# THE EFFECTS OF COMPETITIVE ENVIRONMENTS ON CORPORATE SELECTIVE HEDGING BEHAVIOUR


by

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***~ Dedicated to Ritchie ~***

*Life is never easy. But, fortunately, it can be changed by persistency.*

*When it is changing with love, you won't be alone.*

***Love Dad***

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# ABSTRACT

This thesis examines corporate derivative use and selective hedging behaviour taking into account the competitive environment in which the firm and its decision makers are involved. The effects of competitive environments are investigated from different levels. One is the industry level which considers the predation risk that firms could encounter because of product market competition. The other is at the board level; specifically the conflicts in board decision making because of board gender diversity. The test results support the explanatory power of both predation risk and board gender diversity on corporate selective hedging behaviour. Firms encountering higher predation risk are more likely to use derivatives to time the market for extra returns. Female participation on boards encourages selective hedging behaviour. However, adverse effects appear stronger on selective hedging when more females are appointed as directors. Once a critical mass is achieved (a board with over 20% or at least three female members), the intensity of selective hedging behaviour is significantly mitigated. A bell-shaped relationship between board gender diversity and selective hedging behaviour is found. Though a competitive environment has different levels and dimensions, by analysing this issue from both external and internal perspectives, this study emphasises the importance of contextual settings in discussing corporate decision making and risk management.

# DECLARATION

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I acknowledge the support I have received for my research through the provision of an Australian Government Research Training Program Scholarship.

Signature: ____________

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# CHAPTER ONE: INTRODUCTION

## 1.1 Motivation for the Study

Non-financial firms disclose in their annual reports that they have used derivatives only for hedging purposes. However, studies claim that using derivatives to time the market based on a manager's active view for extra returns is commonly adopted in practice (Bodnar, Hayt & Marston, 1998; Brown, 2001; Brown et al., 2006; Faulkender, 2005; Glaum, 2002; Loss, 2012; Wojakowsk, 2012). This profit-oriented and forecast-based hedging behaviour is defined as selective hedging (Stulz, 1996). Selective hedging does not necessarily mitigate market risk exposure. Indeed, it could magnify financial losses when managers wrongly predict market movements. In addition, unhedged cash flow volatility would raise additional indirect costs such as underinvestment (Froot, Scharfstein & Stein, 1993), costly financial distress (Mayers & Smith, 1982; Smith & Stulz, 1985), and greater tax burden (Mayers & Smith, 1982; Smith & Stulz, 1985). Because of the lack of detailed disclosure in annual reports, investors have difficulty in identifying the timing and extent of selective hedging behaviour (Géczy, Minton & Schrand, 2007)[1]. To help investors realise the potential risks embedded in corporate derivative use, investigation of what affects a firm's selective hedging behaviour is valuable. Given that improving transparency in the disclosure of financial derivative use is demanded, it is beneficial to have a discussion on how corporate hedging behaviour is affected by the contextual environment in which firms operate.

## 1.2 Research Objectives

As argued by Stulz (1996), adequate financial strength is the condition under which firms can conduct selective hedging behaviour. However, Stulz(1996) also claims that firms in financial

1 Géczy et al. (2007) fail to find that speculating can be identified by reading the public corporate disclosure in a confidential survey. They report that firms may claim to use derivatives for hedging purposes even if they take the positions based on market views. This opinion is consistent with the results based on the inspection of a firm's internal documents by Brown (2001).

distress have incentives to time the market, which is consistent with Adam, Fernando and Salas's (2017) empirical findings. Apart from adequate financial strength, a manager's belief in informational advantages is another prerequisite condition in exercising a selective hedge (Stulz, 1996). Though a manager's belief in informational advantages is unobservable, the factors that could possibly affect a manager's belief have been investigated by past studies. For example, Adam, Fernando and Golubeva (2015) find that firms use derivatives based on the prior consequences of speculation; Beber and Fabbri (2012) claim that market timing is affected by the degree of the manager's overconfidence, which is sourced in a CEO's personal characteristics. Apart from the above two factors argued in Stulz (1996), past studies have examined what affects corporate selective hedging from other perspectives such as managerial compensation, corporate governance, earnings management and fundamental financial characteristics (Adam et al., 2017; Brown et al., 2006; Géczy et al., 2007; Chemenko & Faulkender, 2011; Glaum 2002). These studies investigated corporate selective hedging behaviour from isolated angles by focusing on the manager or the firm itself. However, financial decisions are always contextual in practice (Schubert, Brown, Gysler & Brachinger, 1999). Without taking into account the contextual environments in which firms are involved, investigation of how corporate selective hedging behaviour is affected is not complete.

Studies in social ecology suggest that human risk-taking behaviour, including making risk-taking economic decisions, could be largely affected by the competitive environment within which they exist. For example, Ermer, Cosmides and Tooby (2008) claim that humans have a higher risk preference when they are observed by observers who have equal status compared with a skewed status in which the observers are not equal. Hill and Buss (2010) explain the incentive to take risks is the result of comparative advantages beyond the competitors. Within the consideration of competitive environments, people may discriminate the consequences of the decisions that they make. Bault, Coricelli and Rustichini (2008) reveal that people weigh the worry of loss more heavily when making a decision in private whereas the possibility of winning is of more concern when decisions are made public. Rosati and Hare (2012) suggest that social context, especially in a competitive environment, increases risk-taking behaviour because social context affects the valuation of different resources.

As discussed above, literature in social ecology implies that human risk-taking behaviour is affected by competitive environments. However, there is a lack of discussion on how corporate decision making on selective hedging, as a risk-taking behaviour, is affected by the competitive environments within which a firm (or the decision makers) is involved. Given that competitive environments have different dimensions, in this study, both external and internal environments are examined. For the external competitive environment, the effects of product market competition at industry level are investigated. For the internal environment, board structure, particularly board gender composition, is analysed.

## 1.3 Theoretical Framework

In this study, different theoretical underpinnings are framed to investigate how corporate selective hedging behaviour is affected by external and internal competitive environments. The external competitive environment, i.e., product market competition, is discussed based on the predation theory explained by Bolton and Scharfstein (1990). The internal competitive environment related to board gender diversity is hypothesised based on the female risk aversion, social identity, self-categorisation, and critical mass theories.

### 1.3.1 Theoretical underpinnings for the effect of predation risk on corporate selective hedging behaviour

In the spirit of Bolton and Scharfstein (1990), predation risk is the risk of being driven out of the market because of the limited capacity to secure external financing. Predation risk could arise from a rival's aggressive pricing[2]. In addition to predatory pricing, strategic investing is commonly adopted as an efficient means of predation (OECD, Paris, 1989). A rival's predatory actions enhance a firm's requirement for cash funds (Chi & Su, 2016; Haushalter, Klasa & Maxwell, 2007; Morellec, Nikolov & Zucchi, 2014)[3]. A lack of sufficient cash funds leads to difficulty in exercising investment opportunities. Failure to exercise competitive investment opportunities can cause a firm to lose market share and be driven out of the market.

Firms can benefit from derivative hedges. Using derivatives to hedge against uncertainty in financial markets can mitigate the cash flow volatility (Myeres, 1977)[4]. Mitigation of cash flow volatility helps to avoid forgone investment opportunities because of costly external financing (Froot, Scharfstein & Stein, 1993). However, under product market competition, limited opportunities for external financing results in a lack of adequate cash funds to satisfy the requirements to exercise investment opportunities. This happens, in particular, when a firm is under threat from a rival's strategic investing activities. Mitigation of cash flow volatility cannot solve the underinvestment problem caused by insufficient funds. When a firm encounters a rival's strategic investing, using derivatives to time the market (i.e., selective hedging), could possibly alleviate the threat of insufficient cash funds to exercise investments (Mello & Ruckes, 2003, 2005). Consistent with Harris & Raviv's (2017) argument, a firm could benefit more by enhancing

2 Predatory pricing is a competitive strategy that lowers the price of output to a level that rivals cannot tolerate (OECD, Paris, 1989).
3 Haushalter et al. (2007) and Chi and Su (2016) provide evidence on the effect of strategic investing on needs for cash funds.
4 Market uncertainty indicates the uncertainty in the markets based on change of foreign exchange rates, interest rates and commodity prices.

cash funds rather than mitigating cash flow volatility. In summary, firms encountering predation risk are more likely to selectively hedge foreign currency risk expecting to collect extra returns.

### 1.3.2 Theoretical underpinnings for the effect of board gender diversity on corporate selective hedging behaviour

Different theories are used as lenses to discuss the effect of board gender diversity on corporate selective hedging behaviour. Though different voices exist, female risk aversion is supported by most empirical findings. Studies explain female risk aversion from different perspectives such as psychological traits (Croson & Gneezy, 2009; He, Inman & Mittal, 2008), biological attributes (Coates & Herbert, 2008; Harris, Jenkins & Glaser, 2006), and social and cultural factors (Booth & Nolen, 2012, 2014; Olsen & Cox, 2001). If female risk aversion exists in corporate financial decision making, then it is expected that more women appointed as directors will lower the board's overall risk propensity. Hence firms with more female directors are less likely to use derivatives to time the market, i.e., selective hedging.

In addition to considering differences in risk propensity by gender, board decisions on derivative use are discussed based on theories focusing on inter-group behaviours. Female participation on boards forms psychological groups of directors identified by gender. Social identity theory (Tajfel, 1978) highlights discrimination of in-group members against out-group members. Self-categorisation theory focuses on self-categorisation and emphasises the cognitive processes with contextual affiliation to social groups. Both theories imply an in-group bias that creates inter-group conflicts. When it comes to corporate selective hedging against foreign currency risk, this in-group bias results in a conflict of opinions in the different domains of foreign currency risk management. These divergent opinions could be about the types of derivative instruments used, the derivative instruments used with different expiry dates, estimation of the risk that the firm is exposed to, and prediction of future market movements. These conflicts in board decision making exist if female directors prefer a more conservative use of derivatives because of risk aversion. Without considering female directors' risk aversion, the in-group bias arising from the psychological grouping by gender could still lead to inter-group cognitive conflicts in deciding how to manage foreign currency risk. These cognitive conflicts negatively affect corporate decision-making processes and enlarge instability in foreign currency risk management. Instability in foreign currency risk management is explicitly expressed as volatility in derivative use.

Without considering female directors' risk aversion, social identity and self-categorisation theories imply a positive relationship between board gender diversity and corporate selective hedging. If female risk aversion exists and affects board decisions, social identity and self-categorisation theory do not deny the negative effect of board gender diversity on corporate selective hedging.

Tokenism is a phenomenon of symbolic presence of minorities in groups. Minorities, regarded as tokens, fail to bring the expected functional utility to groups. Given that female directors present as minorities on boards, studies have examined how the dynamic change of female participation on Boards could bring substantial changes in board decision making and economic outcomes (Kanter, 1977; Kramer, Konrad, Erkut & Hooper, 2008; Konrad & Erkut, 2006). In these studies, critical mass theory supports the arguments. Critical mass, borrowed from nuclear physics, represents the extent of board diversity that brings substantial changes. Before board diversity attains the critical mass, there is no significant change in board decision making and subsequent economic consequences.

If a critical mass exists in board decisions on corporate derivative use, female participation on boards could not discourage corporate selective hedging behaviour until the critical mass is attained. Given that female directors are considered to be risk-averse, they are presented as a symbolic presence on boards that cannot lower the overall board risk propensity. When a critical mass of female participation on boards is attained, boards with a lower overall risk propensity will more conservatively deal with risk in derivative use. As described above, according to social identity and self-categorisation theories, in-group biases as the result of board gender diversity create conflicts in board decision making in managing foreign currency risk. This in-group bias leads to instability in the use of derivatives. Objectively, instability in derivative use reflects the extent of market timing. Therefore, combining critical mass theory with female risk aversion and social identity and self-categorisation theories, a bell-shaped relationship between board gender diversity and corporate selective hedging behaviour is expected.

## 1.4 Research Methodology

In this study non-financial firms in the Standard & Poor 500 (S&P 500) from the year 2009 to 2014 are sampled as a panel. Beber and Fabbri's (2012) residual model is employed to identify corporate selective hedging behaviour. Past studies suggest fundamental financial characteristics to explain why a firm uses derivatives to hedge (e.g., Froot et al., 1993; Smith & Stulz, 1985; Tufano, 1996). In this study, the gross notional amounts of derivatives are initially regressed on these fundamental financial characteristics. The standard deviation of the residual derivative holdings on fundamental financial characteristics in a time series represents corporate selective hedging behaviour. A greater standard deviation of the residuals indicates that a firm is more likely to use derivatives to time the market. The gross notional amounts of derivative holdings against foreign currency risk are manually collected by searching for keywords in the 10-K files in the Electronic Data Gathering, Analysis, and Retrieval system (EDGAR) and annual reports (Beber & Fabbri, 2012; Graham & Rogers, 2002).

