (board size). Female executives as a percentage of total number of executives

Table IV Summary statistics

Variable	*Mean*	*SD*	*Minimum*	*Maximum*	N
Independent variables					
Inflation	2.192	0.886	−0.338	3.846	1,499
GDP growth	1.815	1.114	−2.7	3.125	1,499
Board size	10.794	2.893	5	23	1,499
Stock compensation	16.013	20.908	0	92.638	1,499
Meeting attendance	76.338	5.021	70.83	100	1,448
Meetings per year	11.666	5.893	0	129	1,485
Board duration	2.271	0.966	1	4	1,492
Non-executive directors	85.123	7.535	50	100	1,499
Women on board	0.107	0.086	0	0.5	1,497
Number of changes	1.127	1.74	0	20	1,499
CEO duality	0.342	0.474	0	1	1,495
Audit committee meetings	7.877	3.821	0	25	1,491
Female executives	12.891	14.932	0	100	1,288
Non-interest income	0.229	0.13	−0.191	1	1,492

Notes: The table presents the descriptive statistics for macroeconomic and corporate governance indicators over 2007-2013; stock compensation is measured as a percentage of total board compensation in the form of shares or stock options; meeting attendance represents the number of meetings attended relative to the total number of meetings; non-interest income is defined as non-interest income divided by total income (the sum of non-interest income and interest income); non-executive directors as a percentage of total number of directors (board size). Female executives as a percentage of total number of executives; women on board are defined as a percentage of the total number of directors

optimal board size is around 15; for banks with more than 10,000 employees, an optimal board size is around 16.

We also confirm an inverted U-shaped relationship between the degree of board independence and banking efficiency. This result supports the guidelines provided in BCBS (2014) with respect to board composition: "the board should be composed of a sufficient number of independent directors" (par. 45, p. 11). Higher percentage of independent directors may limit the conflict of interest between managers and shareholders and thus enhance oversight and advisory roles of the board. On the other hand, several studies (Minton *et al.*, 2012) reported that outside directors in financial institutions often lack relevant banking expertise. Therefore, inside directors may provide valuable information, taking into account the increasing complexity and opacity of banking operations. We find that an optimal percentage of independent directors is around 86 per cent, the level which is close to de Andrés and Vallelado (2008).

Meanwhile, the banks where the Chairman also executes the CEO responsibility, show lower efficiency. The concentration of senior management duties and board supervision may lead to CEO entrenchment and result in excessive power given to a single individual. This may undermine the efficiency of decision-making process, in particular achieving the return objective at the lowest possible cost (Jensen, 1993; Finkelstein and D'Aveni, 1994). This finding is in line with previous empirical evidence (Pi and Timme, 1993; Larcker *et al.*, 2007; Wang *et al.*, 2012). However, the analysis of the interaction variable (CEO duality × Non-executive directors) reveals that there is a significant positive relationship between the fraction of non-executive directors and bank efficiency (or, alternatively, a negative relationship between non-executive directors and inefficiency) in banks where the same person serves as the Chairman of the Board and the CEO. The result indicates that a higher percentage of independent board members may mitigate the conflict of interest and lower efficiency stemming from the CEO duality. It is in line with Hardwick *et al.* (2011). This finding also corroborates the corporate governance framework proposed by the BCBS:

> In jurisdictions where the chair is permitted to assume executive duties, the bank should have measures in place to mitigate the adverse impact on the bank's checks and balances of such situations. This may include [. . .] having a larger number of non-executives on the board so as to provide effective challenge to executive board members (BCBS, 2014, par. 61, p. 13).

