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Board composition and operational risk events of financial institutions

Tawei Wang [a], Carol Hsu [b,*]

[a] School of Accountancy, Shidler College of Business, University of Hawaii at Manoa, Honolulu, HI 96822, USA
[b] Department of Information Management, National Taiwan University, Taipei 106, Taiwan

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ABSTRACT

We investigate the relation between board composition and operational risk events of financial institutions in the period from 1996 to 2010. Drawing from corporate governance literature, we consider the impact of board characteristics on the likelihood of operational risk events. Overall, our findings suggest that board size is negatively and non-linearly associated with the possibility of operational risk events. For the event types of "Clients, Products, and Business Practices," and "Internal Fraud and External Fraud," firms with a higher proportion of independent directors are less likely to suffer from fraud or failure to comply with professional obligations to clients. Our results on age and tenure heterogeneity also indicate that having a more diverse board can have an adverse impact on the board monitoring function. These results can shed new light on board demographics and operational risk management in financial institutions.

1. Introduction

Since the 1990s, major operational loss events have caused financial institutions and regulators to pay increasing attention to the development and improvement of managerial practices that could prevent or mitigate these emerging operational risks. Operational risks are those risks associated with failures related to internal processes, people, and/or systems, or the impact from external events. More specially, the Basel Committee on Banking Supervision (BCBS) classifies operational risk events into 7 plus 1 types: (1) Internal Fraud, (2) External Fraud, (3) Employment Practices and Workplace Safety, (4) Clients, Products, and Business Practices, (5) Damage to Physical Assets, (6) Business Disruption and System Failures, (7) Execution, Delivery, and Process Management, and (8) other non-BIS events.[1] Over the past decade, high-profile operational risk events include the rogue trading resulting in the 1995 bankruptcy of the Barings Bank, the financial losses of Allied Irish Bank in the early 2000s and Société Générale in 2008, the failure of Turquoise leading to the loss of trading volume in 2009, and the insider trading of NASDAQ's managing director between 2006 and 2009, to name a few. In the finance literature, studies have shown that while operational losses have an immediate impact on market performance (Cummins et al., 2006; Gillet et al., 2010), they also increase banks' risk exposures if the losses materialize over a period of time (Chernobai and Yildirim, 2008). In June 2011, recognizing the importance of operational risk, the BCBS issued a report which points out the imperative duty of the corporate board to ensure that an appropriate governance structure and culture is in place. The document states that "*sound operational risk senior management is a reflection of the effectiveness of the board and bank's management in administrating its portfolio of products, activities, processes, and systems*" (BCBS, 2011, p. 3). Within this particular context, this research attempts to investigate and address the relation between board composition and the occurrence of operational risk events.

Existing empirical research provides evidence that the corporate board is an important element in the governance structure of the organization (Beasley, 1996; de Andres and Vallelado, 2008). Economists argue that from the firm's agent-principal perspective, agency problems emerge when there is a divergence or conflict of interest between managers and stockholders. The board is designed to mediate agency conflicts, facilitate effective governance, and increase stockholders' share value. Thus, the board receives its powers from the shareholders and has the responsibility to oversee and monitor management action and ensure that a sound control environment is in place. An inadequate or failed control environment is a major contributing factor to significant operational losses, as indicated in the earlier examples. While the BCBS highlights the central role of the board in operational risk management, the document lacks specific guidance regarding board characteristics that might be relevant and essential to an organization's establishment of a strong control environment and risk culture.

* Corresponding author. Address: No. 1. Sec. 4, Roosevelt Rd., Taipei 106, Taiwan. Tel.: +886 2 3366 1196; fax: +886 2 3366 1199.
E-mail addresses: twwang@hawaii.edu (T. Wang), carolhsu@ntu.edu.tw (C. Hsu).

[1] See http://www.bis.org/bcbs/qis/oprdata.pdf for a detailed discussion of event types.

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Given that this is a relatively new research area, work on the determination of operational risk events from a corporate governance perspective remains very limited, with the notable exception of the study by Chernobai et al. (2011). Their study provided empirical evidence of the relation between the incidence of operational risk events and an environment of weak internal control among US financial institutions. Their pioneering work found internal control indicators such as internal control weaknesses (ICWs), G-index, and CEO compensation are highly connected to the frequency of operational risk events. However, to our knowledge, no one has conducted an empirical analysis to test the direct relation between the composition of the board of directors and the occurrence of operational risk events in corporations. Thus, the findings in this study are expected to have important implications for understanding operational risk management. First, this study can extend additional empirical support to the claims put forward by the BCBS and Chernobai et al. (2011) with respect to the role of the board in ensuring the soundness of operational risk management in financial institutions. Our findings can further strengthen the argument that operational risk management needs to be seen as the cornerstone of good corporate governance in firms. Second, this study attempts to analyze the effect of board characteristics on establishing, enhancing, and maintaining an effective governance structure for managing operational risk. The underpinning argument is that the board characteristics (size, proportion of independent directors, and age/tenure heterogeneity) might have implications regarding the ability of the board to monitor and offer support to management in the development and implementation of appropriate operational risk policies and standards. We anticipate that a board, which is more effective in overseeing and advising senior management, can implement and maintain a better governance structure which, in turn, helps reduce a firm's chances of experiencing potentially damaging operational risk events. In particular, the study's results can shed light on the relative importance of specific board composition characteristics as they pertain to operational risk management.