### 1.4.1 Model specification on investigating the effect of predation risk on corporate selective hedging behaviour.

Three proxy variables are employed to test the extent of predation risk when engaging in corporate selective hedging behaviour. Creditors are very concerned about managers' incentives. According to Bolton and Scharfstein (1990), this concern leads to financial contracts being designed with terms that are sensitive to a firm's performance. The high sensitivity of (re)financing decisions to a firm's performance indicates high predation risk (Bolton & Scharfstein, 1990). The standard deviation of operating cash flow and the market-to-book ratio of assets are utilised to represent predation risk. The standard deviation of operating cash flow reflects the intensity of performance change. The intensity of performance change gives rise to creditors' concerns about agency problems and a firm's ability for debt repayment. These creditors' concerns affect the sensitivity of refinancing decisions to a firm's performance. The market-to-book ratio reflects the degree of information asymmetry on evaluating the unidentified intangibility of the assets (Harris & Raviv, 2017). Information asymmetry increases creditors' concerns about managers' incentives, which affects creditors' assessments of debt financing decisions (Harris & Raviv, 2017; Krishnaswami, Spindt & Subramaniam, 1999). The consideration of potential conflicts of interest against creditors is embodied in the establishment of corporate debt contracts such as cut-throat termination terms, debt placement structures, and debt maturity (Barclay & Smith, 1995; Bolton & Scharfstein, 1990; Krishnaswami et al., 1999). Debt maturity reflects the creditor's concerns about a manager's incentives (Barclay & Smith, 1995; Harford, Klasa & Maxwell, 2014; Myers, 1977). Accordingly, the percentage of debt maturity is also employed as a proxy for predation risk.

Haushalter et al. (2007) investigate the impact of predation threat on corporate derivative use. They recognise a rivals' strategic investing as a predation threat and argue that predation risk is higher when a firm's investment opportunities are more interdependent with competitors.

Interdependence of investment opportunities indicates the importance of investment opportunities to a firm's success in competition. This importance could place a firm under a rival's predatory actions. Not only that, but it also stimulates a capable firm's incentives to conduct strategic investing. As argued by Bolton and Scharfstein (1990), only firms who are poor-in-cash encounter a high predation risk when their investment opportunities are interdependent with competitors. Haushalter et al.'s (2007) arguments about the interdependence of investment opportunities cannot identify the firm that truly encounters predation risk from competitors.

To verify if interdependence of investment opportunities can explain corporate derivative use, specifically corporate selective hedging behaviour, the proxy variables used in Haushalter et al. (2007) are employed. These proxy variables are beta on industry returns, demeaned capital-to-labour ratio and industry concentration measures. In addition, the text-based variable of product fluidity measured by Hoberg, Phillips and Prabhala (2014) is also used.

### 1.4.2 Model specification for investigating the effect of board gender diversity on corporate selective hedging behaviour

To test how board gender diversity affects corporate selective hedging behaviour, three proxy variables are used to reflect board gender composition. They are the number of female directors on the board, the proportion of female directors on the board and the Blau's (1977) index by gender. To examine the existence of a critical mass that explains the non-linear relationship between board gender diversity and corporate selective hedging behaviour, quadratic functions are added into the regressions. In addition, categorical variables are employed. Sample firms are categorised by both the number of female directors on the board and the proportion of female directors referring to Kanter's (1977a, b) categorisation method. In addition to the ordinary least squared (OLS) model, the instrumental model with the generalised method of moments (GMM) estimators is tested to alleviate the endogeneity issue arising from the problem of reverse causality.

## 1.5 Summary of Key Findings

This study is about how corporate selective hedging behaviour is affected by both predation risk that a firm could encounter and board gender diversity. The key findings are summarised separately.

### 1.5.1 Summary of key findings for predation risk

To test for the effect of predation risk on corporate selective hedging behaviour, three measures of predation risk are created according to the theoretical arguments in Bolton and Scharfstein (1990). The test results indicate a positive relationship between the degree of predation risk that a firm encounters and intensity of conducting selective hedging behaviour. Bolton and Scharfstein (1990) explain that predation risk is a risk of being driven out of the market because of the limited capacity a firm has to secure external financing. Instead of focusing on the perspective of financing, prior studies investigated the issue of predation risk from the perspective of investing, specifically, the interdependence of investment opportunities. This study discusses the inappropriateness of interdependence of investment opportunities to represent predation risk and provides evidence that interdependence of investment opportunities fails to explain corporate derivative use and selective hedging behaviour.

### 1.5.2 Summary of key findings for board gender diversity

To test the effect of board gender diversity on corporate selective hedging behaviour, both female risk aversion theory and theories in social psychology are used to explain the potential conflicts. A negative linear relationship is found. The test results are consistent when endogeneity issues arising from the problem of reverse causality are mitigated by GMM estimators. However, given that, when female directors are a minority on boards they could be regarded as tokens, critical mass theory supports the extent of participation of female directors that could affect corporate risk management differently. A bell-shaped relationship between board gender diversity and selective hedging behaviour is found by testing with added quadratic terms, using categorised variables and employing sub-sample analysis.

### 1.5.3 Summary of key findings for mediation function of predation risk

Except for the direct relationship between board gender diversity and corporate selective hedging behaviour, the indirect relationship between these two variables through the intervening function of predation risk is also investigated. Both the Sobel-Goodman mediation tests and structural equation modelling are employed. According to the results, corporate selective hedging behaviour is affected by both predation risk that a firm encounters and female board participation. However, predation risk has no mediating effect on the relationship between board gender diversity and corporate selective hedging behaviour.

## 1.6 Research Contributions

By investigating how external and internal competitive environments affect corporate selective hedging behaviour, this study contributes to the literature in a number of ways. First, investigation of corporate derivative use is explored in greater depth than previously. Prior studies focus on why firms use derivatives but largely ignore the existence of selective hedging. When selective hedging behaviour is examined by aiming at variations in derivative use, industry level factors are rarely inspected. Without considering the effect of industry level factors and derivative speculation, the test results could be materially biased (Aretz & Bartram, 2010; Brown, 2001; Tufano, 1996). This study highlights the importance of a competitive industry environment in explaining why firms use derivatives to time the market.

Secondly, this study contributes to the literature on corporate decision making when firms encounter predation risk. Past studies claim that predation risk is an important factor determining cash holdings (Chi & Su, 2016; Harford et al., 2014; Harris & Raviv, 2017; Haushalter et al., 2007), cost of debt (Valta, 2012) and corporate derivative use (Haushalter et al., 2007). This study provides further evidence that predation risk stimulates firms to selectively hedge for extra returns.

Thirdly, this study re-examines the relationships among predation risk, strategic investing, the interdependence of investment opportunities and corporate derivatives use. Interdependence of investment opportunities itself cannot identify the firm to be either prey or predator. The predation risk that firms encounter as the result of the rivals' strategic investing differs according to the firm's capacity for external financing (Bolton & Scharfstein, 1990). Therefore, using the proxy of the interdependence of investment opportunities to represent the predation risk is arguable.

Fourthly, the findings support the endogeneity of the industry concentration measure. Industry concentration has been widely used as a proxy for product market competition in past studies (Akdogu & MacKay, 2008; Chi & Su, 2016; Ghosal & Lougani, 1996; Haushalter, et al., 2007; Klepsch, 2016). However, greater industry concentration does not necessarily indicate less competition (Karuna, 2007; Karuna, Subramanyam & Tian, 2015). In this study, three factors, i.e., market power, strategic investing, and governance mechanism to mitigate information asymmetry, are teased out from the measures of industry concentration separately. The explanatory power that industry concentration has on corporate selective hedging behaviour is solely attributable to its function of alleviating information asymmetry. This is a reminder of the cautious interpretation of industry concentration in related empirical studies.

Fifthly, this study focusing on corporate derivative use further discusses the economic outcome of board gender diversity. Prior studies claim that corporate selective hedging behaviour is affected by corporate governance and managerial compensation (Brown et al., 2006; Chernenko and Faulkender, 2011; Géczy et al., 2007). Though both corporate governance and managerial compensation rely heavily on the decision making of the board of directors, how the composition of the board of directors directly affects corporate selective hedging behaviour has not been investigated. By addressing this issue, knowledge about how board composition can affect corporate selective hedging behaviour is gained.

Lastly, this study supports the application of critical mass theory to discuss the different economic consequences of board gender diversity. Critical mass theory has recently been applied to explain the non-linear impact of board gender diversity on board decisions and financial outcomes, since tokenism is a phenomenon of female participation on boards (Joecks et al., 2013; Konrad, Kramer & Erkut, 2008; Kramer et al, 2006; Liu, Wei & Xie, 2014; Post, Rahman & Rubow, 2011; Schwartz-Ziv, 2015; Torchia, Calabrò & Huse, 2011). This study's findings can be explained by referring to the tokenism-critical mass theory. That is, female directors as a minority on boards are reluctant to express their real risk-averse preferences until the number of female directors reaches a critical mass. As a contribution, by focusing on managing a particular risk, i.e., corporate selective hedging, this study provides evidence of the existence of a critical mass in explaining how corporate decisions or outcomes can be affected differently by the dynamic changes in board gender composition.

## 1.7 Structure of the Thesis

The remainder of this thesis is structured as follows. Chapter two reviews the literature that relates to the determinants of derivative use and corporate selective hedging behaviour. This study investigates how corporate selective hedging behaviour is affected by predation risk and board gender diversity. This is followed by a discussion of predation and predation theory (Bolton & Scharfstein, 1990) and a review of the literature about board gender diversity. In chapter three, the hypotheses are developed based on the theoretical framework of predation risk and board gender diversity. Chapter four describes the research methodology including sample and data collection, the model designed for hypotheses testing and the variables' descriptions. In chapter five the findings are reported and discussed. Finally, a summary of the key findings, research contributions, research limitations and suggestions for future research are presented in chapter six.

# CHAPTER TWO: LITERATURE REVIEW

## 2.1 Overview

This chapter provides an overview of the literature. First, in section 2.2 studies investigating the determinants of derivative hedges are introduced. This is followed in section 2.3 by a summary of the literature that focuses on corporate selective hedging behaviour. Predation and predation theory are discussed in section 2.4. The literature on gender difference in risk preferences and board gender diversity are reviewed in sections 2.5 and 2.6, respectively. Lastly, section 2.7 provides a summary and highlights the gaps in the literature.

## 2.2 Determinants of Derivative Hedges

Prior studies focus on the determinants of hedging policies from different perspectives. Stulz (1984) claims that corporate hedging can mitigate agency problems. Smith & Stulz (1985) suggest that both corporate tax and the cost of financial distress affect corporate hedging decisions. Subsequently, mitigating the cash flow volatility to resolve the underinvestment issue was suggested as the main factor in establishing a firm's hedging policies (Froot et al., 1993). Firm size (Dionne & Triki, 2013; Géczy, Minton & Schrand, 1997; Nance, Smith & Smithson, 1993), and managerial risk aversion (Guay & Kothari, 2003; Haushalter, 2000; Tufano, 1996) are also considered to affect policies on derivative hedge use. Studies follow the above fundamental theories in investigating the determinants of corporate derivative hedges. However, empirical findings are mixed[5].

5 Examples of mixed evidence include Nance et al. (1993), Gay and Nam (1998), and Knopf, Nam and Thornton (2002) who claim that firms encountering the underinvestment issue are more likely to use derivatives to hedge. However, Bartram et al. (2009), Beneda (2012) and Borokhovich et al. (2004) provide opposite findings. Berkman and Bradbury (1996), Bartram et al. (2009), Kim, Mathur and Nam (2006), and Mian (1996) suggest that larger firms are more likely to use derivatives to hedge. However, Guay and Kothari (2003) find that smaller firms hedge more. In addition, Dionne and Triki (2013), Knopf et al. (2002), and Tufano (1996) report an insignificant relationship between hedging and firm size.

### 2.2.1 Underinvestment

A general framework is provided by Froot et al. (1993) for analysing corporate hedging when external financing is considered costly compared with internally generated funds. Market risks could lead to cash flow volatility so that current or projected investments could encounter a shortage of cash. This cash shortage could cause firms to forgo investment opportunities (Myers 1977, Myers & Majluf 1984). Hedging can mitigate the variance in cash flows. This can reduce the likelihood of having insufficient internally generated funds available to use for optimal investment opportunities. Froot et al. (1993) therefore claim that hedging can solve underinvestment problems.

The empirical findings on underinvestment as a determinant of hedging policies are mixed. Some studies find that investment opportunities are positively related to corporate hedging (Géczy, Minton & Schrand 1997; Gay & Nam 1998; Nance et al., 1993). In contrast, Berkman and Bradbury (1996) find that the positive relationship between hedging policy and growth opportunity exists only when the fair value of derivatives is utilised to measure the extent of hedging. However, findings based on the dollar notional amount of derivatives are insignificant. Mian (1996) uses market-to-book value and the extent of regulation as proxies for investment opportunity to test Froot et al.'s (1993) theory. The findings are contradictory. Mian's (1996) study also documents a negative relationship between market-to-book values and the extent of hedging against interest rate risks.

