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Corporate Diversification, Board Diversity and Stock-price Crash Risk: Evidence from Publicly Listed Firms in Malaysia

KIAN-TEK LEE[a*], CHAI-AUN OOI[b] AND CHEE-WOOI HOOY[c]

[a]*Business School, Sunway University, Malaysia*
[b]*School of Economics, Finance and Banking, Universiti Utara Malaysia, Malaysia*
[c]*School of Management, Universiti Sains Malaysia, Malaysia*

ABSTRACT

This study investigates whether corporate diversification can be a predictability variable contender for future stock-price crash risk. Using a sample of Malaysian firms based on 2010-2015 data, our study shows evidence of the mitigating effect of diversification on crash risk, consistent with the theory of coinsurance effect. However, our further analysis shows that the mitigating effect of diversification on crash risk is only evident on highly diversified firms but not on firms of low to moderate degree of diversification. This finding is aligned with the dominant view of the existence of crash risk following the managerial bad-news hoarding model. Furthermore, our study finds that the mitigating effect of diversification is more pronounced for firms with board diversity in gender which is in support of the notion of board diversity in promoting corporate governance. Our findings are useful to firms (and shareholders) who want to manage "tail risk" in stock prices and to investors who want to incorporate crash risk as parts of their portfolio and risk management decisions.

JEL Classification: G11, G31, M14
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* Corresponding author: Email: jasonl@sunway.edu.my

INTRODUCTION

In this fast growing financial world, studies on volatility spillover between the stock markets is necessary due to its importance in investment decisions and risk diversification. If there exist spillover across the stock market, it means that there are fewer chances for diversification. Hence, the investors can leverage on segmented stock to diversify their portfolio. According to Kumar and Kamaiah (2017), the chances of volatility spillover among the equity markets has increased. This happens due to the increased amount of information flow and the trade and financial liberalization policies.

The prevalent adoption of corporate diversification on the basis of venturing into different business segments as part of firms' growth strategy have warranted many studies on the subject, particularly on its economic significances. So far, the dominant subject found in the extant literature of diversification is centred on the relation between diversification and financial performance and valuation (e.g., Berger and Ofek 1995, Lins and Servaes 2002, Fauver et al. 2003, Hoechle et al. 2012). After almost three decades of extensive study, a consensus has finally been reached in recent years contending that corporate diversification would lead to lower valuation or weaker performance for firms. Despite the negative findings against diversification initiatives, in reality, the support of investors towards diversified firms is still proven resilient particularly in the emerging markets (Lee and Hooy, 2018a). In this study, we examine the relation between diversification and firm-specific stock price crash risk.

The world's stock market has experienced a few disastrous worldwide market crash events, and billions of dollars have been wiped out from the market each time it happened. This phenomenon of plunge in stock prices has presented a momentous risk factor to investors, and thus it has inevitably warranted many studies to investigate on stock price crash risk in recent years predominantly on probing for potential predictability variables and mitigation mechanisms for this crash risk. Most studies have attributed stock price crash risk to managerial bad-news hoarding behaviours where managers are alleged to have the tendency to conceal bad news or information from investors due to their own private interest concerns (Kothari et al, 2009). When more bad news is accumulated over time to the extent that it can no longer be withheld, managers would have no choice but to release all of the bad news at once, ensuing investors' negative response amid taking a large-scale liquidation of their stocks and eventually leading to stock price crashes (Jin and Myers, 2006).

The explanation of "bad-news hoarding" model also echoes the outcome of the agency conflict between managers and shareholders over information disclosure preferences which is also part of the big framework of corporate governance (Shleifer and Vishny, 1997). This contention may imply that diversification might open opportunities for managers to entrench themselves through concealing bad news from investors due to career, compensation, and other personal interests. For example, managers of diversified firms could easily hide the bad news on one or a few of their business segment(s) from their shareholders by diverting the attention to other (more positive) news on the other business segments in order to entrench themselves in terms of their career security, promotion, and/or compensation.

However, one might counter argues that managerial entrenchment through diversification is solely an exterior assumption without any intrinsic theoretical supports, implying that diversification itself does not bring any harm to the firms (Graham et al., 2002). Furthermore, there are a number of theories that are in support of corporate diversification, namely, internal capital market (Williamson, 1970), coinsurance effect (Lewellen, 1971), economies of scope (Teece, 1980), market power (Villalonga, 2000), and resource-based perspective (Barney, 1991). Among all these theories that support firms' efforts of diversification, coinsurance effect (Lewellen 1971, Shleifer and Vishny 1992) model stands out in our study in arguing that when a firm combines two or more different business segments together, the idiosyncratic risk of its cash flows is lower. This argument is strongly supported by a recent study of Dominik (2018) where his empirical analysis shows that diversified firms benefit from coinsurance through financial as well as accounting synergies which entail considerable value-enhancing potentials. From the Dominik's study (2018), it implies that idiosyncratic risk of stock returns for diversified firms should be lower than non-diversified firms.

The two competing contentions have motivated us to investigate whether corporate diversification would be able to predict future stock price crash risk, in which we hypothesize the mitigation effect of diversification on crash risk similar to the findings of Dominik (2018). Unlike prior studies such as Dominik (2018) who measured idiosyncratic risk (a second moment of return distribution), we focus on conditional skewness, the third moment of return distribution (following the study of Chen et al., 2001). This measure allows us to evaluate the relationship between diversification and stock price crash risk because, if managers disclose all randomly arriving good and bad news, we would expect symmetrically distributed stock returns (Kothari et al., 2009). However, when news is particularly bad and managers cannot hoard the bad news any longer, the one-time release of bad news could result in a large-scale, abrupt decline in stock price or simply stock price crash.