Our empirical analysis focuses on financial institutions and collects operational risk events from the FIRST database between 1996 and 2010. Given the 7 plus 1 different operational risk event types, in this study, we perform our test in two steps. First, we evaluate the association between board composition and the likelihood of operational risk events at the aggregate level. Second, we follow the Basel II classification of risk events and perform our analyses on categories that are more relevant to the board's decision-making, such as "Clients, Products, and Business Practices," and "Internal Fraud and External Fraud". Overall, we observe a U-shaped relation between board size and the likelihood of operational risk events aggregately or by event types. This finding was consistent with some studies indicating that the monitoring and controlling function grows stronger as the board size grows. However, our U-shaped finding further indicates that as the board grows beyond a certain size, the effectiveness of monitoring and decision-making quality starts to diminish. This finding also offers a complementary support to the earlier observation by Chernobai et al. (2011) that firms with operational risk events seem to have larger boards. With respect to the influence of independent directors, we observe that collectively there is no statistically significant relation between independent directors and the likelihood of operational risk events. Nonetheless, when we break down the operational risk event types, our results in the category of "Clients, Products, and Business Practices", and "Internal Fraud and External Fraud" indicate that firms with a higher proportion of independent directors have a lower likelihood of operational risk events. This finding is consistent with the prior literature that independent directors are imperative in overseeing and monitoring management, resulting in an environment of stronger internal controls (Fama and Jensen, 1983; Beasley, 1996; Chernobai et al., 2011).

Apart from board size and the proportion of independent directors, age and tenure heterogeneity are examined in this empirical investigation. The findings from the aggregate level demonstrate that age heterogeneity is positively related to the likelihood of operational risk events, but for the heterogeneity of tenure, the findings were not statistically significant. However, the heterogeneity of tenure has a significantly positive association with the likelihood of operational risk events when we focus on the event type "Clients, Products, and Business Practices". In the context of operational risk management, our results show that board diversity can lead to an increase in communication cost and impede board efficacy in evaluating the quality of operational risk measurements.

The organization of the paper is as follows. Section 2 describes the theoretical background on board composition and develops our hypotheses. Section 3 details the data collection process and methodological approach used for our study. Section 4 presents our empirical results both at the aggregate level and by different categories. Finally, we conclude with research implications in Section 5.

2. Board composition and hypothesis development

Corporate research discusses board composition as an internal governance mechanism to mitigate agency problems within the firm (Baysigner and Butler, 1985; Raheja, 2005; Carter et al., 2003). With the authority to select, dismiss, and reward important decision-makers in the organization, the board serves to monitor management actions in order to protect the corporation's value for its stockholders. Although various theories have been applied to discover the most significant board characteristics, there is yet no common agreement in the literature in this regard (Pathan and Skully, 2010). Of those characteristics that have been studied, we consider the following board characteristics to be the most relevant, widely adopted variables, and we classify them into two groups: (1) board size and independent directors and (2) heterogeneity of board member age and tenure.

Board size has been widely examined and discussed concerning its impact on firm performance (Eisenberg et al., 1998; Boone et al., 2007), financial fraud (Beasley, 1996), and the efficiency of decision-making (Dalton et al., 1999). No consensus has been reached on the relation between board size and firm performance. Dalton et al. (1999) suggest that support for a larger board is grounded in resource dependence theory. This theoretical viewpoint argues that the board is essential to acquiring external funding or accessing a wider spectrum of knowledge. Hence, a larger board can collectively help generate more external resources to improve firm performance. Nonetheless, not all studies show favorable results regarding larger boards (Goodstein et al., 1994; Firstenberg and Malkiel, 1994). The counter argument is that as board size grows, group communication likely becomes decreasingly effective because of social loafing and increasing conflicts. Such problems can lead to difficulties in achieving consensus and initiating strategic actions. Jensen (1993) argues that a smaller board is more effective in its controlling function, while a larger board tends to give control power to the CEO. Since operational risk management is a relatively new arena, top management can benefit from a larger board's greater knowledge pool. However, a larger board can reduce decision-making quality and hinder the organization's ability to determine an appropriate level of operational risk management. Thus, we expect a trade-off between the benefits of additional knowledge and the drawbacks of poor decision-making quality as board size grows. In our hypothesis, although we expect to see a negative association between board size and the likelihood of operational risk events, we expect the trade-off to be reflected in a nonlinear (U-shaped) relation between the two.

In addition to discussing board size, scholarly work has also highlighted the significance of independent directors in ensuring

the effective monitoring function of the board. In general, the board is composed of two groups of players: insider directors (the firm's senior management and CEO) and independent directors who are not affiliated with the organization. The two groups provide different resources and add value to the firm's performance in different ways. Insider directors are considered to have access to a greater amount and better quality of organization-specific information relevant to strategic decisions, while independent directors are perceived to be important for the protection of shareholders' interests, especially when serious agency problems arise. From the agency problem perspective, Fama and Jensen (1983) explain that without the involvement of independent directors, management is more likely to initiate and implement decisions that might conflict with the interests of stockholders. Furthermore, Fama and Jensen (1983) believe that independent directors have more incentive to create and maintain an effective control function. They argue that independent directors are keen to show the external market their capabilities and expertise in decision control because the majority of independent directors in large corporations are usually internal managers or other important decision-makers in other corporations. Rosenstein and Wyatt (1990) demonstrate a positive stock price reaction around the announcement date of an additional outside director and suggest that shareholder wealth is affected by the proportion of outside directors. Beasley (1996) found that firms with a higher percentage of independent directors are less likely to incur financial statement fraud. Chernobai et al. (2011) found that firms with more independent directors can increase the monitoring and internal control function, reducing the likelihood of operational risk events among US financial institutions. In this study, similar to the argument put forward by Chernobai et al. (2011), we consider that having a higher percentage of independent directors can institute stronger decision control in the corporation and hence reduce the occurrence of operational risk events. Thus, we expect a negative relation between the number of independent directors and the likelihood of operational risk events.