### 2.2.2 Cost of financial distress

Early studies focusing on the use of hedging to reduce the cost of financial distress appeared in the 1980s. Smith and Stulz (1985) and Mayers and Smith (1982) examine firm value enhancement by reducing the cost of financial distress by hedging. Smith and Stulz (1985) argue that using hedging to control cash flow volatility reduces the cost of financial distress, thus effectively mitigating the probability of bankruptcy. Leland (1998) argues that hedging increases a firm's debt capacity by reducing the earnings volatility and probability of financial distress. The associated tax benefit from further increased debt financing enhances firm value. Leland (1998) also emphasises that, even without future increased external financing, unused debt capacity lowers the cost of financial distress and hence increases firm value. Ross (1998) suggests that firms obtain more benefit from hedging through tax shielding as a result of increased leverage than through the reduced cost of financial distress.

Some studies found a positive association between the cost of financial distress and hedging policies (Berkman & Bradbury, 1996; Haushalter, 2000; Dionne & Triki, 2013), however, the findings from others are not consistent. Insignificance is reported when debt ratio is utilised as a proxy for the cost of financial distress (Fok, Carroll & Chiou, 1997; Géczy et al., 1997; Guay & Kothari, 2003; Haushalter, 2000; Kim, Mathur & Nam, 2006). When interest cover ratio is borrowed, the findings are also reported to be insignificant (Fok et al., 1997; Gay & Nam, 1998; Knopf et al., 2002; Nance et al., 1993).

### 2.2.3 Tax convexity

Early research by Smith and Stulz (1985) and Mayers and Smith (1982) consider the tax benefits of hedging. When tax payments are a function of the convexity of taxable income, hedging reduces volatility in taxable income and enhances a firm's value by cutting the average tax payments. The progressive tax codes and tax shields, such as tax losses carried forward and foreign tax credits, are considered to contribute to the formation of tax convexity. The function of tax convexity was found to be related to hedging policies in Berkman and Bradbury (1996) and Nance et al. (1993).

However, many researchers provide insignificant findings (Allayannis & Ofek, 2001; Gay & Nam, 1998; Géczy et al., 1997; Graham & Rogers, 1999; Haushalter, 2000; Mian, 1996).

### 2.2.4 Information asymmetry

Managers are assumed to be most familiar with a firm's operations and private information held by managers is costly to transfer to shareholders (Demarzo & Duffie, 1995). Managers can use this informational advantage to maximise their own interests. Large institution ownership could reduce information asymmetry and mitigate the agency conflict (Breeden & Viswanathan, 2016; Demarzo & Duffie, 1991). Breeden and Viswanathan (2016) suggest that managers may focus more on their reputation rather than compensation. Volatility generates noise in earnings. Good managers may prefer to hedge so that they can be identified from bad managers in earnings volatility management competence. Large institution ownership reduces information asymmetry in the identification of management ability. Therefore, both Breeden and Viswanathan (2016) and Demarzo and Duffie (1991) argue that large institution ownership makes managers have less incentive to hedge. Dionne and Triki (2012), Géczy et al. (1997) and Tufano (1996) provide supportive findings[6]. However, many studies provide inconsistent results (Bartram et al., 2009; Borokhovich, Brunarski, Crutchley & Simkins, 2004; Graham & Rogers, 1999; Haushalter, 2000; Knopf et al., 2002).

### 2.2.5 Managerial risk aversion

Smith and Stulz (1985) predict that the managers' investment risk is mainly concentrated in the firm rather than fully diversified. Stulz (1984) finds that the more risk adverse a manager is, the more firms will hedge. The extent of risk aversion is related to the manager's compensation. If the

6 Géczy et al. (1997) use the number of analysts following as a proxy to represent the information asymmetry. They find a positive relationship between the number of analysts following and derivatives use.

manager's compensation is a function of share's price in the shape of convexity, managers will choose no hedging as the optimal strategy. This is because increased earnings volatility in a firm's favour as a surprise to the market creates more chances for managers to obtain greater compensation. However, if there is no such convex mechanism in managers' compensation then managers will benefit more by hedging against risks.

Roger (2002) describes the different management compensation functions as managers' holdings of either common stock or share options. They find that, in the absence of convexity, common stock holdings as compensation are linearly related to firm value and positively related to the extent of hedging, whereas ownership of share options reduces the manager's incentive to hedge. The above findings are consistent with the prediction by Tufano (1996). However, when the sophisticated proxy 'delta-to-Vega'[7] was used by Roger (2002), the test results are mixed when different models are used. Other studies also document insignificant or mixed findings (Borokhovich et al., 2004; Géczy et al., 1997; Haushalter, 2000; Knopf et al., 2002).

### 2.2.6 Industry competition

In addition to the literature on the determinants of hedging decisions focusing on firm-specific factors, industry level factors have also been investigated. Allayannis and Weston (1999) empirically study foreign currency derivatives and argue that the more competitive an industry is, the more likely firms in the industry will use derivatives to hedge. Allayannis and Ihrig's (2001) theoretical work attributes the above relationship to the impact of industry structures on determining a firm's market risk exposure. Intense competition prevents firms in the industry from

7 'Vega' and 'Delta' are derived from Black-Scholes-Merton option pricing model and defined in Roger (2002). 'Vega' is a measure of CEO incentives to increase risk according to the partial derivative of the dividend-adjusted Black-Scholes equation with respect to the annual standard deviation of stock returns. 'Delta' is a measure of CEO incentives to increase stock price according to the partial derivative of the Black-Scholes equation with respect to stock price.

being output price makers. Firms having no flexibility in output price settings cannot maintain their profit margin by passing off the cost shocks to the output price. Using derivatives to hedge the market risk can effectively mitigate the influence of cost shocks. Consistently, Mello and Wang (2012) claim that market power "works as a natural hedge", without which, the importance of derivative hedges against cash flow volatility is more prominent.

Focusing on the effect of investment interactions, Loss (2012) claims that a firm hedges more when investments are strategic substitutes but they hedge less when investments are strategic complements. Mello and Ruckes (2005) examine derivative hedges by focusing on industry competition and argue that intensively strategic competition results in oligopolistic firms hedging the least. For a firm encountering intensive strategic competition, the remaining unhedged exposure can possibly carry extra profits. Obtaining extra profits creates a competitive advantage and benefits the firm more than a reduction in earnings or cash flow volatility (Mello & Ruckes, 2003). By using a dummy variable indicating the derivative hedge, Haushalter et al. (2007) state that firms under threat of a rival's strategic investing are more likely to use derivatives to hedge. Without derivative hedges, underinvestment could bring a firm more severe consequences, including being driven out of the market.

In summary, prior studies focussed on the impact of industry level factors on corporate derivative use from different aspects, i.e., market power and strategic interaction. Market power determines the flexibility of output product pricing. The flexibility of output pricing affects how a firm's risk exposure is altered under competition. Strategic interaction affects the competitive advantages. To obtain a competitive advantage using derivatives for either hedging or speculation needs to be thoughtfully balanced.

In addition to the studies about product market competition, some theoretical studies further highlight competitors' interplay in deciding their hedging policies. Adam and Nain (2013) claim that a firm encounters lower risk exposure when it imitates the hedging policy of the majority in the industry. Specifically, firms in less competitive industries are more likely to hedge if most of its competitors' hedge for their risk exposure. Adam, Dasgupta and Titman (2007) suggest that the heterogeneity of hedging policies in an industry exists in equilibrium. Hedging policies are more diversified for firms in more competitive industries with more inelastic demand and less convexity in production costs. In summary, studies argue differently, by using theoretical modelling to demonstrate how industry competition affects corporate derivative use. However, limited studies offer empirical evidence, especially where selective hedging is concerned.

### 2.2.7 Reasons for mixed findings

Different theories attempt to explain the determinants of hedging policies under market imperfection. However, the empirical findings are mixed as discussed above. The inconsistencies could result from imperfect research techniques or methods. First, proxies for the determinants of hedging policy have been used to explain different theories. For example, a tax-loss carried forward can represent either the convexity function of tax or the possibility of financial distress, and R&D expenditure indicating an investment opportunity can also represent a level of costly external financing (Froot et al., 1993; Gay and Nam, 1998)[8]. Secondly, different corporate policies on items such as hedging, dividends and capital structure, could be simultaneously determined. Few studies have tried to control simultaneous effects (Bartram, Brown & Fehle, 2009; Dionne & Triki 2013; Géczy et al., 1997; Graham & Rogers, 1999; Jin & Jorion, 2006). Without considering

8 Gay and Nam (1998) argue that R&D expenditure can represent the level of information asymmetry about the quality of the new projects and can also link to the intangibles that are not regarded as good collateral for lenders.

the interactions between different corporate policies, the findings could be biased (Aretz & Bartram, 2010). Thirdly, the proxies for hedging policy are arguable. Many studies use (scaled) notional amounts of derivatives or dummy variables to represent hedging policies (Berkman & Bradbury, 1996; Borokhovich et al., 2004; Haushalter, 2000). Some also use the fair value of derivatives (Berkman & Bradbury; 1996) and net notional amount of derivatives (Graham & Rogers, 1999; Rogers, 2002). However, none can fully reflect the complexity in derivative use in hedging policies (Aretz & Bartram, 2010; Berkman & Bradbury, 1996)[9].

Apart from the above potential weaknesses in research techniques and methods, the inconsistent findings in previous studies could be derived from incomplete theories since some important factors, such as product market competition and selective hedging, are not fully considered (Aretz & Bartram, 2010; Brown, 2001; Tufano, 1996).

## 2.3 Corporate Selective Hedging Behaviour and its Determinants

Selective hedging is defined as profit-oriented and forecast-based hedging behaviour (Glaum, 2002; Stulz, 1996). By selective hedging, firms use derivatives to speculate by varying the size and timing of their derivative transactions based on the managers' active market views (Brown et al., 2006; Loss, 2012). Wojakowsk's (2012) analytical models indicate that selective hedging is valued with regard to a firm's convex cash flow structures. Surveys and empirical studies find that selective hedging is widely adopted (Adam & Fernando, 2006; Bodnar et al., 1998; Brown et al., 2006; Faulkender, 2005; Glaum, 2002; Knill, Minnick & Nejadmalayeri, 2006). Brown (2001) interviewed HDG's[10] managers and examined the firm's internal documents and found that one

9 For example, in Berkman and Bradbury (1996), the authors argue that fair value measures are potentially noisy as they depend on two factors that are not related to the actual hedge ratio of the derivatives position. One is past movement of the risk variable, the other is the time elapsed since derivatives were contracted. The contractual measures are also not perfect since they cannot reflect maturity and aggregate long and short positions.

10 HDG is a leading manufacturer of durable equipment in the U.S. (pseudonym).

hedging policy goal is to respond to the impact of currency movements on competitors, which implies that selective hedging is conducted.

Stulz (1996) formally introduces the notion of selective hedging and documents two necessary conditions under which it can enhance a firm's value: 1) the managers have the belief on holding private information on market movements; and 2) the firm has adequate financial strength to undertake market timing. However, Stulz (1996) suggests that firms in financial distress could also have an incentive to hedge selectively. The empirical studies explaining why firms hedge selectively are limited and give inconsistent findings. Based on a survey about risk management of German non-financial firms, Glaum (2002) finds firms with lower leverage, lower profitability and significant bank ownership are more likely to hedge selectively against foreign currency risk. However, these factors cannot be used to explain selective hedging against interest rate risk. Adam et al. (2017), focusing on the gold mining industry, investigate how firms' financial characteristics affect corporate selective hedging behaviour. They find smaller firms and those that are closer to financial distress are more likely to hedge selectively. They explain their findings as being driven by asset-substitution motives. In addition, they did not find that managerial compensation can explain selective hedging behaviour. Conversely, by examining interest rate risk, Chernenko and Faulkender (2011) find that firms use derivatives to speculate when managerial compensation schemes are more performance-sensitive. Géczy et al.'s (2007) confidential survey supports the importance of incentive-aligning compensation arrangements. In addition to the above studies focusing on a firm's fundamental financial characteristics and managerial compensation, some studies analyse managers' characteristics from the perspective of behavioural corporate finance. Adam et al. (2015) find asymmetric derivative use according to the prior consequences of speculation, i.e., more speculation is carried out when gains were generated by previous speculation but there is no reduction in speculation following previous speculation losses. They argue that these findings are attributable to a manager's behavioural biases. Beber and Fabbri (2012) investigate if CEOs' individual characteristics affect their personal beliefs on market timing decisions. They find that a firm with a CEO who is young, less experienced and has an MBA degree speculates more. The above studies discuss selective hedging focusing on firm and CEO level factors. However, there is a lack of understanding of how industry level factors affect selective hedging. In this study, the competitive environment in which a firm is involved is considered with a particular focus on the effect of predation risk.