Table V Effect of corporate governance (board-related) indicators on cost *ine*fficiency

	Model C1	*Model C2*	*Model C3*	*Model C4*	*Model C5*	*Model C6*
Inflation	0.0850 (1.03)	0.0908 (1.09)	0.0883 (1.10)	0.0803 (0.97)	0.0924 (1.08)	0.0895 (1.07)
GDP growth	0.0599 (0.81)	0.0570 (0.77)	0.0569 (0.79)	0.0387 (0.49)	0.0406 (0.50)	0.0394 (0.50)
ln Equity	−0.545*** (−3.65)	−0.552*** (−3.61)	−0.532*** (−3.96)	−0.484*** (−3.85)	−0.501*** (−3.73)	−0.483*** (−3.86)
Board size	−21.41** (−2.53)	−21.20** (−2.47)	−20.04*** (−2.81)	−19.60*** (−3.09)	−19.71*** (−2.88)	−18.74*** (−3.04)
Board size^2	44.25** (2.28)	43.90** (2.23)	41.68** (2.40)	44.69*** (2.69)	44.59** (2.56)	42.58*** (2.62)
Non-executive directors	−0.0196** (−2.49)	−0.166* (−1.62)	−0.173* (−1.69)	−0.0199*** (−2.62)	−0.212** (−2.10)	−0.218** (−2.17)
Non-executive directors^2		0.001017* (1.67)	0.00106* (1.65)		0.00122* (1.91)	0.00125** (1.98)
Stock compensation	0.00881*** (2.84)	0.00892*** (2.86)	0.00921*** (3.01)	0.00630** (2.10)	0.00668** (2.17)	0.00697** (2.29)
Meeting attendance	−0.00736 (−0.52)	−0.00705 (−0.49)	−0.00598 (−0.45)	−0.00463 (−0.35)	−0.00395 (−0.28)	−0.00289 (−0.22)
Meetings per year	0.0175* (1.55)	0.0176* (1.56)	0.0178* (1.60)	0.0134 (1.22)	0.0141 (1.27)	0.0142 (1.29)
Audit committee meetings per year	0.0146 (0.86)	0.0141 (0.83)	0.0122 (0.73)	0.0188 (1.11)	0.0188 (1.10)	0.0170 (1.01)
Board duration	−0.246*** (−3.19)	−0.246*** (−3.15)	2.464* (1.68)	−0.238*** (−3.33)	−0.245*** (−3.26)	2.415* (1.66)
Board duration^2			−0.674* (−1.85)			−0.661* (−1.82)
Number of changes	0.0672** (2.31)	0.0674** (2.34)	0.0696** (2.45)	0.0746*** (2.61)	0.0754*** (2.63)	0.0775*** (2.73)
CEO duality	0.169 (1.28)	0.174 (1.31)	0.194 (1.48)	0.158 (1.20)	0.166 (1.25)	0.186 (1.41)
Constant	1.303 (0.80)	7.006* (1.59)	5.043 (1.14)	0.819 (0.56)	8.288* (1.93)	6.327 (1.45)
N	1,256	1,256	1,256	1,256	1,256	1,256

Notes: The table reports the results of the simultaneous estimation of determinants of cost efficiency using the methodology suggested by Battese and Coelli (1995); models C4-C6 are traditional stochastic frontier models with two outputs, loans and other earning assets; models C1-C3 account for non-traditional banking activities by including non-interest income in the output vector; the board size is normalized by the number of employees; *significant at the 10% level; **significant at the 5% level; ***significant at the 1% level; *t*-statistics are provided in the parentheses

Table VI Effect of corporate governance (board-related) indicators on cost *in*efficiency

	Model C7	*Model C8*	*Model C9*
Inflation	0.115 (1.06)	0.150 (1.05)	0.123 (1.13)
GDP growth	0.102 (1.06)	0.118 (0.97)	0.0961 (1.03)
ln Equity	−0.710*** (−7.28)	−0.786*** (−6.75)	−0.653*** (−5.38)
Board size	−32.46*** (−3.45)	−38.86*** (−4.15)	−26.58*** (−5.17)
Board size^2	72.16*** (7.01)	82.99*** (7.72)	58.53 (.)
Non-executive directors	−0.0203** (−2.42)	−0.248** (−2.19)	−0.260** (−2.41)
Non-executive directors^2		0.00146** (2.03)	0.00153** (2.25)
Stock compensation	0.00863** (2.56)	0.00946*** (2.63)	0.00902*** (2.72)
Meeting attendance	−0.0102 (−0.42)	−0.00770 (−0.20)	−0.00555 (−0.26)
Meetings per year	0.00538 (0.45)	0.00630 (0.51)	0.00604 (0.52)
Audit committee meetings	0.0290 (1.49)	0.0305 (1.39)	0.0256 (1.39)
Board duration	−0.234*** (−2.90)	−0.258*** (−2.62)	2.506* (1.55)
Board duration^2			−0.678* (−1.69)
Number of changes	0.0995*** (3.08)	0.102*** (3.00)	0.0987*** (3.13)
CEO duality	0.0745 (0.49)	0.0723 (0.44)	0.107 (0.74)
Constant	2.383 (1.20)	11.29** (2.10)	8.770* (1.79)
N	1,181	1,181	1,181