In evaluating the dynamics and capabilities of the board as an effective control mechanism, board demography becomes relevant because the heterogeneity of the board can influence the decision making process and outcome. The National Association of Corporate Directors suggests that firms need to consider director diversity when forming the board.[2] When considering demographical variables, age and tenure heterogeneity are widely adopted in the literature since age and tenure are associated with the director's experience and cognitive capabilities in making effective decisions (Westphal and Zajac, 1995; Muth and Donaldson, 1998; Anderson et al., 2011). Age is relevant because cognitive capabilities such as learning ability and memory seem to fade away with age (Bantel and Jackson, 1989). Furthermore, according to Muth and Donaldson (1998), younger directors are more open to innovation and to engaging in risk-taking behaviors while older directors are likely to be risk averse. Organizational tenure is important from the viewpoint of shared organizational experiences and education background. Vafeas (2003) found that increases in board tenure are associated with greater commitment and committee participation in organizations, but senior directors are also associated with more inflated CEO salaries.

With respect to the effects of board heterogeneity, a diverse board can bring multiple perspectives and greater access to information, resulting in creative problem solving and oversight function (Erhardt et al., 2003; Anderson et al., 2011). On the other hand, heterogeneous groups may also adversely impact the effectiveness of board function resulting from coordination difficulties, increased internal conflict, and the lack of cohesiveness (Simons and Peterson, 2000; Baranchuk and Dybvig, 2009). Focusing on operational risk management, we believe that age and tenure heterogeneity of the board can help reduce the occurrence of operational risk events because of the variety of organizational experience, input of new perspectives, and more creativity in problem solving. However, as board heterogeneity increases, we expect to observe an adverse impact on the board's effectiveness resulting from coordination obstacles and failure to reach agreement which might lead to a higher likelihood of operational risk events. We further explore whether there exists a U-shape relation between board heterogeneity and operational risk events.

3. Sample, variables, and econometric model

3.1. Data

In this research, we solicit relevant data from multiple databases for our empirical investigation. First, we collect operational risk events from the FIRST database. The FIRST database details most operational risk events dating back to the 1970s and covers a wide variety of industry sectors. For the purpose of this study, we concentrate on collecting operational risk events within financial institutions (with the first-digit SIC code 6) during the period from 1996 to 2010. Second, to assess the relation between board composition and operational risk events, we further collect information regarding a firm's board of directors from the Investor Responsibility Research Center (the RiskMetrics database). In 1996, the Investor Responsibility Research Center (IRRC, known as ISS after 2005) began accumulating information about the organizational demography—name, age, and independence classification of boards of directors—for S&P 1500 companies. We obtain all the data from 1996 to 2010, inclusively.[3] Furthermore, in order to obtain more board information for our sample, we also manually search for such information in proxy statements through the EDGAR database (http://www.sec.gov/edgar.shtml). Last, the Compustat database provides us with the firm characteristics for the control variables.

We then combine all the datasets discussed above, namely, the dataset from the FIRST database, RiskMetrics, and Compustat. However, this sample does not include any firms without previous operational risk events. To form a list of firms without operational risk events, we randomly match each firm with operational risk events to two non-event firms, if available, within the same industry and with similar firm age as listed in the RiskMetrics database in our sample period. Note that given the data availability in the RiskMetrics database, not all firm-event observations can be matched to non-event firms. We use firm age because Chernobai et al. (2011) show that firm age affects the possibility of operational risk events. The resulting sample consists of 298 firm-event and non-firm-event observations. Our sample is distributed across the following types of financial institutions: 40.61% are Depository Institutions, 20.13% are Security Brokers and Dealers, 25.83% are Insurance Carriers, and 13.43% are the other four types of financial institutions.

3.2. Variables and statistics

We measure a firm's possibility of having operational risk events by the variable *OP*, which equals one if a firm has an operational risk event in a certain year in our sample period, 0

[2] http://www.nacdonline.org/Resources/RSSDetail.cfm?RSSID=38150.

[3] ISS has changed the data collection methodology since 2007. However, the primary variables affected were about anti-takeover measures. Our data are not affected.

otherwise (see Table 1 for variable definitions). As discussed in Section 2, we consider several measures for board composition at the beginning of the year in our sample period. First, we take into account board size, which is the number of directors on the board of a firm (*BSIZE*). Furthermore, we measure the number of independent directors of a firm by calculating the percentage of independent directors on the board (*IBSIZE*). As mentioned earlier, board size and independent directors affect the decision quality of a firm, which in turn affects the occurrence of operational risk events. In addition to board size and the percentage of independent directors, the demographic makeup of the board is captured by the heterogeneity of the directors, which is measured by the coefficient of variation of age (*CVAGE*) (i.e., the standard deviation of age divided by average age) and the coefficient of variation of tenure (*CVTENURE*) (i.e., the standard deviation of tenure divided by average tenure).

The descriptive statistics of the variables mentioned earlier are given in Table 2. Table 2 Panel A shows that for the whole sample, about 89% of the firms have operational risk events (*OP*). For board characteristics, each firm has, on average, 11 directors (*BSIZE*) on the board and the percentage of independent directors is about 39% (*IBSIZE*). The heterogeneities of age (*CVAGE*) and tenure (*CVTENURE*), on average, are about 0.15 and 0.69, which means that the standard deviation is 0.15 and 0.69 times the average. Furthermore, we present the descriptive statistics of the board characteristics for the firms with and without operational risk events. Both groups have a board size (*BSIZE*) of about 11 directors. Approximately 38% and 39% of them are independent directors (*IBSIZE*) for the group with and without operational risk events. The heterogeneities of age and tenure for the groups with and without operational risk events are 0.150 vs. 0.145, and 0.727 vs. 0.586, respectively. The means of the above-mentioned variables do not differ significantly between firms with and without operational events except for *CVTENURE* ($p < 0.01$).

Consistent with prior literature discussed earlier, we control for a firm's control environment, firm complexity, and macroeconomic conditions. We use firm size and number of segments to capture the environment faced by the firm. First, firm size (*FSIZE*) is the logarithm of a firm's total assets (data item AT in Compustat). The complexity of business operations (*SEGMENT*) is measured by the number of operating and geographical segments reported in Compustat (Chernobai et al., 2011). Last, we control for macroeconomic conditions by using the change in GDP (*GDP*) and disposable personal income (*DPI*) as in Chernobai et al. (2011).