## 2.4 Predation and Predation Theory Explained in Bolton and Scharfstein (1990)

Predation is defined as a short-term behaviour that seeks to exclude rivals on a basis other than efficiency to protect or acquire market power. Predation includes both predatory pricing and non-price predation (OECD, Paris, 1989). Predatory pricing is a competitive strategy to lower the prices of outputs to the level that rivals cannot tolerate. After the rivals are driven out of the market, the predator will charge higher prices to compensate for the predation losses and to obtain significantly greater gains (OECD, Paris, 1989). Non-price predation is a strategic behaviour intended to raise a rival's costs (Carlton & Perloff, 2015). It is not limited to the abuse of judicial and administrative procedures to impede rivals' business operation. It also includes aggressive capital investments such as advertising, research and development, and strategic capacity expansion (Glossary, 1993). Though some studies doubt the feasibility of predatory actions (Easterbrook, 1981; McGee, 1958)[11], imperfect information on predation's costs and strategies enhance the feasibility of predation (Easly, Masson & Reynolds, 1985; Kreps & Wilson, 1982).

To explain predation, early studies focused on how a rival's predatory actions can change a firm's view on costs, demand and profitability (Saloner, 1987; Salop & Shapiro, 1982; Scharfstein, 1984). However, Bolton and Scharfstein (1990) argue that a firm's view of profitability cannot be effectively changed by a rival's predatory actions. They document the source of predation risk based on agency problems in financial contracting. As argued, a manager's incentives are a concern because of information asymmetry that lowers a firm's ability to obtain external financing. This, in turn, can induce a rival's predatory actions. Using brokerage house mergers and closure events as exogenous shocks, Billett, Garfinkel and Yu (2017) empirically test the causal effect of information asymmetry on predation risk that a firm could encounter. Their findings support Boton and Scharfstein's (1990) view[12].

## 2.5 Gender Difference in Risk Preference

In this section, the literature on gender difference in risk preference from different domains is first introduced. Then, related studies focusing on gender difference in risk preference of financial decision making and in professional sub-populations is reviewed. Lastly, the reasons for the mixed findings in prior studies are summarised.

11 Easterbrook (1981) and McGee (1958) doubt that the cost of predation cannot be compensated for because of unrealisable future monopoly profits. They argue that the target of predation can survive with help from outside capital providers. In addition, help can be sourced from customers by using long-term packaged contracts since successful predation will burden customers with more costs in the future that are greater than the discount received from present predatory pricing. According to the present losses and forgone profits resulting from predation and the uncertainty of future monopoly profits, Easterbrook (1981) argues that the threat of predation is not credible. If capital providers and prey (victims) see through a predator's intention, it is unlikely to be a successful predator. Unlikeliness of predation success predation mitigates the incentive for predators to engage in predatory actions (Easterbrook, 1981; McGee, 1958). The benefits of predation from lowering merger and acquisition costs and enhancement of reputation are also criticised by Easterbrook (1981) and McGee (1958).

12 Billett et al. (2017) use the movements of analyst coverage to represent the change of the level of information asymmetry and the industry-adjusted sales growth as the consequence of the strategic investing to reflect the predation risk that firms encounter.

### 2.5.1 Gender difference in risk preference from different domains

There is a large body of studies focused on gender difference in risk propensity. Most of these studies document that women have more conservative risk preferences. For example, by investigating six safety product choices (smoking, seat belt use, teeth flossing, frequent teeth brushing, exercise and blood pressure checking), Hersch (1996) reports women are more risk averse in physical health and safety. Weber, Blais & Betz (2002) present that, except for social risk, women are more risk-averse in financial, health and safety, recreational, and ethical decisions. By assessing the gender difference in the likelihood of risk activity engagement in four domains (gambling, health, recreation and social), Harris et al. (2006) support Weber et al. (2002). Past studies also document that women are more risk averse in other risky behaviour such as crime activities (Daderman, 1999), sport (Dervaux, Baylé, Laqueille, Bourdel, Borgne, Olié & Krebs, 2001), drug and alcohol consumption (Freixanet, 1999; Hersch, 1996; Pacula, 1997), driving (Powell & Ansic, 1997), sexual behaviour (Schroth, 1996; Swanson, Dibble & Trocki, 1995), and impending death (Harrant & Vaillant, 2008). A meta-analysis of 150 studies about gender difference in risk-taking tendencies was done by Byrnes, Miller and Schafer (1999). Their findings strongly support the idea that men are more likely to take risks.

### 2.5.2 Gender difference in risk preference of financial decision making

Among the studies on gender difference in risk preference, financial decisions have often been investigated (e.g., Agnew, Anderson, Gerlach & Szykman, 2008; Badunenko, Barasinska & Schafer, 2009; Bajtelsmit & Vanderhei, 1997; Beckmann & Menkhoff, 2008; Bernasek & Shwiff, 2001; Dwyer, Gilkeson & List, 2002; Fellner & Maciejovsky, 2007; Finucane, Slovic, Mertz, Flynn, & Satterfield, 2000; Halko, Kaustia & Alanko, 2012; He et al., 2008; Hibbert, Lawrence & Prakash, 2013; Olsen & Cox, 2001; Powell & Ansic, 1997; Sunden & Surette, 1998; Watson &

McNaughton, 2007). Badunenko et al. (2009) reviewed the literature categorising articles into observed and self-reported behaviour. They find that most prior studies provide consistent evidence of women's risk aversion in investment decisions. Croson and Gneezy (2009) reviewed experimental studies on gender difference in risk preference[13]. They document that studies in laboratory settings and field studies on investment decisions provide consistent evidence that women are more risk averse than men. However, inconsistent voices exist. Schubert et al. (1999) examined gender difference in risk propensity by designing experiments with either context or abstract treatments. They argue that financial decisions in practice are always contextual so that previous abstract gambling experiments cannot reflect gender opportunity sets. They report no gender difference in risk propensity. Eckel and Grossman (2008) also reviewed experimental studies on gender difference in risk propensity by separating abstract gambling experiments from contextual experiments. They find that abstract gambling experiments and field studies in investment and insurance provide consistent findings to support the idea that females are more risk averse. However, the findings in contextual experiment studies are not so conclusive. He et al. (2008) argue that the gender-risk preference relationship is largely contingent. The propensity for risk-taking depends on "issue capability" in which gender plays a moderating role[14].

### 2.5.3 Gender difference in risk preference on professional sub-populations

Some studies analysed gender difference in risk propensity by focusing on subjects in professional sub-populations. Bechmann and Menkhoff (2008) focus on professional fund managers and claim that female professionals are more risk-averse than male colleagues. Olsen and Cox (2001)

13 Croson and Gneezy (2009) focus on three factors: risk preference, social preference and reaction to competition and conclude that women are more averse to both risk and competition whereas women's social preference is more situationally specific.

14 The concept of "issue capability" is borrowed from Mittal, Ross and Tsiros (2002) and defined as "the extent to which decision makers perceive that they have the resources or skills to resolve an issue".

document that not only female professional investment managers but also female non-professional investors are more risk-averse. Halko et al. (2012) claim that women have a lower risk preference than men in almost all domains of risk and in populations familiar with financial risk[15].

However, different findings exist. Hibbert et al. (2013) surveyed professors with either finance or English educational backgrounds in universities across the United States to investigate the effect of gender on individual overall portfolio allocations and retirement savings. They find women are more risk averse than men for highly educated individuals. However, they also report that professional knowledge in finance mitigates gender difference in financial risk aversion. Johnson and Powell (1994) report that gender stereotypes are dysfunctional in managerial sub-populations; both males and females have similar risk propensity. Based on the Simmons Gender and Risk Survey database, Maxfield, Shapiro, Gupta & Hass (2010) investigated possible gender bias in specific managerial contexts and find no gender difference in risk propensity. With women on corporate boards, Adams and Funk (2012) document that female directors are more risk-loving instead of risk-averse than male directors. This can possibly be explained by: 1) women avoid competition on boards against male directors, which results in similarity in leadership styles; 2) director nominations show a preference towards females who have a male-like style, preference or personality; or 3) female directors adapt their behaviour as a result of male-dominated environments.

### 2.5.4 Reasons for the mixed findings

Most studies mentioned above are in sociology and psychology and employ lab experiments (abstract gambling or contextual environment) or field studies in investment and insurance (see

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15 Halko et al. (2012) define the “cool factor” as general and financial risk attitudes and define the “hot factor” as risk taking in non-financial areas such as health, driving and sports, etc. They also find that subjects who are familiar with financial risk have similar tastes within “cool factors” separating from “hot factors”.

reviews by Croson and Gneezy (2009) and Eckel and Grossman (2008)). Some studies analysed the reasons from the perspective of the research method to explain the inconclusive evidence of gender difference in risk propensity. Schubert et al. (1999) state that abstract gambling experiments cannot assess risk behaviour in context. In Eckel and Grossman (2008), it is argued that both field and laboratory studies generate bias as the result of a failure to control factors such as knowledge, marital status and other demographic features. A similar comment is in Schubert et al. (1999). Further, findings in experimental studies are not comparable so that conclusions can hardly be drawn. Inconclusive findings could result from the employment of inconsistent measures of risk aversion across tasks. Croson and Gneezy (2009) criticise laboratory experiments that set up the decision under risk with a certain probability, which is rarely the case in practice where situations with ambiguity dominate[16]. In addition to non-comparable experimental design and limited sample size in experimental studies, Manning and Saidi (2010) argue that the gender difference may be meant to be magnified, which could be incentivised by selection bias of articles (Charness and Gneezy, 2012).

### 2.5.5 Diverse explanations of women's risk aversion

Though the studies on gender difference in risk propensity in different contexts reserve the view to some extent, most prior studies support that women are risk-averse. As for the reason for women's risk aversion, the literature provides diverse explanations. Croson and Gneezy (2009) identify three reasons to explain why women are more risk-averse. First, women have stronger

16 Risk and ambiguity are conceptualised differently. Ambiguity is conceptualised as "the degree of uncertainty about the nature and type of probability distribution underlying a risky situation" (Powell and Ansic, 1997; Harrant and Vaillant 2008). However, risk refers to situations where the probabilities of outcomes are known (Knight, 2012). Assuming the continuous distribution of potential outcomes is known, risk in finance is structured as the "variability of the returns offered by a choice" (Harris et al., 2006). Some studies focus on gender difference by differentiating the ambiguity from the risk, although "one can assign subjective probabilities to outcomes" in ambiguity (Croson & Gneezy, 2009). With respect to ambiguity, the findings are not conclusive though women are more risk averse is more consistently evidenced. Schubert et al. (1999) claim that women are more ambiguity-averse in the gain domain contextual environments (e.g., investments) when ambiguity is strong, which is consistent with findings in Moore and Eckel (2003). However, females are not more ambiguity-averse in loss domain contextual environments, sometimes males are more ambiguity-averse (Schubert et al., 2000; Moore and Eckel, 2003). Powell and Ansic (1997) document women are both risk-averse and ambiguity-averse.

emotional reactions and a worse experiences than men when they face negative outcomes, so they form lower utility of risky choices that result in women being more risk-averse. Secondly, women have a lower level of overconfidence on task performance in uncertain situations than men, which contributes to women's risk aversion. Lastly, risk framing is different by gender. Women are inclined to regard risks as a threat and more likely to avoid them whereas men see risks as a challenge to overcome. The different attitudes to uncertainty affect human risk behaviour differently. Based on the agency-communion theory (Bakan, 1966) and self-construal theory (Cross & Madson 1997), He et al. (2008) identify psychological differences by gender to explain why women are more risk-averse, i.e., men pay more attention to gains as general traits of agentic orientation and independent self-view whereas women are sensitive to losses because of their communion orientation and interdependent self-view.

Although Croson and Gneezy (2009) and He et al. (2008) provide explanations based on psychological attributes, why these psychological attributes differ by gender is unknown. Harris et al. (2006) introduce two interpretations of gender difference in risk behaviour. One is derived from the theory of parental investment. Males have greater variability than women in adapting Darwinian fitness in mate seeking, which attracts males to take higher or more risks. The other is the "offspring risk hypothesis" in which women have a higher risk perception from being more effective at protection and care of offspring, which leads to women being more risk-averse. Both parental investment and offspring hypotheses are derived from the human reproduction process focusing on biological and evolutionary factors (Olsen & Cox, 2001). In addition, Olsen and Cox (2001) address social and cultural factors to explain the gender difference in risk-taking. They argue that pressure and expectancies in society and culture cause females to be feminine and males to be masculine. Risk-taking has a greater masculine nature than feminine. Consequently, risk preferences by gender differ. Booth and Nolen (2012, 2014) do not deny that inherent gender traits result in different risky behaviour[17]. However, social learning is emphasised as another element explaining different risk preferences by gender; social learning can even modify gender traits. Some studies provide similar reasons to explain the gender difference in risk-taking such as biological and social explanations (Meier-Pesti & Goetz, 2006), and nature and nurture (Bertrand, 2011). Coates and Herbert (2008) claim that the human endocrine system and the level of steroids result in the shift of risk preferences. There are substantially different endocrine systems and different levels of steroids in women and men. Although the authors mainly focus on changes in steroids in male traders' bodies, it could imply the gender difference in risk preference is from the physiology perspective. Weber et al. (2002) investigated the relationship between risk perception and risk-taking behaviour. They find that the gender difference in risk-taking behaviour is associated with risk perception rather than attitude towards perceived risks.