Our empirical approach requires us to measure stock price crash risk and diversification both at the firm level. First, we measure firm-specific crash risk by the negative skewness of firm-specific weekly returns and the asymmetric volatility of negative and positive stock returns (e.g., Chen et al. 2001) using two variables: (1) the negative coefficient of skewness of firm-specific daily returns (NCSKEW), and (2) the down-to-up volatility of firm-specific daily returns (DUVOL). Second, consistent with prior literature on diversification (Chen et al., 2012), we measure diversification based on the Herfindahl index (Berry 1971). Using a sample of Malaysian publicly listed firms from 2010 to 2015, we find evidence of mitigating effect of diversification on crash risk. The results are robust after controlling for other predictors of future stock price crash risk identified in prior studies.

This study examines the influencing effect of board diversity on the relationship between diversification and stock-price crash risk. In a typical organizational structure of a firm, board of directors is the highest authority who are responsible for making all important and strategic decisions related to the firm's business including business diversification decisions. Essentially, board composition and heterogeneity of its members plays an important role in determining the board effectiveness (Martin and Herrero, 2018), and thus it has been widely promoted as one of the key factors of effectiveness in the board decision making process. To a greater extant, board diversity is considered as an important element of tackling agency problems arises within a firm (Carter et al., 2003). Gul et al. (2011) argue that board diversity is an important aspect of corporate governance in the reduction of information asymmetry of stock prices. In the study by Ooi et al. (2017), it is found that certain aspects of board diversity significantly reduce the negative impact of a crisis hitting firm performance. In this case, higher (lower) board diversity would reduce (increase) the chances of managers exerting the bad-news hoarding behaviour in firms with diversified businesses, and therefore affect the intensity of the mitigating effect of diversification on stock price crash risk. In our study, we find gender diversity in the board has a significant influencing effect on the relation between diversification and crash risk, where crash risk is lower for diversified firms with a higher number of female directors on the board. These findings are consistent with the notion that board diversity characteristics can boost corporate governance level, and thus reducing stock-price crash risk.

Malaysia offers a unique environment for examining the relationship between diversification and stock price crash risk for numerous reasons. First, there is a high degree of diversification among Malaysian firms in which the Malaysian sample would act as a good platform for further exploration of this topic (Claessens et al., 2000; Lins and Servaes, 2002; Ayoib et al., 2003, Lee et al., 2012, Lee and Hooy, 2018b). Second, the current development in highly promoting board diversity particularly in gender and ethnicity among Malaysian publicly listed firms, fits well in our research framework (Shukeri et al., 2012; Abdullah et al., 2012, Ooi et al, 2017).

Our study makes several important contributions to two branches of the literature. First, our study extends the growing literature on stock-price crash risk. We extend prior studies (e.g., Chen et al. 2001, Hong and Stein 2003, Jin and Myers 2006, Hutton et al. 2009, Kim et al. 2011a, 2011b, Xu et al. 2014, Kim et al. 2014, Callen and Fang 2015a, Zhang et al. 2016, Kim and Zhang 2016, Bhargava et al., 2017) by identifying a new factor that predicts the future stock-price crash risk. We contribute to this literature by showing that corporate diversification significantly and negatively impacts stock-price crash risk which is an important factor in mitigating crash risk. However, such an effect is only applicable to firms with an extremely high

degree of corporate diversification. Instead, lower degrees of diversification cannot meet the objective of risk minimization, but may instead increase managers' incentive for bad-news hoarding, which induce stock-price crash risk. Our study is useful to firms (and shareholders) who want to manage "tail risk" in the stock market and to investors who want to incorporate crash risk into their portfolio and risk management decisions. Second, our study adds to the growing literature on diversification and its economic consequences. As discussed earlier, much work in this area has focused on the impact of diversification on firm performance and, to a lesser extent, firm risk. We depart from these studies and focus on the unique role of diversification in reducing crash risk, which captures asymmetry in risk, or the third moment of stock-return distribution. This role is distinct from the effect of diversification on stock-return performance (first moment) or firm risk (second moment) documented in prior studies. Our results thus broaden our understanding of the implications of diversification for firms and investors.

The rest of this paper is organized in the following manner: Section 2 reviews relevant literature and develops hypotheses. Section 3 describes sample selection, variable measurements, and research design. Section 4 presents summary statistics and the empirical results. Section 5 concludes the paper.

LITERATURE REVIEW AND HYPOTHESIS DEVELOPMENT

Our study is principally compelled by the convergence of two distinct branches of literature. First, we draw from the recent literature on the determinants of firm-specific crash risk originating in the theoretical arguments of Jin and Myers (2006). According to Jin and Myers (2006), managers may have the tendency to withhold and "hoard" bad news up to a certain threshold level, at which managers will then forcefully reveal the accumulated bad news to the market as soon as the threshold is reached, leading to an abnormally large plunge in the stock price. Many empirical studies have followed this rationale, in an effort to determine the factors that predict stock-price crash risk, by focusing on the firms' corporate activities and firm-specific characteristics proliferating many studies ranging widely from earning management (Hutton et al. 2009), aggressive tax avoidance (Kim et al. 2011a), corporate social responsibility (Kim et al. 2014), religion (Callen and Fang 2015a), corporate philanthropy (Zhang et al. 2016), stock option compensation (Kim et al. 2016), takeover protection (Bhargava et al. 2017), corporate governance (Tarkovska 2017), business strategy (Habib and Hasan 2017), to political connections (Luo et al. 2016; Tee, 2018).

Second, our study also relies on another branch of literature that deliberates on the economic impacts of corporate diversification. Essentially, in the existing finance literature, agency theory has been the central explanation offered for the economic consequences of diversification. It is widely argued that diversification strategies undertaken by firms may not necessarily intend to benefit the firms, but are more for the private benefit of managers or controlling shareholders (Denis et al. 1997, Lins and Servaes 2002, Aggarwal and Samwick 2003). On a positive note, there are benefits of pursuing diversification explained by a few dominant theories which are well documented in the literature such as: coinsurance effect (Lewellen 1971, Shleifer and Vishny 1992), economies of scale and scope (Chandler 1977, Teece 1980), market power (Scott 1982, Tirole 1995, Villalonga, 2000), and internal capital markets (Williamson 1970, Stulz 1990, Gertner et al. 1994, Stein 1997).