Furthermore, from Table 2 Panel A, our descriptive results indicate that firms have an average of 11 reported segments with total assets of about 7.6 billion (after the logarithm transformation). Table 2 Panel B and Panel C show that, on average, firms without operational risk events have about six reported segments, whereas firms with operational risk events have about 12 segments. The size of the firms without operational risk events is about 3.8 billion (after the logarithm transformation) while about 8.1 billion (after the logarithm transformation) for the firms with operational risk events. When comparing the means of the control variables across both groups (with and without operational risk events), both *FSIZE* and *SEGMENT* differ ($p < 0.01$). Table 3 shows the correlations of all the variables. We do not observe any high correlations among the independent variables that might affect our regression results.

3.3. Econometric model

The regression model we use captures a U-shaped relation, if any, between the size of the board or the percentage of independent directors and the possibility of operational risk events as proposed in prior literature (de Andres and Vallelado, 2008). In addition, we also explore whether there exists a U-shaped relation between the board heterogeneity and the likelihood of operational risk events. Eq. (1) is the basic model for our analyses.

$$OP = \beta_0 + \beta_1 BSIZE + \beta_2 BSIZE^2 + \beta_3 IBSIZE + \beta_4 IBSIZE^2 + \beta_5 FSIZE + \beta_6 SEGMENT + \beta_7 GDP + \beta_8 DPI + \Sigma \text{Year} + \varepsilon \quad (1)$$

The variables in Eq. (1) are defined earlier and in Table 1. Eq. (1) is estimated using logistic regression models. The model takes into account the year fixed effect and is estimated by considering the potential serial correlation of firms as suggested by Petersen (2009). Note that Eq. (1) is the basic model before considering *CVAGE* or *CVTENURE*. Our analyses are based on Eq. (1) as follows. First, at the aggregate level, we focus only on the board size and independent directors with and without the squared terms. Once we determine whether non-linear relations exist at the aggregate level, we apply the model with demographic factors, heterogeneity of age or tenure, as defined earlier, with and without the squared terms. Next, we re-perform the analyses by different operational risk event types as mentioned in Section 1.

4. Results

4.1. Empirical results at the aggregate level

In this sub-section, we apply our model to evaluate the relation between the board composition and the likelihood of operational risk events at a collective level. Our findings are given in Tables 4 and 5. Table 4 presents our results for board size and independent directors with and without squared terms. First, as shown in Table 4, both the size of a firm (*SIZE*) and the complexity of a firm's operation (*SEGMENT*) are significantly positive, which suggests that as size and the complexity of its operations increase, the firm might face more operational risk events. Second, board size (*BSIZE*)

Table 1
Variable definitions.

Variable	Definition	Source
OP	A dummy variable that equals one if a firm has an operational risk event in a certain year in our sample period, 0 otherwise	FIRST database
BSIZE	Board size, the number of directors on the board of a firm at the beginning of the year in our sample period	RiskMetrics proxy statement
IBSIZE	The percentage of independent directors on the board of a firm at the beginning of the year in our sample period	RiskMetrics
CVAGE	The coefficient variation of the age of the directors on the board of a firm at the beginning of the year in our sample period which equals the standard deviation of age of the directors divided by the average age of the directors	RiskMetrics
CVTENURE	The coefficient variation of tenure of the directors on the board of a firm at the beginning of the year in our sample period which equals the standard deviation of tenure of the directors divided by the average tenure of the directors	RiskMetrics
FSIZE	Firm size which is the logarithm of total assets of a firm at the beginning of the year in our sample period	Compustat
SEGMENT	The number of operating and geographical segments reported on Compustat of a firm at the beginning of the year in our sample period.	Compustat
GDP	The change in Gross Domestic Product for a certain year	BEA
DPI	The current dollar disposable income for a certain year	BEA

Table 2
Descriptive statistics.

Variable	N	Mean	Std. dev.	Quartiles		
				Q1	Q2	Q3
Panel A: all sample						
OP	298	0.893	0.3101	1.000	1.000	1.000
BSIZE	218	10.651	3.7426	8.000	10.000	12.000
IBSIZE	218	0.385	0.1803	0.278	0.375	0.500
CVAGE	211	0.149	0.0539	0.109	0.138	0.180
CVTENURE	107	0.685	0.2786	0.484	0.724	0.878
FSIZE	255	7.604	2.6982	5.950	7.555	9.352
SEGMENT	159	10.591	7.1034	4.000	9.000	15.000
GDP	298	4.640	1.8200	4.000	5.000	6.000
DPI	298	8753.040	1501.2900	7648.000	8378.000	10424.000
Panel B: OP = 1						
BSIZE	186	10.602	3.7866	8.000	10.000	12.000
IBSIZE	186	0.384	0.1617	0.300	0.375	0.471
CVAGE	179	0.150	0.0521	0.111	0.138	0.180
CVTENURE	75	0.727	0.2718	0.581	0.749	0.907
FSIZE	223	8.146	2.4225	6.629	8.074	9.706
SEGMENT	127	11.756	7.2130	6.000	12.000	16.000
GDP	266	4.820	1.5500	4.000	5.000	6.000
DPI	266	8709.770	1486.0500	7648.000	8378.000	10424.000
Panel C: OP = 0						
BSIZE	32	10.938	3.5190	8.000	10.500	13.500
IBSIZE	32	0.388	0.2675	0.111	0.450	0.580
CVAGE	32	0.145	0.0639	0.106	0.129	0.178
CVTENURE	32	0.586	0.2729	0.404	0.580	0.808
FSIZE	32	3.823	0.8699	3.185	3.768	4.657
SEGMENT	32	5.969	4.2539	3.000	4.000	8.500
GDP	32	3.190	2.9800	2.000	4.000	6.000
DPI	32	9112.720	1601.9100	7327.000	8633.500	10722.000

Table 3
Correlation of the variables. The bold values are significant at 5%.