## 2.6 The Effects of Board Gender Diversity

In this section, the literature that discusses the effects of board gender diversity on different perspectives is reviewed. Then the theoretical grounds for the effect of gender diversity argued in prior studies are summarised. Investigations of the effects of gender diversity on risks in corporations are introduced.

### 2.6.1 The effects of board gender diversity on different perspectives

Beyond the view of ethical or social expectations, female representation on boards as a business case has long been discussed in terms of the trend of demographic diversity in board composition and the mandatory gender quotas in different countries. Previous studies have investigated the

17 A trait is defined as a general predisposition that is stable across time and situations (Powell and Ansic, 1997).

financial outcomes of board diversity from different perspectives, such as a firm's reputation (Bear, Rahman & Post, 2010; Miller & Triana, 2009), corporate social responsibility including corporate philanthropy (Boulouta, 2013; Landry, Bernardi & Bosco, 2016; Liao, Luo & Tang, 2015; McGuinness, Vieito & Wang, 2017; Post et al., 2011), mergers and acquisitions (Levi, Li & Zhang, 2014), capital market reaction (Kang, Ding & Charoenwong, 2010), stock price informativeness (Gul, Srinidhi & Ng, 2011), earnings management (Srinidhi, Gul & Tsui, 2011), innovation (Kearney, Gebert & Voelpel, 2009; Miller and Triana, 2009), and board activities and commitments (Adams & Ferreira, 2009; Cook & Glass, 2015; Schwartz-Ziv, 2015).

In the literature, the effects of board diversity on performance are most heavily discussed (Adams & Ferreira, 2009; Ali, Ng, & Kulik, 2014; Bohren & Strom, 2010; Campbell & Minguez-Vera, 2008; Carter, D'Souza, Simkins & Simpson, 2010; Dang & Nguyen, 2014; Francoeur, Labelle & Sinclair-Desgagné, 2008; Hutchinson et al., 2015; Joecks et al., 2013; Liu et al., 2014). Rhode and Packel (2014) not only reviewed the literature on the effects of board gender and ethnicity diversity on performance, but they also investigated the reasons for the barriers to achieving diversity. Dos Reis, Castillo & Dobón (2007) extensively reviewed the research studying the impact of diversity on performance at different levels (individual, group and organization levels). Not only the direct relationships but also the moderated and mediated relationships are categorised in their study for the diversity effects from different dimensions such as ethnicity, sex/gender, age, group tenure, organizational tenure, functional background, and educational background. Terjesen, Sealy & Singh (2009) evaluated how board gender diversity affects corporate governance through which performance is affected by individual, board, firm and industry perspectives. However, their findings are inconclusive. Some studies state a positive relationship between board gender diversity and performance (Campbell & Minguez-Vera, 2008; Krishnan & Park 2005) but negative relationships have also been found (Adams & Ferreira 2009; Bohren & Strom 2010). Inconsistent findings are documented in past studies referring to different measures of performance. Focusing on the 288 largest Australian firms, Ali et al. (2014) find board gender diversity is positively associated with performance measured by employee productivity. However, the result is statistically insignificant when performance is measured by ROA. Both ROA and Tobin's q are employed as the measures of performance in Dang and Nguyen (2014); quantile regression analysis indicates that board gender heterogeneity is positively related to ROA but negatively associated with q. Schneid, Isidor, Li, and Kabst (2015) investigated the gender-performance relationship by meta-analysis. They find gender diversity is negatively related to contextual performance but has no significant impact on task performance[18]. Many past studies claim no findings on the relationship between gender diversity and performance (Carter et al., 2010; Chapple & Humphrey 2014; Kakabadse, Figueira, Nicolopoulou, Hong, Kakabadse & Özbilgin, 2015). Arguments in past studies attribute the inconclusiveness to factors such as sample size and selection, measurements of performance and gender diversity, and the endogenous nature of gender diversity (Dang & Nguyen, 2014; Joecks et al., 2013; Jurkus, Park & Woodard, 2011; Rhode & Packel, 2014).

### 2.6.2 Theoretical grounds for the effects of gender diversity

Though methodology issues can possibly explain the inconsistent findings, diverse theories in social psychology, human resource management and organisation support the reasonability of the existence of mixed findings. Terjesen et al. (2009) categorised the theories that can be used to explain the impact of gender diversity into different groups such as human capital theory, status

18 In Schneid et al. (2015), task performance is defined as the work activities that contribute to an organisation's technical core while contextual performance is defined as activities that contribute to the social network and psychological climate of the organization.

characteristics theory, and gender self-schema theory at the individual level; resource dependence theory, institutional theory, and agency theory at the firm level; social identity theory, social network and social cohesion, gendered trust, ingratiation and leadership at the board level; and institutional theory and critical management at the industry and environment level. By reviewing the literature, Rhode and Packel (2014) summarise three theories to explain the processes through which gender diversity could enhance performance. First, female presence on boards improves valuable capabilities; secondly, female directors produce more cognitive conflicts that improve innovation and produce more productive problem-solving options. The third theory implies gender diversity provides a positive signalling effect to the public and smooth board dynamics in more positive ways. Shore, Chung-Herrera, Dean, Ehrhart, Jung, Randel & Singh (2009) reviewed and summarised the theories according to the different predictions on the relationship between gender diversity and performance. In their study, similarity-attraction (Byrne, 1971), social identity (Tajfel, 1981), discrimination (Meyerson & Fletcher, 2000), status hierarchy (Chattopadhyay, 2003; Graves & Elsass, 2005), gender reproduction theory (Young & Hurlic, 2007) and theories of stereotypes and social roles (Duehr & Bono, 2006) support the negative view; but social cognitive theory (Lee & Farh, 2004; Bandura, 1977), and person-organisation fit (Kristof, 1996) predict positively. However, some theories used in gender diversity studies provide unclear predictions, e.g., the structural hole theory (Balkundi, Kilduff, Barsness, & Michael, 2006) and configurational theory (Dwyer, Richard, & Chadwick, 2003). Cabo, Gimeno and Nieto (2012) and Carter et al. (2010) highlight four theories frequently discussed in the literature on diversity, i.e., resource dependence theory, agency theory, human capital theory and social psychological theory. However, predictions of the effect of gender diversity on performance are not conclusive[19].

The above-mentioned theories are generally utilised to explain or predict if board diversity has an effect on a firm's performance. Some studies are grounded in theories such as tokenism and critical mass theory (Konrad et al., 2008; Kramer et al, 2006) to investigate how the dynamics change of the number or percentage of women directors makes differences in corporate decision making, hence influences performance. Tokenism is a phenomenon that minority members could be isolated as a symbolic presence with immaterial influence on group decision making processes (Kanter, 1977). When it comes to board composition, a skewed number of female directors is considered as tokens associated with three occurrences: visibility, polarisation and assimilation (Kanter, 1977)[20]. A minority of female directors on boards is no different from dominant male counterparts in decision making because they hide behind the stereotypes, responding to the pressure and ignorance of male dominants (Joecks et al., 2013). However, when the female numbers increase on boards, they can choose to either actively or passively be allied as a coalition or have different voices against each other. The former forms more assertive voices from female directors. The latter leads them away from feminine stereotyping. Nevertheless, both ways could draw more serious attention to female directors by the board dominants and alleviate their token image (Childs & Krook, 2008; Konrad et al., 2008; Kramer et al., 2006).

19 Carter et al. (2010) argue that the resource dependent theory predicts positive effects of gender diversity on performance. Human capital theory is relevant to contingency theory by Fiedler (2006), Lawrence and Lorsch (1967). Agency theory links female participation on boards with monitoring function of corporate governance which is not necessary to improve the firm value or performance. Social psychological theory indicates both positive and negative influences of board heterogeneity in corporate decision making. Therefore, the last three theories cannot suggest monotonic predictions.

20 Kanter (1977) describes three phenomena linked to tokens. Visibility creates performance pressure; polarization expedites within-group isolation of minorities and assimilation hides minority behind stereotypes.

The critical mass of the number of female directors has been specifically investigated. Following the categories constructed by Kanter (1977), Joecks et al. (2013) examined how the effects of women directors on corporate performance are different when the boards are composed by gender as uniform, skewed, tilted and balanced[21]. They find firms with a tilted board have significantly enhanced performance. When Blau's (1977) index is employed to represent gender diversity, the findings indicate an inverse bell-shaped relationship between board gender diversity and performance. In addition, Blau claims that the number of female directors makes a difference and that performance increases significantly for firms with three or more female directors. Liu et al. (2014) document results similar to Joeck et al.'s (2013)[22]. Konrad et al. (2008) interviewed 50 women directors in firms from the Fortune 1000 and conclude that the status with three or more women on the board makes female directors more comfortable to be themselves and more likely to be heard. The effects of being tokens, such as invisibility, being stereotyped, and hard work to be heard, are mitigated when the critical mass, i.e., three or more female directors, is reached. Torchia et al. (2011) focussed on a sample of 317 Norwegian firms and document the enhanced innovation by three or more female board directors. Post et al. (2011) analysed the effects of board composition on environmental corporate social responsibility by sampling 78 Fortune 1000 firms. They document the highest KLD (Kinder Lydenberg Domini ratings data) strength scores for the firms with three or more female directors on the boards. Schwartz-Ziv (2015) examine how the board gender diversity affects detailed minutes of board meetings of Israeli companies in which the government occupies extensive equity interest. They find three is the critical mass for firms with women participation on boards where directors are more active in attendance and more likely

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21 The categories constructed by Kanter (1977) are uniform groups (all board members are males), skewed groups (female directors exist and present up to 20% of the members in boards), tilted groups (female directors occupy 20-40% of the positions on boards), and balanced groups (over 40% of board directors are female).

22 Liu et al. (2014) find dummy variables for both two women directors and three or more directors on boards are significantly related to performance, however, a dummy variable for three or more directors captures higher coefficients.

to replace underperforming CEOs. In Schwartz-Ziv (2015), the term “dual critical mass” is introduced as gender-balanced boards are most active where there are at least three male and three female directors.

### 2.6.3 The effects of gender diversity on risk in corporations (gender diversity on boards and in top management teams)

This section reviews studies on gender diversity on boards and women’s participation in top management teams. Berger, Kick & Schaeck (2014) focus on the gender diversity of executive teams in banks in Germany. Using the ratio of risk-weighted assets to total assets and the HHI index of loan portfolio concentration as measures, they find a positive relationship between banks’ portfolio risk and the executive team’s gender diversity[23]. They attribute the positive relationship to female executives having less experience than their male counterparts, although they mention the negative impact of board heterogeneity such as more complicated communication and difficult cooperation. Bogan, Just and Dev (2013) investigated the effect of the composition of mutual fund management teams on decision making of risky investments in experimental settings. They find that an all-male fund management team is not the most risk-seeking group; the more gender-balanced teams are. In addition, a greater male presence makes the management team more loss averse. They suggest that the findings can be explained by the female positive risk preference shifting when they are involved in a group for decision making. Given that innovation is regarded as a corporate risk-taking decision, Miller and Triana (2009) indicate a positive association between board gender heterogeneity and innovation measured by corporate research and development (R&D) intensity. They explain it as board gender diversity providing more available and diversified information, which improves innovativeness of board decision making. However,

23 Berger et al. (2014) also examine the effect of age and education diversity of executives on portfolio risk. They find a negative association for age and mixed findings for divergence of educational background.

opposite evidence exists. Using the variability of corporate performance to represent a firm's risks, Lenard et al. (2014) state that the participation of more female directors on the board results in lower firm risk[24]. Levi et al. (2014) focussed on acquisition bid initiations and bid premium in mergers and acquisitions (M&A) and claim that boards with more female directors are less likely to make M&A decisions. In addition, a lower acquisition bid premium is paid for M&A cases decided by boards with more female directors. Chen, Ni and Tong (2016) investigated the effect of board gender diversity with two measures of R&D risk[25]. They document a negative relationship between gender diversity and R&D risk in that female directors diminish the effect of R&D expenditure on performance volatility and mitigate the adverse effect of R&D on the cost of debt. These studies contribute to the negative effect board gender diversity has on risk by female directors' risk aversion[26].

Other studies find insignificant relationships between board gender diversity and risk. Sila, Gonzalez and Hagendorff (2016) separately examine both financial and non-financial firms for the effect of board gender diversity on risk-taking by employing both market-based risk measures (total market risk, systematic risk and idiosyncratic risk) and firm policy risk measures (CEO vega, R&D expenditure, leverage, diversification, and standard deviation of ROA, etc.). Except for the

24 Lenard et al. (2014) use different measures of risk for robustness tests such as standard deviation of monthly stock returns as the total risk, standard deviation of residuals from single-index market model by Anderson and Fraser (2000) as the idiosyncratic risk. In addition, they employ other measures such as standard deviation of operating cash flow, standard deviation of ROA, standard deviation of Tobin's q, standard market adjusted returns, and standard stock daily returns.