Notes: The table reports the results of the simultaneous estimation of determinants of cost efficiency using the methodology suggested by Battese and Coelli (1995); all the models control for non-traditional banking activities by replacing non-interest income with off-balance sheet commitments; the board size is normalized by the number of employees; *significant at the 10% level; **significant at the 5% level; ***significant at the 1% level; *t*-statistics are provided in the parentheses

Table VII Effect of corporate governance (board-related) indicators on cost *in*efficiency

	Model C10	*Model C11*	*Model C12*
Inflation	0.0824 (1.08)	0.0923 (1.27)	0.0976 (0.73)
GDP growth	0.0550 (0.80)	−0.00435 (−0.07)	−0.0510 (−0.48)
ln Equity	−0.515*** (−4.44)	−0.515*** (−4.48)	−0.540*** (−4.23)
Board size	−19.37*** (−3.42)	−19.85*** (−3.61)	−23.84*** (−2.98)
Board size^2	40.34*** (2.67)	43.38*** (2.83)	53.36*** (2.80)
Non-executive directors	−0.00579 (−0.61)	−0.00540 (−0.57)	−0.000998 (−0.10)
Stock compensation	0.00951*** (3.20)	0.00926*** (3.11)	0.00721** (2.32)
Meeting attendance	−0.00783 (−0.63)	−0.00698 (−0.57)	−0.00302 (−0.23)
Meetings per year	0.0188* (1.70)	0.0183* (1.68)	0.00800 (0.70)
Audit committee meetings per year	0.00813 (0.49)	0.00935 (0.57)	0.0115 (0.67)
Board duration	2.407* (1.68)	2.418* (1.70)	2.119 (1.51)
Board duration^2	−0.660* (−1.85)	−0.661* (−1.86)	−0.576* (−1.65)
Number of changes	0.0658** (2.37)	0.0598** (2.18)	0.0814*** (2.79)
CEO duality	2.952** (2.38)	2.989** (2.42)	3.181** (2.53)
CEO duality × non-executive directors	−0.0330** (−2.25)	−0.0336** (−2.29)	−0.0364** (−2.44)
Constant	−1.987 (−1.08)	−1.960 (−1.08)	−2.046 (−1.07)
N	1,256	1,256	1,181

Notes: The table reports the results of the simultaneous estimation of determinants of cost efficiency using the methodology suggested by Battese and Coelli (1995); model C11 is a traditional stochastic frontier model with two outputs, loans and other earning assets; model C10 accounts for non-traditional banking activities by including non-interest income in the output vector; model C12 controls for non-traditional banking activities by replacing non-interest income with off-balance sheet commitments; the board size is normalized by the number of employees; *significant at the 10% level; **significant at the 5% level; ***significant at the 1% level; *t*-statistics are provided in the parentheses

Therefore, we assert that the BCBS emphasis on advising a board composition that provides for a sufficient degree of director independence, is consistent with enhancing banking efficiency. We therefore fail to reject our *H2*, *H3* and *H4* with regards to board independence, CEO duality and interaction between the two, respectively.