Variable	*OP*	*BSIZE*	*IBSIZE*	*CVAGE*	*CVTENURE*	*FSIZE*	*SEGMENT*	*GDP*	*DPI*
OP	1.000	**0.151***	**−0.267***	−0.071	0.053	**0.715***	**0.411***	0.142	**0.179***
BSIZE	−0.032	1.000	−0.066	**−0.128***	0.128	**0.539***	0.108	0.149	0.035
IBSIZE	−0.007	**−0.331***	1.000	−0.139	0.020	−0.141	0.125	**0.351***	**−0.482***
CVAGE	0.033	**−0.166***	−0.017	1.000	0.106	**−0.287***	**−0.227***	−0.125	−0.037
CVTENURE	**0.234***	0.102	0.037	0.157	1.000	0.033	0.107	0.081	−0.066
FSIZE	**0.532***	**0.338***	−0.075	**−0.240***	**0.237***	1.000	**0.388***	**0.161***	**0.153***
SEGMENT	**0.328***	0.144	0.081	**−0.291***	**0.272***	**0.499***	1.000	0.099	0.053
GDP	**0.182***	0.070	**0.249***	−0.067	0.090	**0.125***	**0.130***	1.000	**−0.602***
DPI	**0.112***	0.057	**−0.322***	−0.068	0.012	**0.254***	0.103	**−0.414***	1.000

* Significant at 5%, the numbers below (above) the diagonal are Pearson (Spearman) correlation.

is consistently significantly and negatively associated with the possibility of operational risk events (−0.491, −2.583, −0.507, and −2.403, $p < 0.05$ and $p < 0.01$). Third, when we consider the non-linear relation (the tradeoff between knowledge diversity and decision quality) as in prior literature, the results are given in the second column (With *BSIZE* and $BSIZE^2$), the third column (With *IBSIZE* and $IBSIZE^2$), and the last column (with With *BSIZE*, $BSIZE^2$, *IBSIZE* and $IBSIZE^2$).

To capture such a relation, as suggested by prior literature (e.g., de Andres and Vallelado, 2008), we first take the non-linear term of board size ($BSIZE^2$) into account. When considering the squared term ($BSIZE^2$), as given in the second column of Table 4, the association between board size and the likelihood of operational risk events is U-shaped and the size of the board is negatively associated with the possibility of operational risk events (i.e., the coefficient of $BSIZE^2$ is 0.091, $p < 0.01$ and the coefficient of *BSIZE* is −2.583, $p < 0.01$). From our discussion in Section 2, our findings suggest that though board size could reduce the overall possibility of operational risk events, it demonstrates a non-linear characteristic. This finding is consistent with past studies (Boone et al., 2007) indicating that while an additional board member can contribute to knowledge development, such an advantage can be compromised when the board grows beyond a certain size. Raheja (2005) explains that in a larger board context, the monitoring function can be rendered ineffective by the free-ride problem and the escalation of communication and coordination difficulties. de Andres and Vallelado (2008) also found a non-linear effect of board size on bank performance. In the context of operational risk management, having additional director can bring more human capital and develop a greater knowledge pool to advise on manager's decisions. This can be valuable when establishing a sound operational risk management in financial institutions. Based on our sample, our finding shows that when the number of board members reaches around 14, adding a new board member can increase the likelihood of operational risk events. This implies that beyond the board size of about 14 directors, the challenge and problem of communication and conflicts can outweigh the advantage of knowledge development.

Moreover, it seems that independent directors do not affect the likelihood of operational risk events. This finding does not offer significant support to the literature on the value of independent directors in relation to firm performance (Rosenstein and Wyatt, 1990;

Table 4
Empirical results without demographic characteristics. The bold values are significant at 5%.

	With *BSIZE*	With *BSIZE* and $BSIZE^2$	With *IBSIZE* and $IBSIZE^2$	With *BSIZE*, $BSIZE^2$, *IBSIZE*, and $IBSIZE^2$
Intercept	−0.142	7.722	1.799	8.707
	(3.06)	(8.24)	(4.72)	(0.26)
BSIZE	**−0.491****	**−2.583*****	**−0.507****	**−2.403*****
	(0.23)	**(0.75)**	**(0.22)**	**(0.86)**
$BSIZE^2$		**0.091*****		**0.081****
		(0.03)		**(0.04)**
IBSIZE	−1.555	−3.462	−9.032	−4.494
	(3.51)	(3.83)	(9.53)	(7.31)
$IBSIZE^2$			7.744	−0.297
			(10.13)	(7.25)
FSIZE	**1.223****	**1.516****	**1.272****	**1.327*****
	(0.57)	**(0.60)**	**(0.52)**	**(0.34)**
SEGMENT	**0.145***	**0.217****	**0.178****	**0.174***
	(0.09)	**(0.10)**	**(0.09)**	**(0.10)**
GDP	0.191	0.317	0.230	**0.512***
	(0.28)	(0.44)	(0.26)	**(0.26)**
DPI	−0.000	−0.000	−0.000	0.000
	(0.00)	(0.00)	(0.00)	(0.00)
Year effect	Yes	Yes	Yes	Yes
N	103	103	103	78
χ^2	18.30	38.21	35.81	98.46

Standard errors are in parentheses and are estimated by controlling the firm effects as in Petersen (2009).
* Significant at 10%.
** Significant at 5%.
*** Significant at 1%.

de Andres and Vallelado, 2008), bankruptcy (Daily and Dalton, 1994) and financial statement fraud (Beasley, 1996). We consider that this inconsistency may result from the aggregation of event types. As we explained earlier, independent directors are important for their role to monitor managerial activities and protect shareholder's interests to avoid agency problems. From this perspective, it may explain the insignificant results since the analysis at the aggregate level has included some of operational risk events, such as damage to physical assets and system failures, which are not directly associated with decisions that may conflict with the

Table 5
Empirical results with heterogeneity of age and tenure. The bold values are significant at 5%.