25 Chen et al. (2016) employ two measures of R&D risk. One is R&D investment-performance volatility sensitivity; the other is R&D investment-cost of debt sensitivity.

26 Levi et al. (2014) do not disentangle risk aversion and overconfidence. Overconfidence and risk tolerance are different psychological attributes and the literature doesn't provide clear-cut differentiation between the two. Niederle and Vesterlund (2007) find that gender difference in compensation choice can be consistently explained by overconfidence, risk preference and also the taste of competition. Sonfield, Lussier, Corman & McKinney (2001) claim that both risk preference and overconfidence can explain individual overinvestment and excessive merger activities. Croson and Gneezy (2009) provide three reasons to explain women's risk aversion, of which overconfidence is one. Bertrand (2011) states that overconfidence is a source that widely exists to affect risk preference, participation in competence, social preference, attitude towards negotiation, etc. Levi et al. (2014) explain the negative relationship between board gender diversity and acquisition bid initiations and bid premiums in M&A by less overconfidence of women directors. However, they admit that they cannot distinguish women's less over-confidence from women's risk aversion because of the ambiguity and complexity to clearly identify these two. In order to answer why CEO gender helps to explain corporate risk taking, Faccio, Marchica & Mura (2016) provide some possible explanations, in which females, being more risk averse and less overconfident, are rational.

negative association with operation diversification, no significant effect of board gender diversity is found on the risk measures. Loukil and Yousfi (2013) investigated how financial and managerial risk-taking behaviour are affected by board gender heterogeneity. Managerial risk is measured by R&D expenditure, annual assets growth rate, and the market-book ratio of assets; financial risk is measured by long-term debt ratio, debt-to-equity ratio, the standard of daily stock returns and cash ratio. Except for cash-holdings, the above relationships are not significant. Francoeur et al. (2008) consider gender diversity in both boards and top management teams to examine market performance by taking into account the risk level by using the Fama and French (1992, 1993) model. They find performance is positively related to gender diversity in top management teams. However, the results indicate insignificance for board gender diversity.

In addition to the above studies testing for a linear relationship between board gender diversity and firm risk, some studies focus on moderator functions. According to the predictions based on agency theory and the behavioural agency model, Baixauli-Soler, Belda-Ruiz & Sanchez-Marin (2015) find a bell-shaped relationship between executive stock options (ESOs) and firm risk-taking. Further, gender diversity in the top management team (TMT) conservatively moderates the above relationship as a result of females being more risk-averse. Hutchinson, Mack & Plastow (2015) examined how risks affect corporate performance. They find that a positive relationship exists when performance is measured by Tobin's q but corporate risk is negatively associated when performance is measured by the ROA. Interestingly, board gender diversity oppositely moderates both these relationships.

## 2.7 Summary and the Gaps in the Literature

This chapter reviews the literature on corporate derivative use and corporate selective hedging behaviour. Assuming that firms use derivatives to hedge against market risks, different theories have been suggested to explain why derivatives are used. Firm-level and industry-level factors are investigated as the determinants of derivative hedging. However, these studies ignore the existence of selective hedges. Without considering the fact that firms use derivatives to speculate, investigation of the determinants of corporate derivative use could be biased. When selective hedges are the focus, there is a lack of understanding of how corporate selective hedging is affected by the competitive environment. Bolton and Scharfstein (1990) provide predation theory to explain how a firm is driven out of the market in product market competition. In the next chapter, Bolton and Scharfstein's (1990) predation theory is used to develop the first research hypothesis.

Since the Global Financial Crisis (GFC) in 2008, pressure from market regulators to recommend more female participation on the boards of directors has increased. Some European countries passed legislation for the enforcement of a mandatory gender quotas on boards (Norway in 2003, Belgium, France, Netherlands and Italy in 2011, and Germany in 2016). Whatever the social benefits from gender equality, as a business case, the effects of board gender diversity on performance have been heavily discussed in the last decade (Adams & Ferreira, 2009; Ali et al., 2014; Campbell & Minguez-Vera, 2008; Carter et al., 2010; He & Huang, 2011; Liu et al., 2014).

Studies' findings on whether corporate performance can be enhanced by an increased proportion of women on boards are mixed (see the review in Joecks, Pull & Vetter, 2013). Some studies also investigate the impact of board gender diversity on corporate risks represented by the market- or accounting performance-based measures (Baixauli-Soler et al., 2015; Francoeur et al., 2008; Lenard et al., 2014; Sila et al., 2016). By doing so, how different risks are dealt with in a firm are integrated into these consequence-oriented measures. However, the test results based upon these consequence-oriented measures do not clarify whether the mechanisms under which risks firms encounter are affected by board gender diversity are different[27]. In addition, the analysis of the overall consequences of risk-taking behaviours cannot specifically identify the effects of board gender diversity on each risk that could possibly interact with others[28]. In summary, without separately investigating how each risk is affected by board gender diversity and modified by other corporate risks, the conclusions based on the integrated consequence-oriented measures of firm risk could be arbitrary and lack persuasion. The impact of board gender diversity on different corporate policy risks is specifically examined in studies such as risk in leverage (Loukil & Yousfi, 2013; Sila et al., 2016), risk in diversification (Sila et al., 2016), risk in R&D and innovation (Chen et al., 2016; Loukil & Yousfi, 2013; Miller & Triana, 2009; Sila et al., 2016), and risk in M&A (Levi et al., 2014). However, the studies on the impact of board gender diversity on risk in derivative use are limited. To test if a firm's internal competitive environment can affect corporate selective hedging behaviour, board gender diversity is the focus. The hypotheses related to board gender diversity are developed in the next chapter.

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27 The test results based upon these consequence-oriented measures cannot clarify whether there is any difference in the mechanisms under which different risks are affected by board gender diversity. Even if the risks that are generated by causes of homogeneity, the explanations given by board gender diversity could be still different. For example, derivatives are widely used to manage foreign currency risk, interest rate risk and risk in the change of commodity prices. All mentioned risks are the risks that a firm could encounter because of market fluctuations. However, different risk management strategies could be applied to the different market risks that a firm encounters. Firms exposed to different market risks could apply their own risk management strategies. Without empirical testing taking into account the particular context in which a firm is involved, the test results related to whether board gender diversity can homogenously affect these risks are inconclusive.

28 An example is made according to the discussions in chapter two about the effect of predation risk on corporate selective hedging behaviour. Bolton and Scharfstein (1990) theoretically explain the cause of predation risk by focusing on the performance-sensitive financial contracts that are designed to avoid agency problems. The limited extension of external financing causes increased predation risk. As argued in chapter two, firms could possibly take risk-taking behaviours (e.g., selective hedging) expecting to get extra cash funds to mitigate the threat of predation. Accordingly, risks could be balanced after weighting up the costs and benefits of the financial decisions of each risk that a firm encounters.

# CHAPTER THREE: HYPOTHESES DEVELOPMENT

## 3.1 Overview

To investigate how the competitive environments in which firms operate affect corporate selective hedging behaviour, both external and internal competitive environments are separately analysed in this study. For the external competitive environment, predation risk because of product market competition is the focus and board gender composition is considered an important perspective of the internal competitive environment. In this chapter, hypotheses relevant to these two issues are developed.

## 3.2 A Hypothesis Relevant to Predation Risk

Derivatives can be used for both hedging and speculative purposes. Derivative hedges can prevent a firm from suffering unexpected losses arising from the downside risk. Derivative hedges can also mitigate cash flow or earnings volatility because of market fluctuations. Firms benefit from derivative hedges because enlarged cash flow or earnings volatility gives rise to issues such as underinvestment (Froot et al., 1993), costly financial distress (Mayers & Smith, 1982; Stulz, 1985), and more tax payments due to tax convexity (Mayers & Smith, 1982; Smith & Stulz, 1985). Though using derivatives to hedge is valuable, it foregoes opportunities to obtain extra returns through being exposed to the risks. Derivative speculation is risky. However, the risk embedded in derivative contracts is expected to bring worthy monetary returns to firms. Mitigation of earnings or cash flow volatility and enhancement of earnings or cash holdings are balanced as objectives of corporate derivative use. The benefits brought from both derivative hedging and speculating are contemplated, which decides the application of selective hedging. The desire for cash funds makes market-timing more weighted in deciding how derivatives are used, especially for firms poor in cash and encountering an external environment in which more cash funds implies obtaining competitive advantage.

Predation risk arises from worries about rivals' predatory actions. Rivals' predatory actions could be predatory pricing or non-price predation (OECD, 1989). Rivals' strategic investing as non-price predation has beenis discussed in past studies (Haushalter et al., 2007; Chi & Su, 2016). Bolton and Scharfstein (1990) analyse financial contracts and theoretically explain how a rival's strategic actions could lead to a firm being driven out of the market. As argued in Bolton and Scharfstein (1990), there is a trade-off between deterring a rival's predatory actions and mitigating agency problems. Creditors' concerns about managers' moral hazards result in financing contracts being designed with terms quite sensitive to the firm performance. However, these optimally designed contracts that protect creditors' benefits invite rivals' predatory actions (Fudenberg & Tirole, 1986). A rival's predatory actions cause the firm's performance to deteriorate which, in turn, further limits the firm's capacity to obtain external financing. If sufficient funds cannot be raised, the firm under predation threat could be driven out of the market through loss of investment opportunities. Bolton and Scharfstein (1990) highlight predation risk as the risk of being driven out of the market by limited capacity to secure external financing. This limited capacity results in failure to exercise typical investment opportunities, a situation in which a firm can hardly survive. With limited external financing, enhancement of internally generated funds increases the chance of a firm's survival from a rival's predatory threats (Bolton & Scharfstein, 1990, Chi & Su, 2016).

Earnings or cash flow volatility because of the uncertainty of financial markets results in costly external financing[29]. When concerned about exercising investment opportunities, costly external

29 The uncertainty of financial markets includes the uncertainty derived from the fluctuation of exchange rates, interest rates and commodity prices.

financing could give rise to underinvestment problems (Froot et al., 1993; Myeres, 1977). Firms value derivative hedges because using derivatives to hedge can mitigate cash flow volatility, which helps to solve underinvestment problems. Froot et al.'s (1993) arguments on derivative hedges are based upon the precondition that shortness of internally generated cash funds leads to costly external financing that causes forgone investment opportunities. However, these forgone investment opportunities do not directly decide a firm's survival in competition. If they do, costly external financing is unable to prevent a firm from exercising these investment opportunities. The barriers that prevent a firm from exercising investment opportunities can only be the occurrences that result in insufficient cash funds. According to the predation risk discussed above in Bolton and Scharfstein (1990), predatory actions arising from product market competition not only limits the capacity to secure external financing but also deteriorates performance. To avoid forgoing these decisive investment opportunities that threaten survival, using derivatives to time the market is a prior strategy relative to using derivatives to hedge the risk exposure. Therefore, the first hypothesis is:

**$H_1$: Firms encountering higher predation risk are more likely to conduct selective hedging.**

## 3.3 Hypotheses Relevant to Board Gender Diversity

Undoubtedly, managers play critical roles in making corporation decisions including decisions on market risk management. However, the board of directors' characteristics, attitudes and preferences should not be overlooked since board members heavily influence a firm's strategy, policy-making and improvement of corporate governance and counselling of management (Cook & Glass 2015; Demb & Neubauer, 1992; Matsa & Miller, 2013; Westphal & Zajac, 1995, 1997). As far as derivative use and market risk management are concerned, studies document that corporate governance and managerial compensation, which are heavily influenced by the board of directors, affect corporate selective hedging behaviour (Chernenko & Faulkender, 2011; Géczy et al., 2007). However, how the board composition affects corporate selective hedging behaviour has not yet been examined. In this study, the focus is on board gender diversity.

Selective hedging is defined as profit-oriented and forecast-based hedging behaviour (Glaum, 2002; Stulz, 1996). When selective hedging is adopted, firms speculate by varying the size and timing of their derivative transactions based on the managers' active market views (Brown et al., 2006; Loss, 2012). Given that the hedged risk exposure varies according to the manager's market view, earnings or cash flow volatility are not necessarily mitigated. Considering the results of volatile earnings or cash flows, selective hedging is a risk-taking behaviour through which a firm manages market instability.