In addition, we argue that business diversification is akin to a financial investment diversification. Following the investment portfolio theory (Markowitz, 1952), investments in different types of assets in creating a portfolio will be able to help investors to diversify away some of the investment risks. Likewise, if a diversified firm's business represents a basket of securities, it is predicted that there would be a potential reduction in the severity of the information problem and a reduction in the trading costs with greater corporate diversification (Subrahmanyan 1991, Gorton and Pennacchi 1993, Hadlock et al. 2001), and thus decreasing crash risk. These authors explain that combining individual securities into baskets may reduce the adverse selection costs of trading. The value of private information about the individual securities that constitute the basket will be diversified away, allowing market makers to set lower spreads, thereby reducing trading costs for uninformed traders, which they termed the "information diversification hypothesis".

After considering both sides of arguments, we conjecture that diversification would mitigate the firm-level stock-price crash risk. Our empirical analysis will shed light on this matter, and we thus propose the following hypothesis:

H1: The degree of diversification is negatively associated with future stock-price crash risk

A considerable body of literature has suggested that effective corporate governance mechanisms can curb suboptimal managerial decision-making (Shleifer and Vishny 1997), and bad-news hoarding is such a suboptimal managerial decision. These findings may indirectly imply that effective corporate governance mechanisms help to reduce opportunistic or entrenched managerial behaviour, and thus lower the firm-specific stock-price crash risk. Within the corporate governance framework, the board of directors is one of the most important tenets, and the recent financial crisis has revealed serious weaknesses in the functionality of the board of directors. Furthermore, one of the recent widespread initiatives on corporate governance improvement has been the focus on board diversity, following the argument that greater board diversity helps to enhance information resources and broadens the cognitive and behavioural range of the board. As a result, board diversity will be able to improve the board's functional roles in monitoring managerial decisions on policies, implementation, and control (Ferrero 2015). In this research context, board diversity may be an imperative component in reducing the probability of managers to commit bad-news hoarding behaviour, and should thus lead to better ability to mitigate crash risk.

From the management perspective, the board of directors is popularly viewed as a group of diverse individuals who have different predispositions and prejudgments, and their behaviours are influenced by power relations and social constraints (Ferreira 2011). This perspective advocates that board diversity plays a key role in the function of the boards. Directors are viewed as the key resource providers of firms, such as connections to important outsiders (e.g., suppliers, financiers, regulators, and others) in addition to providing business advice. Therefore, different dimensions of board diversity clearly become important.

Based on the above discussion, we utilize some commonly used board diversity aspects such as gender, age, nationality, and ethnicity, but based on Malaysian-unique board characteristics. We build our hypotheses as follows:

H2a: Board gender diversity has negative impact on crash risk in diversified firms
H2b: Board nationality diversity has negative impact on crash risk in diversified firms
H2c: Board ethnic diversity has negative impact on crash risk in diversified firms
H2d: Board age diversity has negative impact on crash risk in diversified firms

RESEARCH METHODOLOGY

Sample selection

Our sample consists of all Malaysian publicly listed firms with multi-segment (based on 2-digit SIC) on the main board of the Kuala Lumpur Stock Exchange excluding firms in the financial sector (SIC codes 6000 - 6999) and utility sector (SIC codes 4900 - 4999), for the period 2010-2015. We collect firms' stock prices, returns, and firms' financial data, available in Thomson Reuters Datastream. For board of directors' ethnicity, gender, nationality, and age data, we manually collect these data from the annual reports of each firm.

Measurement of stock price crash risk

This study employs two measures of firm-specific crash risk based on firm-specific weekly returns estimated as the residuals from the market model. The firm-specific returns reveal firm-specific factors that lead to crash risk rather than broad market factors. Specifically, this study estimates the following expanded market model regression:

$$r_{j.s} = \alpha_j + \beta_{1,j} r_{m,s-1} + \beta_{2,j} r_{m,s} + \beta_{4,j} r_{m,s+1} + \varepsilon_{j,s} \quad (1)$$

where rj,s is the return on stock j in week s, and rm,s is the return on the KLCI value-weighted market index in week s. The lead and lag terms for the market index return is included to allow for nonsynchronous trading (Dimson 1979). The firm-specific weekly return for firm j in week s (Wj,s) is calculated as the natural logarithm of one plus the residual return from Equation (1). Using the firm-specific weekly returns, this study calculates crash risk by the negative conditional skewness of the weekly returns over the fiscal year (NCSKEW). NCSKEW is calculated by taking the negative of the third moment of firm-specific weekly returns for each year and normalizing it by the standard deviation of firm-specific weekly returns raised to the third power. Specifically, for each firm j in year t, NCSKEW is calculated as:

$$NCSKEW_{j.s} = -n[n(n-1)^{3/2} \sum W_{j,s}^3] / [(n-1)(n-2)(\sum W_{j,s}^2)^{3/2}] \quad (2)$$

where Wj,s is firm-specific weekly return as defined above, and n is the number of weekly returns during year t. A negative sign is put in front of the third moment such that a higher value of NCSKEW indicates higher crash risk.

The second measure of crash risk is the down-to-up volatility measure (DUVOL) of the crash likelihood. For each firm j over year t, firm-specific weekly returns are separated into two groups: ‘‘down’’ weeks when the returns are below the annual mean, and ‘‘up’’ weeks when the returns are above the annual mean. Standard deviation of firm-specific weekly returns is calculated separately for each of these two groups, and DUVOL is the natural logarithm of the ratio of the standard deviation in the ‘‘down’’ weeks to the standard deviation in the ‘‘up’’ weeks.

$$DUVOL_{j.s} = \log\left\{(n_u - 1)\sum_{down} W_{j,s}^2 \Big/ (n_d - 1)\sum_{up} W_{j,s}^2\right\} \quad (3)$$

where nu and nd are the number of up and down weeks in year t, respectively. A higher value of DUVOL indicates greater crash risk. As suggested in Chen et al. (2001), DUVOL does not involve third moments, and hence is less likely to be overly influenced by extreme weekly returns.