	With *CVAGE*	With *CVAGE* and $CVAGE^2$	With *CVTENURE*	With *CVTENURE* and $CVTENURE^2$	With *CVAGE* and *CVTENURE*	With *CVAGE*, $CVAGE^2$ *CVTENURE*, and $CVTENURE^2$
Intercept	−0.432	−13.04	3.815	4.808	−0.785	**−9.337***
	(7.83)	(13.01)	(6.67)	(6.88)	(6.90)	**(5.38)**
BSIZE	**−2.932*****	**−2.666*****	**−1.676****	**−1.679****	**−1.635****	**−0.568*****
	(0.80)	**(0.70)**	**(0.81)**	**(0.81)**	**(0.80)**	**(0.20)**
$BSIZE^2$	**0.105*****	**0.094*****	**0.060***	**0.060***	**0.057***	**0.113****
	(0.03)	**(0.03)**	**(0.04)**	**(0.04)**	**(0.03)**	**(0.05)**
IBSIZE	−3.150	−1.896	−3.154	−3.223	−3.015	−2.214
	(3.85)	(3.40)	(2.33)	(2.33)	(2.22)	(1.96)
CVAGE	**19.990*****	**94.060***			**11.825***	36.970
	(7.15)	**(55.35)**			**(7.34)**	(41.56)
$CVAGE^2$		−174.500				−61.930
		(113.32)				(90.54)
CVTENURE			1.558	−1.798	0.683	−3.048
			(1.78)	(6.14)	(1.89)	(9.31)
$CVTENURE^2$				2.561		2.671
				(4.15)		(5.89)
FSIZE	**1.858****	**1.932*****	−0.058	−0.100	−0.001	−0.289
	(0.88)	**(0.72)**	(0.24)	(0.26)	(0.25)	(0.28)
SEGMENT	**0.286*****	**0.278*****	**0.389*****	**0.391*****	**0.433*****	**0.495*****
	(0.11)	**(0.11)**	**(0.10)**	**(0.11)**	**(0.12)**	**(0.16)**
GDP	0.513	0.674	0.363	0.385	0.432	0.403
	(0.33)	(0.46)	(0.26)	(0.27)	(0.27)	(0.28)
DPI	0.000	0.001	0.000	0.000	0.000	0.000
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
Year effect	Yes	Yes	Yes	Yes	Yes	Yes
N	100	100	62	62	60	60
χ^2	38.86	49.02	28.61	29.74	24.44	24.57

Standard errors are in parentheses and are estimated by controlling the firm effects as in Petersen (2009).
* Significant at 10%.
** Significant at 5%.
*** Significant at 1%.

Table 6
Results based on the Types of the Events. The bold values are significant at 5%.

	With *BSIZE* and *BSIZE*^{2}	With *CVAGE*	With *CVAGE* and *CVAGE*^{2}	With *CVTENURE*	With *CVTENURE* and *CVTENURE*^{2}
Panel A. Clients, products, and business practices					
Intercept	9.106	−8.575	0.641	**34.500*****	**33.660*****
	(7.56)	(10.49)	(0.64)	**(10.08)**	**(11.14)**
BSIZE	**−2.485*****	**−3.756*****	**−0.176****	**−3.472*****	**−3.447*****
	(0.67)	**(0.89)**	**(0.08)**	**(1.29)**	**(1.23)**
BSIZE^2	**0.090*****	**0.136*****	**0.006***	**0.127****	**0.126*****
	(0.03)	**(0.04)**	**(0.00)**	**(0.05)**	**(0.05)**
IBSIZE	−3.642	−4.309	**−0.399****	**−15.080*****	**−14.880*****
	(2.90)	(4.07)	**(0.20)**	**(4.25)**	**(4.65)**
CVAGE		**32.130****	**4.947****		
		(12.88)	**(2.48)**		
CVAGE^2			−9.220		
			(6.88)		
CVTENURE				**7.743*****	12.850
				(2.616)	(9.15)
CVTENURE^2					−4.077
					(6.85)
FSIZE	**1.199*****	**1.953*****	**0.097*****	−0.073	0.005
	(0.36)	**(0.43)**	**(0.018)**	(0.33)	(0.39)
SEGMENT	**0.177***	**0.284*****	**0.014****	**0.719*****	**0.744*****
	(0.09)	**(0.09)**	**(0.01)**	**(0.24)**	**(0.23)**
GDP	0.297	1.070*	0.028	−0.129	−0.240
	(0.35)	(0.56)	(0.02)	(0.44)	(0.42)
DPI	−0.000	0.001	−0.000	**−0.002*****	**−0.002*****
	(0.00)	(0.00)	(0.00)	**(0.00)**	**(0.00)**
Year effect	Yes	Yes	Yes	Yes	Yes
N	68	67	67	48	48
χ^2	38.48	34.76	37.55	24.89	25.41
Panel B. Internal and external fraud					
Intercept	**6.756***	5.971	0.696	−0.003	0.104
	(3.88)	(3.64)	(0.57)	(0.79)	(0.838)
BSIZE	**−0.183*****	**−0.182*****	**−0.176*****	**−0.315*****	**−0.338*****
	(0.06)	**(0.07)**	**(0.07)**	**(0.11)**	**(0.12)**
BSIZE^2	**0.005****	**0.005***	**0.005***	**0.011****	**0.012****
	(0.00)	**(0.00)**	**(0.00)**	**(0.00)**	**(0.01)**
IBSIZE	**−0.511****	**−0.508*****	**−0.387****	0.021	−0.019
	(0.22)	**(0.19)**	**(0.18)**	(0.275)	(0.30)
CVAGE		0.531	3.122		
		(0.69)	(2.20)		
CVAGE^2			−6.098		
			(5.27)		
CVTENURE				0.142	−0.173
				(0.21)	(0.56)
CVTENURE^2					0.251
					(0.43)
FSIZE	**0.126*****	**0.125*****	**0.122*****	0.043	**0.046***
	(0.01)	**(0.02)**	**(0.01)**	(0.04)	**(0.03)**
SEGMENT	0.004	0.005	0.011	**0.038*****	**0.040*****
	(0.01)	(0.01)	(0.01)	**(0.01)**	**(0.01)**
GDP	**0.083*****	**0.079*****	0.025	**0.066****	**0.069****
	(0.0278)	**(0.02)**	(0.02)	**(0.03)**	**(0.03)**
DPI	−0.001	−0.000	−0.000	**0.0001****	**0.0001*****
	(0.00)	(0.00)	(0.00)	**(0.00)**	**(0.00)**
Year effect	Yes	Yes	Yes	Yes	Yes
N	58	55	55	42	42
χ^2	213.20	185.80	134.18	35.32	112.30
Panel C. Other					
Intercept	0.608	0.452	−1.788	0.274	0.097
	(0.47)	(0.53)	(2.34)	(0.62)	(0.62)
BSIZE	−0.075	−0.078	−0.030	−0.108	−0.118
	(0.06)	(0.06)	(0.06)	(0.08)	(0.08)
BSIZE^2	0.001	0.002	−0.000	0.003	0.003
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
IBSIZE	**−0.477****	**−0.446****	−0.162	−0.367	−0.389
	(0.21)	**(0.21)**	(0.29)	(0.25)	(0.26)
CVAGE		0.398	**3.887***		
		(0.45)	**(2.14)**		
CVAGE^2			−8.884		
			(5.46)		
CVTENURE				0.060	0.373
				(0.14)	(0.50)
CVTENURE^2					−0.229