The board comprises directors with different backgrounds, skills, characteristics and risk preferences. Directors' personal traits affect a board's decision making. More risk-averse directors on a board make the board less likely to take risks. To investigate the impact of board gender diversity on corporate selective hedging as a risk-taking behaviour, whether female directors' risk propensity is different from their male peers is considered. According to the literature review focusing on gender difference in risk preference, the main scholarship agrees that the context determines if gender affects human risk-taking behaviour (Eckel & Grossman, 2008; Harant & Vaillant, 2008; He et al., 2008; Schubert et al., 1999). Financial decisions are always contextual (Schubert el a., 1999). Past studies present inconsistent findings on gender difference in financial risk propensity (see reviews by Badunenko et al., 2009; Croson & Gneezy, 2009; Eckel & Grossman, 2008; Schubert et al., 1999). In addition, findings are not conclusive in studies that focus on professional subjects (Bechmann & Menkhoff, 2008; Halko et al., 2012; Hibbert et al., 2013; Johnson & Powell, 1994; Maxfield et al., 2010; Olsen & Cox, 2001). With respect to women at board and top management levels, studies on corporate risk-taking decisions present inconclusive evidence, although the embedded theoretical rationales are not only restricted to gender differences in risk propensity (Adams & Funk, 2012; Berger et al., 2014; Chen et al., 2016; Francoeur et al., 2008; Lenard et al., 2014; Levi et al., 2014; Loukil & Yousfi, 2013; Miller & Triana, 2009; Sila et al., 2016)[30]. It is not known if corporate selective hedging has a context like decision making on the management of other corporate risks or a firm's overall risk. If female directors are risk-averse in derivative management, a board with more female directors would be less likely to use derivatives to time the market. However, if risk propensity between male and male directors is not significantly different in derivative management, female participation on a board should have no impact on corporate selective hedging behaviour.

The above discussion on the relationship between board gender diversity and corporate selective hedging behaviour is based on how a board's overall risk propensity could be affected by its directors' risk preferences. This inference does not consider the effects of board gender diversity on the effectiveness of the board decision making process. The interactions of board directors because of diversified director demographic attributes are ignored. Social identity theory (Tajfel, 1978) and self-categorisation theory (Turner, 1978; Turner, 1999) place the interest on social identity and self-categorisation to explain human intergroup behaviours. According to the theories, individuals are motivated to strive for a positive self-concept in the interpersonal-intergroup continuum by maximising the gaps between in-group and out-group members. How people in a team are grouped is based on different human demographic attributes such as age, ethnicity and gender. These social identification and self-categorisation mechanisms focusing on comparative

30 Some studies refer to the theories other than the one about risk preference such as resource dependence theory, agency theory, and theories used to explain improvement or impairment of corporate decision making process.

fit and cognitive accessibility create in-group biases that negatively influence corporate decision making at board level (Ali et al., 2014; Hutchinson et al., 2015; Schneid et al., 2015). The negative influences include stereotyping (Loden & Rosener, 1991), conflicts in communication and difficulties in cooperation (Chatman & Flynn, 2001; Ely & Thomas, 2001; Triandis, Kurowski & Gelfand, 1994; Goodstein, Gautam & Boeker, 1994; Shapcott, Carron, Burke, Bradshaw & Estabrooks, 2006).

Social identity theory (Tajfel, 1978) and self-categorisation theory (Turner 1978, Turner, 1999) are widely used to explain the impact of board gender diversity from the perspective of the effectiveness of the decision-making process. Krishnan and Park (2005) developed the hypothesis based on social identity and power theories and market incentive perspectives and find a positive effect of gender diversity in top management teams on financial performance. Francoeur et al. (2008) document mixed evidence of the effects of gender diversity on performance (positive for senior management teams but insignificant for boards). They state that, at least more women participating in business is not a bad policy. Gender diversity positively affects the complicated and rapidly changed business environment in ways such as enhanced innovation, more diversified knowledge, perspectives and skills prevail compared with potential conflicts in decision-making process brought with it. However, Schneid et al. (2015) disagree. They employ the categorisation-elaboration model (CEM) to instantaneously investigate the positive and negative effects of board gender diversity. They find no significance in the relationship between board gender diversity and task performance but board gender diversity negatively affects contextual performance[31]. They claim that the negative effect of board gender diversity explained by social categorisation theories

31 Task performance is defined in Schneid et al. (2015) as "the work activities that contribute to an organisation's technical core (Motowidlo, Borman, & Schmit, 1997)". Contextual performance is defined as "activities that contribute to the social network and psychological climate of the organization" (Motowidlo et al., 1997).

offsets the effects on the enhancement of information processing. For contextual tasks, the negative effects are even more weighted than the positive ones. Ali et al. (2014) focus on the dynamic change of effects that are explained by either the resource dependence theory or social identity theory following augmented board diversity in both gender and age. They report mixed findings on gender but bell-shaped relationship in terms of age[32]. Following hypotheses based on resource dependent theory, social identity theory and agency theory, Hutchinson et al. (2015) report the conflicting results about the effect of board gender diversity on performance and the moderating function of risk on performance[33].

For corporate selective hedging, deciding how to manage foreign currency risk and how much risk exposure hedged is affected by the collective judgment of boards. According to social identity and self-categorisation theories, social identification and self-categorisation mechanisms create in-group bias. This in-group bias results in conflicts over decisions in different domains of foreign currency risk management between female directors and their male peers. These domains include preference on the type of financial instruments used, the decision on a combination of financial instruments with different expiry dates, the prediction of future market movements and the estimation of total foreign currency risk to which a firm could be exposed. Directors' risk propensity affects their judgments on these domains. If female directors are risk-averse on foreign currency risk management, their judgment on these domains could be largely different from male directors. Conflict in the judgment over these domains because of different risk propensity between female and male directors results in less risk-taking decisions. Therefore, in derivative use, firms

32 Ali et al. (2014) report mixed findings on the effects of board gender diversity on performance. The test results are insignificant when performance is measured by ROA but test results are positive when performance is measured by employee productivity (EP).

33 Hutchinson et al. (2015) report an insignificant relationship between gender diversity and performance without risk as a moderator. In addition, risk moderates the association between performance and gender diversity. However, the test results are conflicted because they are positive when performance is measured by q, and negative when performance is measured by ROA.

with more risk-averse female directors are less likely to time the market. However, gaps formed between female and male directors because striving positive self-concept is not necessarily only derived from different risk propensities by gender. The conflict in judgment of risk management in all these domains could still exist even if female directors had no different risk propensity from male peers. If so, gaps by gender because of intra-group comparative fit and cognitive accessibility create inter-group conflicts in risk management that enlarge the instability of corporate decisions on risk management. Instability of corporate decisions on risk management is explicitly expressed as the volatility of derivative use to time the market.

In summary, both female risk aversion and inter-group conflict based on social identity theory (Tajfel, 1978) and self-categorisation theory (Turner 1978, 1999) predict the possible effects of board gender diversity on corporate selective hedging behaviour. If female directors are risk averse, conflict in decision making on risk management because of in-group bias will reduce board overall risk tolerance. Boards with lower overall risk tolerance would be less likely to make risky decisions. Therefore, firms with more female participation on the board are less likely to use derivatives to time the market. Apart from the consideration of different risk propensities by gender, in-group bias because of self-identification and self-categorisation enhances cognitive conflicts by gender. These cognitive conflicts have negative effects on decision making process. Accordingly, the efficacy of foreign exchange risk management is lowered. The different domains of risk management such as the type, size or timing of derivative transactions would lack consistency. This inconsistency of derivative use indicates the extent of speculation. Therefore, without taking into account female directors' risk aversion, board gender diversity facilitates corporate selective hedging behaviour. According to the arguments above, the hypothesis is:

**H2: Board gender diversity affects corporate selective hedging behaviour.**

Theories have been combined to build the above hypothesis. One is the gender difference in risk preference in contextual environments, the other is the social identity and self-categorisation theory. All the arguments are based on the assumption of functional validation of women's presence on board decision making. That is, female directors' risk preferences affect the board's overall risk propensity. Further, women's active thoughts and actions create conflict in boards because of in-group biases by gender. However, functional validation of women's presence on boards could lose efficacy if women directors are mere tokens. Female directors as tokens on boards have immaterial influence in group decision making and are considered as a symbolic presence (Kanter, 1977). Critical mass theory is used to explain how change in the number or percentage of women directors makes a difference to board decisions or corporate outcomes (Joecks et al., 2013; Konrad et al., 2008; Kramer et al, 2006; Liu et al., 2014; Post et al., 2011; Schwartz-Ziv, 2015; Torchia et al., 2011). The term "critical mass" is taken from physics and indicates the presence of female directors who, instead of being tokens, play a substantial role in board decision making. According to critical mass theory, the functional validation of women's presence on boards on deciding market timing would not be documented until the critical mass of women's board participation is established. Therefore, if critical mass exists, a non-linear relationship between board gender diversity and corporate selective hedging behaviour is expected. To verify the existence of a critical mass effect of board gender diversity on corporate selective hedging behaviour, the following hypothesis is proposed:

**H3: Critical mass exists for the effect of board gender diversity on corporate selective hedging behaviour.**

## 3.4 A Hypothesis Relevant to Both Predation Risk and Board Gender Diversity

According to the theoretical analysis in Bolton and Scharfstein (1993), sensitive financial contracts can mitigate managers' incentives. However, they could also make the firm encounter high predation threat. "The optimal response to predation is to lower the sensitivity of the refinancing decision to firm performance" (Bolton & Scharfstein, 1993: 93). Given that investors' concerns of agency problems are alleviated, the sensitivity of a refinancing decision to a firm's performance can be lowered, hence the predation risk is mitigated. According to hypothesis one, mitigated predation risk discourages a firm from using derivatives to time the market for extra funds.

Stakeholder theory proposes that firms should represent the interests of all relevant stakeholders (Freeman, 1983). Accordingly, a more diversified range of directors on boards could provide wider protection for the benefit of different stakeholders, including creditors (Huse & Rindova, 2001; Ruigrok, Peck, Tacheva, Greve & Hu, 2006). If protection for the benefit of creditors from board gender diversity results in alleviated creditors' concerns of agency problems, board gender diversity could possibly lower the sensitivity of refinancing decisions to a firm's performance, hence reducing predation risk. Therefore, it is expected that corporate selective hedging behaviour is affected by board gender diversity, on which predation risk could have a mediating function. To identify the indirect relationship between board gender diversity and corporate selective hedging behaviour mediated by predation risk, an additional hypothesis is proposed:

**H4: Predation risk that a firm encounters mediates the effect of board gender diversity on corporate selective hedging behaviour.**

## 3.5 Summary

Taking into account both the external and internal competitive environments in which firms are involved, hypotheses related to both predation risk and board gender diversity are developed. The predation risk that firms could encounter is hypothesised as intervening in the effect of board gender diversity on corporate selective hedging behaviour. The next chapter details the research design that will enable testing of these hypotheses.

# CHAPTER FOUR: RESEARCH DESIGN

## 4.1 Overview

This chapter outlines the methodology used to test the explanatory power of predation risk and board gender diversity on corporate selective hedging behaviour. The sample selection procedure is presented in section 4.2 followed by an overview in section 4.3 of the model used to test the above relationship. The proxy variables of interest are described in section 4.4. The proxy variables used to represent predation risk according to the arguments in Bolton and Scharfstein (1990) are discussed along with those used by Haushalter et al. (2007). Section 4.5 introduces the different proxy variables used to represent board gender composition. Control variables are introduced in section 4.6. In section 4.7, data collection is described, with the method used to collect the gross amounts of derivatives given in section 4.7. The chapter is summarised in section 4.8.

## 4.2 Sample Selection

Stulz (1996) argues that to an extent some firms who are dominating the market have the capacity to obtain private information. The capacity of obtaining private information can incentivise firms to hedge selectively. In order to avoid the explanatory power of obtaining private information on selective hedging decisions, the foreign currency market is used as it is so enormous that no market participant can dominate it, thus benefit can be hardly obtained from inside information. US firms in the Standard & Poor (S&P) 500 in 2014 are sampled as a panel data set. The panel comprises the firm-year observations between 2009 and 2014. In this study, corporate selective hedging behaviour is identified by focusing on the gross notional amounts of derivatives that are disclosed in annual reports (Beber & Fabbri, 2012; Chernenko & Faulkender, 2011). Before 2009, it was not compulsory to report the gross notional amounts of derivatives, therefore many firms did not disclose this in their annual reports. In March 2008, the FASB issued SFAS No. 161, “Disclosures about Derivative Instruments and Hedging Activities, an amendment of FASB Statement No. 133" (SFAS 161). SFAS 161 required enhanced disclosure of an entity's derivative and hedging activities to improve the transparency of financial reporting. This requirement has been effective since the third quarter of the 2009 fiscal year. In compliance with SFAS 161, most firms report the details of notional amounts of derivatives used to manage market risks. Therefore, data were collected from 2009 until 2014, which was the most recent year available when data collection started.

**Table 4.1: Summary of Sample Selection**

| Selection of Firms and Number of Observations | |
|---|---|
| Firms in S&P 500 in 2014 | 500 |
| Less: Firms in the financial industry | -88 |
| Less: Firms in the utility industry | -31 |
| Less: Firms with no material FX risk exposure in 6 years of sample | -131 |
| Expected sample firms | 250 |
| Expected firm-year observations in 6 years of sample | 1500 |
| Less: Firms lacking disclosure in 6 years of sample | -188 |
| Final sample firm-year observations | 1312 |

Eighty-eight financial firms were excluded from the sample because of the complex use of derivatives. A further 31 firms in utilities were excluded because they operate under different regulations. This study focuses on changes in derivative use, therefore 131 firms that had not employed derivatives to mitigate foreign currency risk were also excluded from the sample. The remaining 250 non-financial, non-utility firms reporting derivative use to hedge against foreign currency risk provide 1,500 firm-year observations. Of these observations, a further 188 observations are excluded because the disclosure of the gross notional amounts of derivatives are unclear. All firms that started to report the gross notional amounts of derivatives after 2009 are included. Firms that did not use derivatives in the early years of the sample are retained (Bebber & Fabbri, 2012; Guay, 1999). Thus, the sample consists of 227 firms with 1,312 firm-year observations (see Table 4.1).