Measurement of diversification

The term diversification in the context of this study is defined as a form of corporate growth strategy by which a firm expands from their core business into other lines of business (or equivalently as segments or industries). In this study, we use the Herfindahl index of diversification as modified by Berry (1971), (HERFINDAHL). This measure was used in the studies of Schoar (2002), Villalonga (2004a&b), and Jara-Bertin (2015). The Herfindahl index of diversification is calculated as follows for each company i:

$$HERFINDAHL = 1 - \sum\left(\frac{Sales\ per\ segment}{Total\ sales}\right)^2 \quad (4)$$

Based on Berry’s modified Herfindahl index of diversification measure, the values range from 0 to 1, and the higher this variable value, the higher is the level of diversification of the firm.

Measurement of board diversity

This study constructs board diversity based on various characteristics of the board of directors, i.e., diversity in gender (BOARDDIVERSITY_FEMALE), diversity in nationality (BOARDDIVERSITY_MALAYSIAN), diversity in ethnicity (BOARDDIVERSITY_ETHNICITY) and diversity in age (BOARDDIVERSITY_AGE). Equations 5 to 8 show the formula for constructing the variables. BOARDDIVERSTIY_ETHNICITY and BOARDDIVERSTIY_AGE are constructed by modifying Gibbs and

Martin's (1962) diversity index measure, as shown in Equations 7 and 8. All of the board diversity variables have minimum and maximum values of zero to one.

$$BOARDDIVERSITY\_FEMALE = \frac{Female\_Directors}{TotalDirectors} \quad (5)$$

where Female_Directors is the number of directors who are female, and TotalDirectors is the total number of directors.

$$BOARDDIVERSITY\_NONMALAYSIAN = \frac{non-Malaysian\_Directors}{TotalDirectors} \quad (6)$$

where non-Malaysian_Directors is the number of directors who are non-Malaysian, and TotalDirectors is the total number of directors.

$$BOARDDIVERSITY\_ETHNICITY = 1 - \sum_{j=1}^{3}\left(\frac{Ethnic_j}{TotalDirectors}\right)^2 \quad (7)$$

where Ethnicj is the number of directors who are Malay, Chinese and Indian for respective category j.

$$BOARDDIVERSITY\_AGE = 1 - \sum_{j=1}^{7}\left(\frac{Age_j}{TotalDirectors}\right)^2 \quad (8)$$

where Agej is the age of the directors which is grouped into either of the seven categories j, i.e. 21-30, 31-40, 41-50, 51-60, 61-70, 71-80 and 81-90.

Empirical models

This study develops a regression model by controlling for firm fundamental variables and stock price variables as shown in Equation 9.

$$\begin{aligned}\{CRASHRISK_{t+1}\} &= \beta_0 + \beta_1 FIRMSIZE_t + \beta_2 LEVERAGE_t + \beta_3 MTBV_t + \beta_4 ROA_t + \beta_5 RETURN_t + \beta_6 SIGMA_t \\ &+ \beta_7 DTURNOVER_t + \beta_8\{CRASHRISK_t\} + HERFINDAHL_t + \varepsilon_t\end{aligned} \quad (9)$$

where the dependent variable of {CRASH_RISKt+1} is proxied by NCSKEWt+1 or DUVOL t+1, which represents stock-price crash risks of year t+1. Following prior studies (such as Chen et al., 2001; Kim et al., 2011), several firm fundamental variables are controlled in the model. FIRMSIZEt is measured by the natural logarithm of total assets of year t. Prior studies reports a firm size is positively related to future crash risk (Chen et al. 2001; Hutton et al. 2009; Callen and Fang 2013; De Fond et al. 2015). LEVERAGEt is measured by the ratio of long-term debt to total assets of year t, which is shown to be negatively associated with future crash risk ((Hutton et al. 2009; Kim et al., 2011a,b). MTBVt is measured by market-to-book value of year t, and Chen et al. (2001) and Hutton et al. (2009) show that growth stocks are more prone to future crash risk. ROAt is measured by return on total assets in which Hutton et al. (2009) and Callen and Fang (2013) report firms with good financial performance are more steady and are less likely to experience crashes. Additionally, the model controls for stock performance variables, including stock returns (RETURNt), which is calculated as the mean of firm-specific weekly returns over the fiscal year t. In prior studies, it has shown that there is a positive association between firm-specific stock return and stock price crash risk, indicating that stocks with high past returns could have accumulated many stochastic bubbles and thus are subject to higher crash risk (Harvey and Siddique 1999; Chen et al. 2001). Stock volatility (SIGMAt), which is calculated as the standard deviation of firm-specific weekly returns over the fiscal year t. Prior studies show more volatile stocks are more likely to experience stock price crashes in the future (Chen et al. 2001; Kim et al. 2011a). DTURNOVERt, which is calculated as the average monthly share turnover in year t minus the average monthly share turnover in t-1, where Chen et al. (2001) indicate that this variable is used to measure

differences of opinion among shareholders and is positively related to crash risk. The lagged variable of crash risk (CRASHRISKt represents NCSKEWt and DUVOL t) are also included in the model to control for potential serial correlation and to predict for next year stock price crash risk. Corporate diversification is measured using the Herfindahl index (HERFINDAHLt) to assess the concentration of diversification.