Table 6 (*continued*)

	With *BSIZE* and $BSIZE^2$	With *CVAGE*	With *CVAGE* and $CVAGE^2$	With *CVTENURE*	With *CVTENURE* and $CVTENURE^2$
					(0.37)
FSIZE	**0.142*****	**0.145*****	**0.130*****	−0.002	0.006
	(0.02)	**(0.02)**	**(0.02)**	(0.02)	(0.02)
SEGMENT	**0.012***	**0.012****	**0.015*****	**0.045*****	**0.045*****
	(0.01)	**(0.01)**	**(0.00)**	**(0.01)**	**(0.01)**
GDP	0.020	0.022	**0.038****	**0.039***	**0.044****
	(0.02)	(0.02)	**(0.02)**	(0.02)	**(0.02)**
DPI	−0.000	−0.000	0.000	0.000	0.000
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
Year effect	Yes	Yes	Yes	Yes	Yes
N	56	54	54	40	40
χ^2	432.1	368.2	16.57	79.31	78.52

Standard errors are in parentheses and are estimated by controlling the firm effects as in Petersen (2009).
* Significant at 10%.
** Significant at 5%.
*** Significant at 1%.

Table 7
Results after considering the potential correlation between firm size and board. The bold values are significant at 5%.

	With *BSIZE* and $BSIZE^2$	With *CVAGE*	With *CVTENURE*
Intercept	−5.436	**−17.270***	−3.463
	(4.96)	**(9.30)**	(5.76)
BSIZE	**−0.981*****	**−1.110*****	**−0.672*****
	(0.24)	**(0.29)**	**(0.22)**
$BSIZE^2$	**0.115*****	**0.131*****	**0.142*****
	(0.04)	**(0.04)**	**(0.05)**
IBSIZE	−2.762	−2.160	−2.322
	(4.16)	(4.24)	(2.13)
CVAGE		**20.170*****	
		(7.33)	
CVTENURE			1.639
			(1.56)
FSIZE	**1.275****	**1.643****	−0.355
	(0.54)	**(0.72)**	(0.24)
SEGMENT	**0.215****	**0.283*****	**0.459*****
	(0.09)	**(0.10)**	**(0.128)**
GDP	0.238	0.466	0.284
	(0.34)	(0.37)	(0.244)
DPI	−0.000	0.000	−0.000
	(0.00)	(0.00)	(0.00)
Year effect	Yes	Yes	Yes
N	103	100	62
χ^2	38.02	38.47	21.64

Standard errors are in parentheses and are estimated by controlling the firm effects as in Petersen (2009).
* Significant at 10%.
** Significant at 5%.
*** Significant at 1%.

interests of shareholders. In our next subsection, we will perform additional analyses to examine the relation between independent directors and the likelihood of operational risk events given different event types. Such analyses would give us further insights into the role of independent directors in the context of operational risk management.

Last, independent directors do not seem to affect the likelihood of operational risk events after we take into account the non-linear term of independent directors ($IBSIZE^2$), while the association between board size and the possibility of operational risk events remains consistent. This finding does not support the argument that a U-shape relation exists between the percentage of independent directors and the likelihood of operational risk events.

As discussed earlier, age and tenure heterogeneity are other important board demographics worth studying. The results, given in Table 5, indicate that age heterogeneity does not change the relation between the likelihood of operational risk events and board size. We still observe a U-shaped association between board size and the likelihood of operational risk events, and board size is negatively associated with the occurrence of operational risk events (the coefficients of $BSIZE^2$ are 0.105 and 0.094, $p < 0.01$; 0.060, 0.060, and 0.057, $p < 0.10$; 0.113, $p < 0.05$; the coefficients of *BSIZE* are −2.932, −2.666, and −0.568, $p < 0.01$; −1.676, −1.679, and −1.635, $p < 0.05$). Independent directors are still insignificantly associated with the possibility of operational risk events.