Another interesting finding lies into the negative relationship between board duration and bank inefficiency and a positive relationship between number of board changes per year and bank inefficiency. Both results point out that boards which are relatively more stable

are likely to increase bank efficiency. Our tests for non-linear relationship between board duration and cost efficiency reveal a U-shaped relationship between the two variables. We therefore fail to reject our *H6* with regards to number of board changes per year. Counter to our expectations in *H5*, a U-shaped relationship between board duration and efficiency stipulates that higher efficiency is attained by banks where board members serve for either one or four years before being re-elected. A possible explanation of this finding might be that in boards with low duration, directors might increase efforts to be re-elected for an additional term. On the other hand, in boards with greater duration, directors' engagement is high for them not to be replaced because this may be harmful for their reputation. Additionally, directors in boards with a greater duration may gain supplementary experience facilitating efficient decision-making.

As for the board compensation structure, we find a negative relationship between stock-related compensation and bank efficiency. This result is qualitatively consistent with Adams and Mehran (2003) who report a negative relationship between deferred stock director compensation, as measured by a dummy variable, and bank value proxied by Tobin's Q. As mentioned by Akhigbe and Martin (2008), higher proportion of board members who own stock in the firm may result in either increased risk taking through riskier investment and financing decisions or decreased risk taking if directors are entrenched. If the assumption about higher risk taking holds, this may lead to lower efficiency.

Contrary to our expectations, we do not find any statistically significant relationship between the frequency of board meetings and cost efficiency. Meanwhile, our results for the number of board meetings per year corroborate empirical findings reported by de Andrés and Vallelado (2008). Similar conclusion can be made with regards to the number of audit committee meetings per year. One of the possible explanations is that the frequency of board meetings does not measure perfectly the quality of information exchanges in the boardroom.

The relationship between meeting attendance and bank efficiency is not statistically significant, and this finding is observed across various alternative measures of attendance (total percentage of meeting attendance, issues with attendance as measured by a dummy equal to 1 if the percentage is below 75 and 0 otherwise, attendance by independent board members). There is scarce empirical evidence on the relation between meeting attendance and bank performance. In one of the rare papers treating this variable, Aebi *et al.* (2012), it is found that issues with attendance are not relevant for buy-and-hold bank stock returns during 2007-2008 financial crisis. It should, however, be noted, that meeting attendance problems were measured differently from our approach, by calculating the percentage of directors who attended less than 75 per cent of meetings. For non-financial firms, Liu *et al.* (2014) claim that attendance by independent directors is important for protecting investor interests in China, especially in non-state-owned companies.

We also fail to find any conclusive results with regards to an average age of board members. This holds for two different measures of age: average age and a dummy equal to 1 if average age is above 72 and 0 otherwise.

We have also tested the relevance of board gender diversity for bank efficiency by including the percentage of women on board in the inefficiency equation. However, in line with previous scant evidence (Carter *et al.*, 2010; Pathan and Faff, 2013), we do not find any statistically significant association between the two indicators. The role of women on board has been discussed in few studies. Some of them focus on the determinants of fraction of female directors, and others measure the relevance for firm value and performance. In the European banking sector, Mateos de Cabo *et al.* (2011) show that banks with lower risk profile, larger board size and higher growth orientation are more likely to have a larger proportion of women on board. For brevity, we do not present the estimation results. They remain available upon request. The absence of statistically significant relationship between gender diversity in the boardroom and banking efficiency may be due to several factors.

First, the fraction of women on US banks' boards remains quite low, and therefore a tokenism issue may explain the absence of a statistically significant relation. Second, considering gender diversity as a dichotomic variable may be excessively restrictive. Indeed, women who have come through a double glass-ceiling by attaining board positions may have profiles similar to their male counterparts in terms of education and experience; therefore, the differences between their attitudes might not be significant.