To further test the effect of board diversity on the relationship between diversification and stock crash risk, this study extends Equation 9 by adding the board diversity variable {BOARD_DIVERSITYt} and the interaction terms of HERFINDAHLt and {BOARD_DIVERSITYt}, as shown in Equation 10. Subsequently, {BOARD_DIVERSITYt} is replaced with BOARDDIVERSITY_FEMALEt, BOARDDIVERSITY_NON MALAYSIANt, BOARDDIVERSITY_ETHNICITYt, and BOARDDIVERSITY_AGEt, respectively.

$$\begin{aligned}\{CRASHRISK_{t+1}\} &= \beta_0 + \beta_1 FIRMSIZE_t + \beta_2 LEVERAGE_t + \beta_3 MTBV_t + \beta_4 ROA_t + \beta_5 RETURN_t \\ &+ \beta_6 SIGMA_t + \beta_7 DTURNOVER_t + \beta_8\{CRASHRISK_t\} + \beta_9 HERFINDAHL_t + \beta_{10}\{BOARD\_DIVERSITY\}_t \\ &+ \beta_{11}(HERFINDAHL_t \times \{BOARD\_DIVERSITY_t\}) + \varepsilon_t\end{aligned} \quad (10)$$

RESULTS AND DISCUSSION

Summary of decriptive statistics

Table 1 presents descriptive statistics for all variables used in the analysis. First, the means of NCSKEWt+1 and DUVOLt+1, are -0.302 and -0.191, respectively, which are comparable to those reported in Xu et al. (2013) and Zhang et al. (2016), based on a China sample, but are higher than the estimates in Kim et al. (2014) and Bhargava et al. (2017) conducted on a U.S. sample. Our sample has an average HERFINDAHLt of 0.343. The mean and median of natural logarithm of total assets is 13.058 and 12.834, respectively. The mean of leverage is 0.088, with a standard deviation of 0.117. The mean of market-to-book is 1.171, indicating positive future growth opportunity of the sample, and this is supported by the positive mean of return of assets (ROAt), which is 0.047.

The sample has a firm-specific weekly return (SIGMAt) of near to zero, indicating that the Malaysian market is conservative and less volatile. This is reasonable for the Malaysian Kuala Lumpur Stock Exchange (KLSE), which has strict rules and regulations on stock trading, and has only limited financial derivatives instruments for trading. Supportively, the mean of monthly share turnover is near to zero too. With regard to board diversity, the descriptive statistics show that board diversity in female directors (BOARDDIVERSITY_FEMALEt) has a low mean value of 0.093, with a standard deviation of 0.115. It indicates that female directors sitting in the boardroom is not a Malaysian corporate norm. Board diversity in Malaysian directors (BOARDDIVERSITY_NONMALAYSIANt) has a low mean value of 0.078, with a standard deviation of 0.841; the distribution of percentile shows that the nationality of the board of directors in a majority of firms are Malaysian, with only a small sample of firms recruiting foreign directors. Board diversity in ethnicity (BOARDDIVERSITY_ETHNICITYt) has a mean of 0.345, with a standard deviation of 0.185, and board diversity in directors' age (BOARDDIVERSITY_AGEt) has a mean of 0.614, with a standard deviation of 0.125.

Table 1 Descriptive statistics

				Percentile		
	N	Mean	S.D	25th	50th	75th
Panel A: Stock Crash Risk Variables						
$NCSKEW_t$	4749	-0.302	0.584	-0.728	-0.259	0.145
$DUVOL_t$	4753	-0.191	0.558	-0.531	-0.182	0.132
Panel B: Corporate Fundamental Variable						
$FIRMSIZE_t$	4632	13.058	1.638	11.928	12.834	13.949
$LEVERAGE_t$	4618	0.088	0.117	0.002	0.042	0.129
$MTBV_t$	4521	1.171	1.385	0.500	0.790	1.310
$RETURN_t$	4595	0.004	0.009	-0.001	0.002	0.007
ROA_t	4487	0.047	0.101	0.014	0.045	0.084
$HERFINDAHL_t$	3866	0.343	0.315	0.000	0.304	0.640
Panel C: Stock Performance Variables						
$SIGMA_t$	4593	0.059	0.171	0.003	0.048	0.067
$DTURNOVER_t$	4426	0.003	0.083	-0.008	0.0000	0.009
Panel D: Board Diversity Variables						
$BOARDDIVERSITY\_FEMALE_t$	4507	0.093	0.115	0.000	0.000	0.154
$BOARDDIVERSITY\_NONMALAYSIAN_t$	5200	0.078	0.841	0.100	0.000	0.000
$BOARDDIVERSITY\_ETHNICITY_t$	4529	0.345	0.185	0.245	0.375	0.480
$BOARDDIVERSITY\_AGE_t$	5224	0.614	0.125	0.568	0.640	0.694

Note: This table presents descriptive statistics for measures of stock-price crash risk, diversification variables, board diversity variables, and control variables.

Panel A of Table 2 shows that the consumer product sector has the highest Herfindahl index on average, i.e., 0.74, followed by the plantations sector, technologies sector, industrial productions sector, trading/services sector, properties sector, and construction sector. Nonetheless, all sectors have more than a 0.5 Herfindahl index, indicating that corporate diversification is still popular among Malaysian markets for each sector of business. In Panel B of Table 2, we observe a pattern of increasing Herfindahl index over the sample period. This indicates that Malaysian firms tend to expand their businesses into more variety of sectors in the recent years. The trend of corporate diversification becomes increasingly significant over time.

Table 2 Distribution of Herfindahl index across sector and across years

Panel A: Distribution of Herfindahl index across sectors		
Sector	Observations	Herfindahl Index
Consumer Products	854	0.34
Plantations	266	0.33
Technologies	1204	0.30
Industrial Productions	497	0.39
Trading/Services	1267	0.32
Properties	644	0.38
Construction	308	0.33
Panel B: Distribution of the mean of Herfindahl index, by years		
Year	Mean of HERFINDAHL, by year	
2010	0.3166	
2011	0.3183	
2012	0.3296	
2013	0.3332	
2014	0.3535	
2015	0.3674	

Note: The classification of sector is according to Bursa Malaysia.

Regression results on the relationship between diversification and stock-price crash risk

Table 3 presents the relationship between Herfindahl index and stock-price crash risk. The estimates of control variables are consistent with our expectations. FIRMSIZEt shows a significant positive relationship with NCSKEWt+1 and DUVOLt+1, respectively. LEVERAGEt shows a negative relationship with NCSKEWt+1 and DUVOLt+1, but only the estimate in the regression with NCSKEWt+1 as dependent variable is statistically significant. MTBVt shows a significant positive relationship with NCSKEWt+1 and DUVOLt+1, respectively, and the lags of NCSKEWt and DUVOLt show a significant positive relationship with NCSKEWt+1 and DUVOLt+1, respectively. Instead, ROAt¬ ¬does not show a significant effect on

NCSKEWt+1 or DUVOLt+1. Stock performance variables, SIGMAt and DTURNOVERt, do not show consistent effects toward both measures of stock-price crash risk, while the effects are not statistically significant.