Our empirical results show that the heterogeneity of age (*CVAGE*) is positively associated with *OP* (the coefficients of *CVAGE* are 19.990, $p < 0.01$; 94.060 and 11.825, $p < 0.10$; 36.970, *n.s.*). The heterogeneity of tenure (*CVTENURE*), however, is not significantly associated with the likelihood of operational risk events (the coefficients of *CVTENURE* are 1.558, −1.798, 0.683, and −3.048, *n.s.*). In addition, findings here do not indicate a non-linear relation between board heterogeneity and the likelihood of operational risk events. In discussing the results on age and tenure heterogeneity, we believe that this specific context is relevant to our findings. Within the particular context of operational risk management,

BCBS identifies two major responsibilities of the board: (1) establishment and review of an operational risk management framework and (2) approval and review of banks' risk appetite and tolerance statements. Our interpretation is that, as pointed out earlier, younger and older directors tend to hold different levels of risk tolerance (Muth and Donaldson, 1998). Thus, heterogeneous boards with a diverse set of values associated with risk-taking and organizational change can increase conflict and disagreement in determining the risk management issue (Anderson et al., 2011; Simons and Peterson, 2000). Consequently, the increased coordination and communication cost as well as the lack of cohesiveness can impede the quality and robustness of decision-making judgment on risk tolerance statements and management frameworks.

4.2. Empirical results given different event types

As highlighted earlier and in Chernobai et al. (2011), some operational risk event types might be more effectively controlled by internal governance, while others might be beyond the control of the board owing to their unpredictable nature. In this study, following the work of Chernobai et al. (2011), we perform additional analyses on the relation between the board composition and the likelihood of operational risk events for "Clients, Products, and Business Practices," and "Internal Fraud and External Fraud." We also include all other risk event types except "Damage to Physical Assets" as one distinct category, namely "Other" in our analysis. Table 6 shows the results of our empirical analysis. Focusing on these three groups of event types ("Clients, Products, and Business Practices," "Internal Fraud and External Fraud," and "Other"), we find consistent support for the hypothesis on the U-shaped relation between the board size and the possibility of an operational risk events. More importantly, in this analysis, our finding indicates that the proportion of independent directors is negatively, though weakly, related to the likelihood of operational risks events across these three groups of event types. This finding is different from our result at the aggregate level, where there is no significant relation. Nonetheless, this finding is consistent with the accounting and finance literature on the independent directors as an effective mechanism in strengthening the environment of internal control, particularly in the context of fraudulent activities. Fama and Jensen (1983) argue that the inclusion of independent directors can visibly enhance the internal control mechanism and create an effective monitor of management actions. In our analysis, all three groups of event types are highly related to the process of management oversight and regulatory compliance; therefore, a larger proportion of independent directors on the board is expected to significantly reduce the likelihood of fraud or of failure to comply with professional obligations to clients (Beasley, 1996; Chernobai et al., 2011).

In terms of age and tenure heterogeneity, we find that both variables for heterogeneity show a positive relation with the occurrence of operational risk events in the category "Clients, Products, and Business Practices," though the variables for heterogeneity are insignificant for "Internal and External Fraud". The results are generally consistent with our finding in the previous stage of analysis. That is, a diverse board increases communication cost, decrease coordination and produces an adverse impact on decision-making process for product evaluation given the difference in risk-taking attitude. Westphal and Bednar (2005) suggest that demographic homogeneity among directors increases the willingness of the directors to express their opinions and concerns in board meetings. This willingness could be important for the evaluation of product risk and design in the context of operational risk management. Adams and Ferreira (2007) also argue that the board depends on the executives to gain access to organization-specific information. Executives might perceive demographically dissimilar directors to be more likely to interfere in the decision-making process, given the difference in their values and beliefs. Consequently, the unwillingness of executives to share information with these demographically dissimilar directors can diminish the effectiveness of the board's monitoring function and evaluation on the effectiveness of operational risk management.

4.3. Robustness test

We perform the following robustness analysis to further validate our results. In particular, though we do not observe a high correlation in Table 3, we agree that it is highly possible that the board size is associated with firm size. Therefore, we perform an additional test to control for this potential association by first regressing the board size on firm size and then using the residual in our analysis. The results, presented in Table 7, are consistent with our main findings.

5. Conclusions

This paper examines the relation between board composition and the likelihood of operational risk events. The Basel Committee on Banking Supervision (BCBS) has highlighted the imperative role of the board in enhancing the effectiveness of the operational risk management in the financial industry. The pioneering work of Chernobai et al. (2011) also points out the relevance of a firm's internal control environment to the incidence of operational risk events. In this study, drawing from prior studies on corporate governance and organizational demography, we consider the role of board size, the proportion of independent directors, and age/tenure heterogeneity on the occurrence of operational risk events in financial institutions. Our findings indicate that both board size and age heterogeneity play important roles in instituting good operational risk management. We also perform an additional analysis in accordance with the Basel II classification of risk events. We find that firms with a higher proportion of independent directors tend to have less likelihood, though weakly, of operational risk events for the categories of "Internal and External Fraud" and "Clients, Products, and Business Practices."

The results reported in this study can contribute to our understanding of the relation between board composition and the soundness of operational risk management. First, this study empirically supports the statement put forward by the BCBS and Chernobai et al. (2011) that the board is an important mechanism in the design, implementation, and maintenance of operational risk management in financial institutions. Second, Chernobai et al. (2011) find a strong link between operational risk events and an environment of weak internal control. Extending from this perspective, our analysis of board composition provides a more insightful prediction of the interplay between board demographics and the likelihood of operational risk events. In summary, we believe this research can shed light on the design and choice of board structure for sound operational risk management in financial institutions.

Appendix A. Supplementary material

Supplementary data associated with this article can be found, in the online version, at http://dx.doi.org/10.1016/j.jbankfin.2013.01.027.

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