5. Further research

5.1 Relevance of risk governance: role of risk committee

We envisage to push the investigation one step further by analyzing additional governance indicators, in particular the risk committee which plays key role in overseeing the risk management practices. All the bank boards have standard committees: audit, compensation and nominating (and governance). However, because of particular features of financial sector and inherent risk-taking behaviour, some banks, especially the largest ones, establish additional standing committees, including risk committee[7], that allow addressing the complexity of banking activities. According to Aebi *et al.* (2012), standard corporate governance indicators fall short in capturing all the governance structure characteristics of banks, making the consideration of risk-related mechanisms relevant. The necessity of efficient risk governance framework has also been underscored by regulators: BCBS (2014) insists on the adoption of the risk appetite statement, requires the presence of a risk committee in systemically important banks, strongly advises it for large banks and strongly recommends for other banks. At the national level, the Financial Stability Board (FSB) published in 2013 a Thematic Review on Risk Governance.

5.2 Alternative specifications

Although efficiency scores derived from parametric (e.g. SFA) or non-parametric (e.g. DEA) approaches encompass a large set of banking variables and are therefore considered among the most complete efficiency indicators, there are other measures that are less technically sophisticated but also widely used and closely monitored by investors. They comprise, among others, cost-to-income ratio, also referred to as efficiency ratio, and ROE. ROE is an accounting profitability of equity and is therefore of particular importance to shareholders. Because these alternative measures of efficiency are disclosed in the company reports (including management discussion and analysis of annual reports) and are under the scrutiny of investment public, the panel data analysis can be performed to study the relevance of board characteristics and risk governance for these ratios.

6. Conclusion

Banks play an important role of financial intermediaries. Their efficiency is essential for financial stability, whereas inefficiency may have a ripple effect on the economy (Qian and Yeung, 2015). It is therefore relevant to understand whether sound corporate governance may improve banking efficiency.

In bank governance, boards of directors play an important role, monitoring managers and advising them in the elaboration and implementation of strategies. This paper contributes to the fragmented literature on corporate governance in banking industry by testing whether certain characteristics of the board, such as board size, independence, duration, frequency of meetings reflect the motivation and abilities of directors to execute these roles. More specifically, we analyze if these characteristics are associated with higher bank efficiency. To the best of our knowledge, this is the first paper on the US banking sector that uses the frontier-based performance measure to assess the importance of board-related characteristics in the recent period. SFA cost efficiency is a more complete measure of

performance relative to widely used accounting measures such as ROE or ROA, and takes a broader perspective than shareholders' focus.

After estimating simultaneously two equations of stochastic frontier cost function, we draw the following conclusions for a sample of US commercial banks and savings institutions for the period 2007-2013. Consistent with the recent literature (de Andrés and Vallelado (2008)), we find an inverted U-shaped relationship between board size and efficiency. Thus, we establish that neither small nor large boards are beneficial for banks. The inclusion of more directors enhances the supervisory and advisory roles by expanding a pool of skills and expertise, but marginal costs of coordination and herding behaviour outweigh marginal benefits beyond an optimum board size. Our empirical study shows that this optimum level depends on the complexity of banking operations. We find that, all else equal, for banks with less than 1,000 employees, the board size should not exceed 12-13 directors; for banks with more than 1,000 employees, but less than 10,000 employees, an optimal board size is around 15; for banks with more than 10,000 employees, an optimal board size is around 16.

Second, our findings partially confirm a widespread belief that a desirable board composition allowing to lessen the conflict of interest between managers and shareholders is the majority of independent directors. The independence principle is also advised by BCBS, along with all corporate governance codes. As with a board size, we find an inverted U-shaped relationship between the proportion of independent directors and cost efficiency. In effect, our study shows that bank efficiency is positively related to the fraction of independent directors on the board, up to a level of approximately 86 per cent. Thus, efficient boards should be complemented by insiders for better decision-making and strategy elaboration. The trade-off between external monitoring and access to confidential information seems to be particularly relevant for the banking industry as compared to non-financial companies because of a higher complexity of operations. This result corroborates the guidelines of BCBS (2014) with respect to board composition, which provides for "a *sufficient* number of independent directors" (par. 45, p. 11) rather than requiring a board entirely composed of outsiders.