HERFINDAHLt shows a significant negative relationship with NCSKEWt+1 and DUVOLt+1. The estimates of HERFINDAHLt do not vary much between the regression with NCSKEWt+1 and DUVOLt+1 as the dependent variable, i.e., -0.0750 and -0.0933. The results indicate that, for every increase of 1 unit in the Herfindahl index, stock price crash risk reduces in the range of 0.0750 - 0.0933. This result is in support of our hypothesis H1, and is also in support of the portfolio theory, which diversification can efficiently minimize the risks of the firms.

In addition to the positive impacts of diversification in risk minimization and increasing economies of scale and scope, early studies such as Lang and Stulz (1994), Berger and Ofek (1995), Bernardo et al. (2000), and Fauver et al. (2004) find diversification produces discounted firm value. The mixture of empirical findings on the effect of diversification support the nonlinearity effects of the Herfindahl index on stock-price crash risk, as shown in Table 4. Panels A and B of Table 4 show that a low percentile Herfindahl index, i.e., DHERFINDAHL_Pctile30t, has a significant positive relationship with NCSKEWt+1 and DUVOLt+1, respectively. At the opposite end, the highest percentile Herfindahl index, i.e., DHERFINDAHL_Pctile70, has a significant negative relationship with NCSKEWt+1 and DUVOLt+1, respectively. Instead, moderate levels of diversification, i.e., DHERFINDAHL_Pctile30-50 and DHERFINDAHL_Pctile50-70 do not show any significant effects on stock-price crash risk.

Table 3 Regression results on the relationship between diversification and stock-price crash risk

	$NCSKEW_{t+1}$	$DUVOL_{t+1}$
$HERFINDAHL_t$	-0.0750**	-0.0933***
	(0.0168)	(0.0008)
$FIRMSIZE_t$	0.0214***	0.0187**
	(0.0067)	(0.0113)
$LEVERAGE_t$	-0.1799*	-0.1508
	(0.0726)	(0.1226)
$MTBV_t$	0.0302***	0.0204**
	(0.0021)	(0.0141)
$RETURN_t$	-0.8703	-2.5586
	(0.6286)	(0.1104)
ROA_t	-0.1834	-0.1617
	(0.1594)	(0.1555)
$SIGMA_t$	0.2512	0.9078***
	(0.4297)	(0.0060)
$DTURNOVER_t$	0.0828	-0.0057
	(0.5385)	(0.9512)
$NCSKEW_t$	0.0606***	
	(0.0004)	
$DUVOL_t$		0.0328**
		(0.0433)
Constant	-0.6555***	-0.5668***
	(0.0000)	(0.0000)
Industry Dummies	Yes	Yes
Year dummies	Yes	Yes
Standard Errors clustered by	Firms	Firms
Observations	3475	3468
Adjusted R^2	0.0270	0.0325

Note: The numbers inside parentheses are *p*-values, based on standard errors adjusted by firms. ***p<0.01, **p<0.05, *p<0.10.

The results from Table 4 support the mixture of empirical findings from the previous studies in the literature on diversification, and add to the body of literature by showing that the optimal risk-minimization effect from diversification is only applicable for a high Herfindahl index. An extremely low Herfindahl index instead increases stock-price crash risk, which may be due to the cost outweighing the benefit generated from a low degree of diversification.

Table 4 The effects of different classes of percentile for Herfindahl index on stock-price crash risk

Panel A: Dependent Variable is $NCSKEW_{t+1}$				
	[PERCENTILE]			
	Pctile Below 30	Pctile 30-50	Pctile50-70	Pctile above 70
$DHERFINDAHL\_[PERCENTILE]_t$	0.0401**	0.0163	-0.0334	-0.0430*
	(0.0323)	(0.5140)	(0.1492)	(0.0647)
Control Variables	Yes	Yes	Yes	Yes
Industry Dummies	Yes	Yes	Yes	Yes
Year dummies	Yes	Yes	Yes	Yes
Standard Errors clustered by	Firms	Firms	Firms	Firms
Obs	3717	3717	3717	3717
Panel B: Dependent Variable is $DUVOL_{t+1}$				
$DHERFINDAHL\_[PERCENTILE]_t$	0.0528***	-0.0051	-0.0283	-0.0477**
	(0.0013)	(0.8189)	(0.1857)	(0.0238)
Control Variables	Yes	Yes	Yes	Yes
Industry Dummies	Yes	Yes	Yes	Yes
Year dummies	Yes	Yes	Yes	Yes
Standard Errors clustered by	Firms	Firms	Firms	Firms
Obs	3716	3716	3716	3716

Note: $DHERFINDAHL\_[PERCENTILE]_t$ is a dummy variable giving a value of one for different classes of $HERFINDAHL_t$ (for the classes of percentile below 30 (pctile30), between 30- and 50 (pctile30 - 50), between 50- and 70 (pctile50 - 70), and above 70 (pctile70)), and giving a zero value otherwise. The numbers inside parentheses are *p*-values, based on standard errors adjusted by firms. ***p<0.01, **p<0.05, *p<0.10. Control variables are not reported here.

Further analysis on the influence of board diversity

Table 5 shows that board diversity in terms of percentage of female directors has progressively increased from 2010 to 2015, while the index of board diversity in ethnicity had a less progressive pattern over time. The progressive increase in board diversity, in terms of female composition may be driven by the Malaysian government's promotion of female leadership, as in the speech by the Prime Minister of Malaysia in 2015 (Najib Razak, 2015). Instead, the Malaysian government has propounded less on the subject of ethnicity and nationality in corporate leadership, hence, less change in board diversity. The issue of ethnicity in Malaysia is a sensitive political issue that may be an obstacle for the private sector or government to make any significant policy restructuring with regard to ethnicity (Pepinsky 2009). Additionally, board diversity in the director's age remains less volatile across the years.