On the other hand, the banks where the Chairman also executes the CEO responsibility, show lower efficiency. However, the analysis of the interaction variable reveals that there is a significant positive relationship between the fraction of non-executive directors and bank efficiency in banks where the same person serves as the Chairman of the Board and the CEO. This finding suggests that a higher percentage of independent board members may mitigate the conflict of interest and lower efficiency stemming from the CEO duality. Here, again, we find an empirical support to the recommendations set out in BCBS (2014), which claim for a larger number of independent directors in banks with unitary leadership structure.

We also find that banks with board duration of either one or four years are more efficient compared to those with a duration of two or three years. Moreover, there is a negative relationship between the number of board changes per year and bank efficiency.

We fail to find any conclusive results with respect to board gender diversity, board average age and meeting attendance.

Our results are relevant for banks and their external and internal stakeholders. As mentioned previously, despite some guidance, there are no strict requirements with respect to bank corporate governance indicators. Consequently, board-related attributes are managed at the discretion of individual financial institutions. Therefore, banks may adjust their current board characteristics to increase the board effectiveness. Externally, potential investors can evaluate the quality of corporate governance of banks before making investment decisions[8]. Finally, our empirical findings can also be useful for regulators imposing corporate governance codes in banking.

Notes

1. Please refer to Section 3.2 for more details.
2. http://emergingmarkets.ey.com/wp-content/uploads/downloads/2012/04/Global_A-new-era-of-customer-expectation_global-consumer-banking-survey_Mar 2011.pdf (p. 7).
3. www.ey.com/GL/en/Industries/Financial-Services/Banking-Capital-Markets/Global-consumer-banking-survey-2014–Trust-and-Confidence
4. However, complexity alone does not explain the difference. For instance, Adams and Mehran (2012) note a decreasing trend in average board size across US bank-holding companies. Even in our sample which spans a relatively short time period, the average number of directors drops slightly from 13 in 2007 to 11 in 2012. In the meantime, the complexity of financial products and the fraction of non-traditional banking activities in total banking operations is ever increasing.
5. All hypotheses presented in this section are stated in the alternative form.
6. Because the DEA scores are derived from linear programming rather than by fitting a function, relatively small number of observations is sufficient.
7. Different banks use different names for this committee, such as Risk Committee, Risk Policy Committee, Risk Management Committee, Risk Management and Finance Committee, Enterprise Risk Management Committee, Risk Oversight Committee or Risk and Compliance Committee. However, the main objective of this committee, regardless of subtleties of the name, is to oversee the coherence of bank investments and lending activities with its risk appetite.
8. It may be applied by investors selecting companies based purely on financial criteria, as there is a relationship between governance and cost efficiency. But it is also important for investors taking into account extra-financial indicators, namely, environmental, social and governance dimensions in asset allocation process.

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Appendix

Table AI Variables description

Name	*Description*
Board size	Number of directors on board
Stock compensation	Stock awards given to directors compared to total director compensation as a percentage
Meeting attendance	Percentage of members in attendance at board meetings during the period
Meetings per year	Total number of corporate board meetings held in the past year
Board duration	Length of a board member's term, in years. For boards which allow renewal of terms, it is the length of a single term prior to renewals
Non-executive directors	Percentage of the board of directors that is comprised of non-executive directors
Women on board	Number of women on the board of directors, as a percentage of board size
Number of changes	Total number of board of directors changes during fiscal year
CEO duality	Indicates whether the company's CEO is also Chairman of the Board. Dummy variable equal to 0 if the two roles are separate
Audit committee meetings	Number of meetings of the board of directors' audit committee during the fiscal year
Female executives	Number of female executives, as a percentage of total executives, as of the fiscal year end
Non-interest income	Non-interest income, as a percentage of total income, i.e. the sum of interest and non-interest income

Notes: The table presents the description of selected variables used in the study; the data were extracted from Bloomberg; some missing data points were derived from annual reports (for financial indicators) or proxy statements (for corporate governance indicators)

Table AII Effect of corporate governance (board-related) indicators on cost *in*efficiency: year fixed effects

	Model C1	*Model C2*	*Model C3*	*Model C4*	*Model C5*	*Model C6*
Inflation	0.122 (0.90)	0.138 (0.97)	0.131 (0.97)	0.00466 (0.04)	0.0205 (0.18)	0.0159 (0.14)
GDP growth	0.0168 (0.15)	0.0156 (0.14)	0.0154 (0.14)	−0.129 (−1.48)	−0.133 (−1.48)	−0.132 (−1.49)
ln Equity	−0.493*** (−4.07)	−0.504*** (−4.01)	−0.491*** (−4.17)	−0.400*** (−4.07)	−0.407*** (−4.11)	−0.396*** (−4.10)
Board size	−18.04*** (−3.02)	−18.06*** (−2.91)	−17.37*** (−3.06)	−17.27*** (−3.55)	−17.06*** (−3.48)	−16.44*** (−3.47)
Board size^2	39.78** (2.49)	39.77** (2.43)	38.32** (2.47)	41.05*** (2.83)	40.25*** (2.79)	38.86*** (2.75)
Non-executive directors	−0.0173** (−2.31)	−0.189* (−1.86)	−0.196* (−1.94)	−0.0189*** (−2.60)	−0.199** (−2.07)	−0.207** (−2.15)
Non-executive direcrors^2		0.00108* (1.70)	0.00113* (1.78)		0.00114* (1.89)	0.00118** (1.97)
Stock compensation	0.00823*** (2.79)	0.00850*** (2.84)	0.00885*** (2.98)	0.00493* (1.78)	0.00519* (1.85)	0.00553** (1.98)
Meeting attendance	−0.00789 (−0.65)	−0.00761 (−0.61)	−0.00663 (−0.55)	−0.00473 (−0.41)	−0.00406 (−0.35)	−0.00311 (−0.27)
Meetings per year	0.0127 (1.17)	0.0129 (1.18)	0.0132 (1.22)	0.00913 (0.88)	0.00982 (0.94)	0.00993 (0.95)
Audit committee meetings	0.00588 (0.36)	0.00584 (0.36)	0.00442 (0.27)	0.0103 (0.64)	0.00985 (0.61)	0.00844 (0.53)
Board duration	−0.237*** (−3.54)	−0.241*** (−3.49)	2.465* (1.80)	−0.191*** (−3.09)	−0.194*** (−3.09)	2.514* (1.84)
Board duration^2			−0.673** (−1.97)			−0.674** (−1.98)
Number of changes	0.0614** (2.24)	0.0622** (2.28)	0.0651** (2.39)	0.0685*** (2.58)	0.0687*** (2.60)	0.0714*** (2.70)
CEO duality	0.156 (1.23)	0.165 (1.29)	0.186 (1.46)	0.174 (1.39)	0.186 (1.48)	0.206* (1.63)
Constant	1.009 (0.74)	7.706* (1.82)	5.817 (1.34)	0.879 (0.67)	7.840** (1.98)	5.943 (1.46)
N	1,256	1,256	1,256	1,256	1,256	1,256

Notes: The table reports the results of the simultaneous estimation of determinants of cost efficiency using the methodology suggested by Battese and Coelli (1995); temporal changes in cost frontier are accounted for by including year fixed effects; models C4-C6 are traditional stochastic frontier models with two outputs, loans and other earning assets; models C1-C3 account for non-traditional banking activities by including non-interest income in the output vector; the board size is normalized by the number of employees; *significant at the 10% level; **significant at the 5% level; ***significant at the 1% level; *t*-statistics are provided in the parentheses

Table AIII Effect of corporate governance (board-related) indicators on cost *in*efficiency: off-balance sheet items in the output vector; year fixed effects