Table 5 Distribution of board diversity across years

Year	*BOARDDIVERSIT_ FEMALE$_t$*	*BOARDDIVERSIT_ MALAYSIAN$_t$*	*BOARDDIVERSIT_ ETHNICITY$_t$*	*BOARDDIVERSITY_ AGE$_t$*
2010	0.0835	0.9253	0.3531	0.6210
2011	0.0869	0.9208	0.3478	0.6171
2012	0.0883	0.9193	0.3443	0.6155
2013	0.0954	0.9177	0.3433	0.6097
2014	0.1020	0.9195	0.3363	0.6084
2015	0.1074	0.9227	0.3359	0.6119

Panel A of Table 6 shows the interaction term between BOARDDIVERSITY_FEMALEt and DHERFINDAHL_Pctile70t is negative which is statistically significant. It indicates that increasing board diversity in gender negatively affects the relationship between Herfindahl index and stock-price crash risk, but the effect of the interaction term is only applicable with a high degree of diversification. This means that increasing the number of female directors can bring a reduction in stock crash risk exposure, but the merit of increasing the number of female directors is only significantly seen in firms that have diversified into many business segments. Firms that instead have a lower degree of diversification do not enjoy the benefits from increasing the number of female directors in a boardroom.

The opposite findings are obtained when increasing the number of non-Malaysian directors in a boardroom of the firms. Panel B of Table 6 shows that the interaction term of BOARDDIVERSITY_NONMALAYSIANt and DHERFINDAHL_Pctile70t has significant positive effect on the relationship between Herfindahl index and stock-price crash risk. In other words, diversifying directors' nationalities in a boardroom significantly increases the stock crash risk exposure of diversification, but such an effect is only significantly applicable to highly diversified firms. In less-diversified firms (below the

medium of Herfindahl index), the effect of BOARDDIVERSITY_NONMALAYSIAN increases stock-price crash risk exposure of diversification, but the effect is not statistically significant. Panels C and D of the table show that increasing board diversity in ethnicity and in age do not have any significant effect on the risk exposure of diversification, while the interaction terms instead have positive coefficients.

Table 6 The influence of board diversity to the effect of different classes of degree of diversification and stock-price crash risk

	$DUVOL_{t+1}$	$NCSKEW_{t+1}$	$DUVOL_{t+1}$	$NCSKEW_{t+1}$
		[PERCENTILE]		
	Pctile30		Pctile3050	
Panel A: Board Diversity in Gender				
DHERFINDAHL_[PERCENTILE]$_t$	0.0425*	0.0532**	-0.0218	-0.0231
	(0.0811)	(0.0113)	(0.4926)	(0.4106)
BOARDDIVERSITY_FEMALE$_t$	0.1016	0.0952	0.0265	0.0648
	(0.3485)	(0.3443)	(0.7729)	(0.4545)
BOARDDIVERSITY_FEMALE$_t$ x	0.0074	0.0380	0.3775*	0.1882
DHERFINDAHL_[PERCENTILE]$_t$	(0.9644)	(0.7948)	(0.0825)	(0.3166)
Panel B: Board Diversity in Nationality				
DHERFINDAHL_[PERCENTILE]$_t$	0.0412*	0.0097	-0.0253	-0.0061
	(0.0693)	-0.711	(0.3381)	(0.8421)
BOARDDIVERSITY_ NONMALAYSIAN$_t$	0.1382**	0.2092***	0.1463**	-0.2031***
	(0.0216)	-0.0025	(0.0136)	-0.0029
*BOARDDIVERSITY_*	-0.0158	-0.0431	-0.0386	-0.0330
NONMALAYSIAN$_t$ x	(0.5279)	(0.1408)	(0.1333)	(0.2964)
PERCENTILE_DHERFINDAHL$_t$				
Panel C: Board Diversity in Ethnicity				
DHERFINDAHL_[PERCENTILE]$_t$	0.0603	0.0735**	0.0507	0.0475
	(0.1370)	(0.0349)	(0.3282)	(0.2534)
BOARDDIVERSITY_ETHNICITY$_t$	0.0659	0.0567	0.0666	0.0664
	(0.3076)	(0.3053)	(0.2503)	(0.1926)
BOARDDIVERSITY_ETHNICITY$_t$	-0.0566	-0.0539	-0.1086	-0.1537
x	(0.5807)	(0.5453)	(0.4195)	(0.1822)
DHERFINDAHL_[PERCENTILE]$_t$				
Panel D: Board Diversity in Age				
DHERFINDAHL_[PERCENTILE]$_t$	0.1486*	0.1086	-0.1319	-0.0655
	(0.0756)	(0.2734)	(0.1956)	(0.5943)
BOARDDIVERSITY_AGE$_t$	0.0534	0.0563	-0.0522	-0.0153
	(0.5557)	(0.5815)	(0.4932)	(0.8589)
BOARDDIVERSITY_AGE$_t$ x	-0.1518	-0.1093	0.2071	0.1286
DHERFINDAHL_[PERCENTILE]$_t$	(0.2510)	(0.4868)	(0.2078)	(0.5164)
Control Variables	Yes	Yes	Yes	Yes
Industry Dummies	Yes	Yes	Yes	Yes
Year dummies	Yes	Yes	Yes	Yes
Standard Errors clustered by	Firms	Firms	Firms	Firms

Note: This table presents the regression results of the influences of various board diversity aspects on the relation between Herfindahl index (*HERFINDAHL*$_t$) and stock-price crash risk (*NCSKEW*$_{t+1}$ and *DUVOL*$_{t+1}$). *DHERFINDAHL_[PERCENTILE]*$_t$ is a dummy variable giving a value of one for different classes of *HERFINDAHL*$_t$ (for the classes of percentile below 30 (pctile30), between 30- and 50 (pctile30-50), between 50- and 70 (pctile50-70), and above 70 (pctile70)), and giving a zero value otherwise. Odd numbered columns show the effect of board diversity on the relation between *DHERFINDAHL_[PERCENTILE]*$_t$ and *DUVOL*$_{t+1}$, while columns with even numbers show the effect of board diversity on the relation between *DHERFINDAHL_[PERCENTILE]*$_t$ and *NCSKEW*$_{t+1}$. Standard errors are clustered by firms, and *p*-values are reported in parentheses. ***p<0.01, **p<0.05, *p<0.10

Table 6 Cont.

	$DUVOL_{t+1}$	$NCSKEW_{t+1}$	$DUVOL_{t+1}$	$NCSKEW_{t+1}$
	[PERCENTILE]			
	Pctile5070		Pctile70	
Panel A: Board Diversity in Gender				
DHERFINDAHL_[PERCENTILE]$_t$	-0.0425	-0.0442	-0.0045	-0.0183
	(0.1639)	(0.1041)	(0.8810)	(0.4927)
BOARDDIVERSITY_FEMALE$_t$	0.0727	0.0671	0.1923**	0.1770**
	(0.4399)	(0.4399)	(0.0378)	(0.0290)
BOARDDIVERSITY_FEMALE$_t$ x	0.1164	0.1588	-0.4398**	-0.3478*
DHERFINDAHL_[PERCENTILE]$_t$	(0.5530)	(0.3779)	(0.0157)	(0.0541)
Panel B: Board Diversity in Nationality				
DHERFINDAHL_[PERCENTILE]$_t$	-0.0199	-0.0137	-0.0181	-0.0074
	(0.4475)	(0.6315)	(0.5025)	(0.8068)
BOARDDIVERSITY_ NONMALAYSIAN$_t$	0.1365**	0.1909***	0.1276**	0.1833***
	(0.0203)	-0.0051	(0.0294)	-0.0068
BOARDDIVERSITY_ NONMALAYSIAN$_t$ x	0.0111	0.0254	0.0476*	0.0533*
PERCENTILE_DHERFINDAHL$_t$	(0.7101)	(0.4225)	(0.0708)	(0.0875)
Panel C: Board Diversity in Ethnicity				
DHERFINDAHL_[PERCENTILE]$_t$	-0.0758	-0.0588	-0.0602	-0.0912*
	(0.1087)	(0.1582)	(0.2421)	(0.0513)
BOARDDIVERSITY_ETHNICITY$_t$	0.0201	0.0223	0.0365	0.0153
	(0.7377)	(0.6683)	(0.5451)	(0.7738)
BOARDDIVERSITY_ETHNICITY$_t$	0.1303	0.0881	0.0486	0.1173
x	(0.2876)	(0.4291)	(0.6979)	(0.2941)
DHERFINDAHL_[PERCENTILE]$_t$				
Panel D: Board Diversity in Age				
DHERFINDAHL_[PERCENTILE]$_t$	-0.0534	0.0447	-0.0664	-0.1462
	(0.6431)	(0.7054)	(0.5503)	(0.2271)
BOARDDIVERSITY_AGE$_t$	-0.0212	0.0287	-0.0258	-0.0319
	(0.7749)	(0.7433)	(0.7312)	(0.7164)
BOARDDIVERSITY_AGE$_t$ x	0.0396	-0.1228	0.0258	0.1679
DHERFINDAHL_[PERCENTILE]$_t$	(0.8300)	(0.5255)	(0.8843)	(0.3876)
Control Variables	Yes	Yes	Yes	Yes
Industry Dummies	Yes	Yes	Yes	Yes
Year dummies	Yes	Yes	Yes	Yes
Standard Errors clustered by	Firms	Firms	Firms	Firms

Note: This table presents the regression results of the influences of various board diversity aspects on the relation between Herfindahl index (*HERFINDAHL*$_t$) and stock-price crash risk (*NCSKEW*$_{t+1}$ and *DUVOL*$_{t+1}$). *DHERFINDAHL_[PERCENTILE]*$_t$ is a dummy variable giving a value of one for different classes of *HERFINDAHL*$_t$ (for the classes of percentile below 30 (pctile30), between 30- and 50 (pctile30-50), between 50- and 70 (pctile50-70), and above 70 (pctile70)), and giving a zero value otherwise. Odd numbered columns show the effect of board diversity on the relation between *DHERFINDAHL_[PERCENTILE]*$_t$ and *DUVOL*$_{t+1}$, while columns with even numbers show the effect of board diversity on the relation between *DHERFINDAHL_[PERCENTILE]*$_t$ and *NCSKEW*$_{t+1}$. Standard errors are clustered by firms, and *p*-values are reported in parentheses. ***p<0.01, **p<0.05, *p<0.10

CONCLUSIONS

This study adds to the body of literature on stock-price crash risk, where our findings provide new insights of the effect of corporate diversification on crash risk minimization. The findings of this study imply that lower degrees of diversification may not prevent managers from adopting bad-news hording behaviour, where managers do not publicize bad news about the firm to investors in a timely manner. The managers can easily manipulate information release in less complicated business environments, such as less-diversified business segment firms. This may induce stock-price crash risk when the bad news is suddenly disclosed in a high-stock pricing position. We add to the body of knowledge related to a reduction of agency problem when the degree of diversification is high. Hence, this study adds to the literature that the risk-minimization effect of corporate diversification is two-fold, and is non-linear.

Further analysis of this study provides additional new insights on the influence of board diversity on the risk-minimization effect of diversification. The findings indicate that increasing board diversity in terms of

female directors can mitigate the stock-price crash risk of diversification, but such influence is only applicable at higher degrees of diversification. This implies that increasing the number of female directors in a boardroom may be a way to counter the self-interested behaviours of managers amid the characteristics of female directors can be effectively used to balance the shareholders' benefits in risk-taking decisions. Future research may look into the policy implications that arise from this study, particularly focusing on the formation of heterogeneous boards for better governance over risky investments by diversified firms.

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