	Model C7	*Model C8*	*Model C9*
Inflation	0.0747 (0.47)	0.103 (0.60)	0.0934 (0.39)
GDP growth	−0.0366 (−0.28)	−0.0360 (−0.26)	−0.0397 (−0.23)
ln Equity	−0.613*** (−6.89)	−0.618*** (−6.77)	−0.603*** (−4.54)
Board size	−27.11*** (−2.78)	−26.15*** (−3.32)	−25.21*** (−3.45)
Board size^2	63.42*** (6.80)	61.46*** (6.68)	59.85 (.)
Non-executive directors	−0.0162** (−2.03)	−0.257** (−2.35)	−0.264** (−2.27)
Non-executive directors^2		0.00153** (2.22)	0.00157** (2.12)
Stock compensation	0.00777** (2.42)	0.00815** (2.50)	0.00844** (2.40)
Meeting attendance	−0.00863 (−0.56)	−0.00839 (−0.53)	−0.00723 (−0.37)
Meetings per year	0.00293 (0.26)	0.00361 (0.32)	0.00373 (0.33)
Audit committee meetings	0.0207 (1.14)	0.0199 (1.09)	0.0183 (1.01)
Board duration	−0.229*** (−3.18)	−0.232*** (−3.11)	2.120* (1.75)
Board duration^2			−0.585* (−1.63)
Number of changes	0.0907*** (3.01)	0.0905*** (3.03)	0.0926*** (2.76)
CEO duality	0.103 (0.72)	0.108 (0.75)	0.128 (0.89)
Constant	1.856 (1.23)	11.11** (2.46)	9.470* (1.82)
N	1,181	1,181	1,181

Notes: The table reports the results of the simultaneous estimation of determinants of cost efficiency using the methodology suggested by Battese and Coelli (1995); all models control for non-traditional banking activities by replacing non-interest income with off-balance sheet commitments; the board size is normalized by the number of employees; *significant at the 10% level; **significant at the 5% level; ***significant at the 1% level; *t*-statistics are provided in the parentheses

Table AIV Effect of corporate governance (board-related) indicators on cost *in*efficiency: interaction variable; year fixed effects

	Model C10	*Model C11*	*Model C12*
Inflation	0.168 (1.22)	0.0126 (0.12)	0.0631 (0.47)
GDP growth	0.0842 (0.74)	−0.124 (−1.45)	−0.0463 (−0.44)
ln Equity	−0.518*** (−4.13)	−0.392*** (−4.09)	−0.572*** (−4.39)
Board size	−20.11*** (−3.17)	−16.59*** (−3.70)	−22.95*** (−2.72)
Board size^2	42.52*** (2.63)	39.30*** (2.88)	54.63*** (2.63)
Non-executive directors	−0.00469 (−0.49)	−0.00372 (−0.41)	0.00139 (0.14)
Stock compensation	0.00984*** (3.22)	0.00595** (2.15)	0.00865*** (2.68)
Meeting attendance	−0.00742 (−0.59)	−0.00573 (−0.50)	−0.00961 (−0.66)
Meetings per year	0.0179* (1.58)	0.0107 (1.02)	0.00470 (0.42)
Audit committee meetings	0.00642 (0.39)	0.00439 (0.28)	0.0126 (0.73)
Board duration	2.446* (1.71)	2.428* (1.80)	2.102 (1.51)
Board duration^2	−0.667* (−1.88)	−0.655* (−1.95)	−0.579* (−1.67)
Number of changes	0.0634** (2.26)	0.0685*** (2.61)	0.0868*** (2.92)
CEO duality	3.053** (2.45)	3.228*** (2.72)	3.516*** (2.70)
CEO duality × non-executive directors	−0.0342** (−2.31)	−0.0362*** (−2.58)	−0.0406*** (−2.63)
Constant	−2.356 (−1.27)	−2.386 (−1.40)	−1.518 (−0.77)
N	1,256	1,256	1,181

Notes: The table reports the results of the simultaneous estimation of determinants of cost efficiency using the methodology suggested by Battese and Coelli (1995); model C11 is a traditional stochastic frontier model with two outputs, loans and other earning assets; model C10 accounts for non-traditional banking activities by including non-interest income in the output vector; model C12 controls for non-traditional banking activities by replacing non-interest income with off-balance sheet commitments; the board size is normalized by the number of employees; *significant at the 10% level; **significant at the 5% level; ***significant at the 1% level; *t*-statistics are provided in the parentheses

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