## 4.3 Model Specification

To investigate how predation risk and board gender diversity affect corporate derivatives used to time the market, Beber and Fabbri's (2012) two-stage model is used to identify corporate selective hedging behaviour. In the first stage, firm-year notional amounts of derivatives are regressed on fundamental financial characteristics.

$$Derivatives_{i,t} = \sum Fundamental_{i,t} + \varepsilon_{i,t},\ where \qquad (1)$$

$Derivatives_{i,t}$ : $Deflated\ notional\ amount\ of\ derivative\ use\ against\ foreign$

$exchange\ risk\ for\ firm\ i\ in\ year\ t$;

$Fundamental_{i,t}$: $proxies\ of\ the\ factors\ that\ explain\ why\ firms\ use\ derivatives\ to\ hedge$

$based\ on\ fundamental\ theories$;

$\varepsilon_{i,t}$: $residual\ values\ for\ firm\ i\ in\ year\ t.$

In the second stage, the standard deviation of residuals brought forward for each firm from the first stage is regressed on the control variables and identified variables of interest based on the arguments of predation risk and board gender diversity.

$$SD\varepsilon_{i,t} = Control_i + PDR_i \text{ / } BGD_{i},\ where \qquad (2)$$

$SD\varepsilon_{i,t}$ : $Standard\ deviation\ of\ residuals\ esitamted\ for\ each\ firm$;

$Control_{i,t}: Control\ variables\ borrowed\ based\ on\ literature\ review;$

$PDR_i: Proxies\ representing\ the\ predation\ risk\ that\ firms\ encounter;$

$BGD_i$: *Proxies representing the board gender diversity.*

In the first stage, the theory-based factors used in prior studies to explain why firms use derivatives to hedge are controlled. The estimated residuals from the first stage reflect the deviation from derivative holdings for hedging purposes that cannot be explained by fundamental financial characteristics. By focusing only on the residuals, selective hedging still cannot be appropriately identified because the estimated residuals could also include unknown explanatory factors of derivative hedges. Not considering the unknown factors could result in bias because of model misspecification. To resolve endogeneity as the result of the omitted variables, the residuals are estimated at the first stage by adopting the fixed effect model with both year and industry factors controlled. In the second stage regression, the measure of selective hedging is constructed by estimating the firm-specific standard deviation of the residuals within the whole sample period. Firms with a greater standard deviation of residuals are considered more likely to use the derivatives to time the market (Beber & Fabbri, 2012).

## 4.4 Proxy Variables Used to Represent Predation Risk

Different proxy variables are used to represent predation risk, which is explained according to Bolton and Scharfstein's (1990) predation theory. Haushalter et al. (2007) argue that firms with more interdependence of investment opportunities with rivals encounter higher predation risk. In Haushalter et al. (2007), predation risk is represented by three proxy variables of the interdependence of investment opportunities. Though Haushalter et al.'s (2007) arguments are criticised in this study, these three proxy variables are also employed for verifying the criticisms.

### 4.4.1 Proxy variables of predation risk according to Bolton and Scharfstein (1990)

Predation risk is the risk of being driven out of the market because of limited capacity to secure external financing (Bolton & Scharfstein, 1990). The ability to secure external financing corresponding to a rival's predatory actions is not observable. However, Bolton and Scharfstein's (1990) seminal paper suggests the importance of sensitivity of the refinancing decision to a firm's performance in explaining the ability to secure external financing. Greater sensitivity of financing contracts to a firm's performance indicates a more limited ability to secure external financing. Therefore, in this study, proxy variables related to the sensitivity of the refinancing decision to a firm's performance are used to represent predation risk. To alleviate the concern that test results could possibly be driven by the choice of proxies, three proxy variables are chosen to represent predation risk. They are the market-to-book ratio of the assets, the percentage of debts maturity, and the standard deviation of operating cash flows.

#### *4.4.1.1 A measure of creditors' concerns of agency problems (MTB)*

Mitigation of cash flow volatility can reduce the potential forgone investment opportunities as the result of costly external financing (Froot et al. 1993; Gay & Nam, 1998; Knopf, Nam & Thornton, 2002). A firm benefits more by mitigating the cash flow volatility if the firm has more investment opportunities. Therefore, for firms with more investment opportunities, derivatives are more likely to be used to hedge foreign currency risks. Considering debts as risky fixed claims in a firm's capital structure, managers have the incentive to reject the investments with positive NPVs when profitability cannot bring shareholders a normal return (Myers, 1977; Myers & Majluf, 1984). The more investment opportunities a firm has, the more severe a conflict of interest exists between shareholders and debt holders on investment decisions (Barclay & Smith, 1995). Therefore, how many investment opportunities that a firm has could represent debt holders' concerns about managers' moral hazard because of information asymmetry (Harris & Raviv, 2017; Krishnaswami et al., 1999; Mclean, 2011).

Market-to-book ratio of assets has been widely adopted as a proxy for the growth of investment opportunities (Guay & Kothari, 2003; Knopf et al., 2002; Main, 1996; Nance et al., 1993). It also indicates the degree of unidentified intangibility of the assets because of information asymmetry (Harris & Raviv, 2017). Given that greater information asymmetry results in the higher contracting costs of moral hazard, the market-to-book ratio of assets is used as a proxy for measuring a creditors' concern about agency problems (Harris & Raviv, 2017; Krishnaswami et al., 1999). Greater concerns about agency problems enhance the sensitivity of (re)financing decisions to a firm's performance (Bolton & Scharfstein, 1990). In this study, the market-to-book ratio of assets is first proxied for growth of investment opportunities to examine what decides corporate hedges. After excluding theory-based fundamental factors, including the growth of investment opportunities, the market-to-book ratio of assets is further used as a proxy for the creditors' concern about agency problems to explain why firms time the market to hedge selectively. It is expected that the market-to-book ratio will be positively associated with derivative use in the baseline model. Also, it has a positive effect on selective hedging that is identified as the standard deviation of residual derivative holdings on fundamentals.

*4.4.1.2 A measure of the percentage of debts maturity (Dm3)*

According to Bolton and Scharfstein (1990), being concerned about a manager's incentives raises creditors' adverse selection. Creditors' adverse selection enhances contracting costs because of the consideration of underinvestment and asset substitution problems (Krishnaswami et al., 1999). Enhanced contracting costs strengthen the sensitivity of refinancing decisions to a firm's performance. The strengthened sensitivity of refinancing decisions to a firm's performance is embodied in debt financing with short maturities. Barclay and Smith (1995) support the contracting-cost hypothesis and argue that shorter-maturity debts are more likely to be used when greater conflict interests exist between shareholders and debt holders. Myers (1977) also considers shortening the effective maturity of debts as an option to mitigate the conflict interests on exercising investment opportunities[34]. Long-term debts with shorter maturity indicate a higher refinancing risk (Harford et al., 2014). Therefore, in this study, debt maturity is utilised as a proxy to represent the degree of sensitivity of financing decisions to a firm's performance, which is determined by concerns about the manager's incentives. To measure the corporate debt maturity, Barclay and Smith's (1995) method is used to examine the percentage of total interest-bearing debt that would mature in 3 or more years. Robustness tests are conducted by examining the percentage of debts maturing in no less than one, two, four and five years[35].

#### *4.4.1.3 A measure of concern about debt repayments (Sd_ocf)*

Besides the measurement of debt maturity (Barclay & Smith, 1995; Harford et al., 2014; Myers, 1977), financing contracts are established with consideration of different other restrictions to mitigate agency problems. For example, Krishnaswami et al. (1999) investigated the effect of information asymmetry on the placement structure of corporate debts and suggest that private debt is preferred with higher contracting costs. Bolton and Scharfstein (1990) claim that concerns about a manager's incentives make the debt contract more likely to be designed with cut-throat termination terms. Without observing all these different restrictions, debt maturity, placement

34 Myers (1977) provides three ways to alleviate the incentive problems on exercising investment opportunities such as reducing the participation of debt holders; setting restrictive covenants on debt agreements; and shortening the maturity of debts.

35 Some observations exist with either less than 0 or more than 100 percent of debts maturing in more than 3 years. Barclay & Smith's (1995) method is followed to exclude these observations from the sample because of the possibility of data-coding errors in the Compustat Database.

structure, and particularly restrictive terms, the sensitivity of refinancing decisions to a firm's performance could not be comprehensively identified. Whatever the restrictions are, the restrictions in the establishment of debt financing contracts are to ensuring the safety of debts repayments. A firm's performance is an important factor that significantly affects creditors' refinancing decisions because performance indicates the sustainable ability to make debt repayments. A large variation of performance gives rise to debt repayment worries as a result of information asymmetry. This concern about debt repayment because of information asymmetry makes financial contracts with terms more sensitive to a firm's performance. Therefore, a variation in performance is expected to be positively associated with the sensitivity of refinancing decisions to a firm's performance. In this study, performance variation is measured by the standard deviation of cash flow from operating activities, which is used as an additional proxy for predation risk.

#### 4.4.2 Discussion of Haushalter et al.'s (2007) arguments about the impact of predation risk on corporate derivative use

In the spirit of Bolton and Scharfstein (1990), predation risk is the risk of being driven out of the market because of low ability to obtain external financing. In past studies, the interdependence of investment opportunities is used to represent predation risk (Chi & Su, 2016; Haushalter et al., 2007). Haushalter et al. (2007) is the most recent study focusing on the impact of predation risk on corporate derivative use. However, the validity of the interdependence of investment opportunities as a proxy for predation risk to explain corporate derivative use is arguable and needs further discussion.

Firms could face significant risk because of changes in the foreign exchange rate, interest rates or the prices of different commodities. Without hedging against risk exposure, uncertainty in financial market movements could enlarge cash flow volatility. Enlarged cash flow volatility enhances the cost of external financing, which induces underinvestment issues (Froot et al., 1993). Underinvestment issues could seriously affect a firm's business growth, even survival. Haushalter et al.'s (2007) empirical study investigated the impact of predation threat on corporate derivative use. They specify predation risk as the risk of being driven out of the market arising from a rival's strategic investing. A firm faces more strategic investing if its investment opportunities are more interdependent with its rival's. Therefore, as argued, more interdependence of investment opportunities indicates a higher predation risk. According to the results of tests with dummies as the dependent variables, they claim that firms encountering higher predation risk hedge more. However, their test results should be interpreted with caution for a number of reasons.

First, their conclusion is based on the assumption that firms use derivatives for hedging only. Given that selective hedging exists, dummy dependent variables cannot identify whether interdependence of investment opportunities results in derivatives being used for either hedging or speculating purposes.

Secondly, Haushalter et al. (2007) employ three proxy variables indicating the degree of interdependence of investment opportunities to represent the predation risk. The reason is that competing with rivals on more interdependent investment opportunities enhances the probability of underinvestment, which could result in the firm being driven out of the market. This argument makes sense for a firm encountering predation threats. However, it should be realised that, when investment opportunities are interdependent, occupying such investment opportunities is important to success in competition for all firms. If possible, all firms have stronger incentives to conduct strategic investing when their investment opportunities are more interdependent with competitors. These strong incentives of conducting strategic investing are predation threats to firms that have competitive disadvantages. Therefore, focusing on the interdependence of investment opportunities itself cannot differentiate the prey encountering predation risk from the predators.

Thirdly, Haushalter et al. (2007) specify predation risk as the risk derived from a competitor's strategic investing activities. They emphasise the form of predation threat but do not capture the essence of the predation risk. How a rival's strategic investing activities could drive a firm out of the market is not answered. To answer it, Bolton and Scharfstein (1990) theoretically explain that the difficulty in raising more cash funds is the reason for the firm to be excluded from the market when it is under a rival's predation threat. Regardless of the form of a competitor's strategic actions, either predatory pricing or non-price predation, only firms that are poor in cash encounter high predation risk[36]. Conversely, for firms with sufficient cash funds or a large capacity to obtain external financing, the predation risk is low. Therefore, even if a firm that has interdependence of investment opportunities with its competitors and the role of prey is assumed, the predation risk that a firm encounters is still not confirmable.

Lastly, their arguments about the relationship between interdependence of investment opportunities and corporate derivative hedges are based on the theoretical analysis of underinvestment in Froot et al. (1993). In this seminal work, derivative hedges help solve the underinvestment problem since it reduces the cash flow volatility that affects the cost of external financing. Haushalter et al. (2007) argue that derivative hedges are highly sought to mitigate the influence of underinvestment on a firm's survival when a firm's investment opportunities are interdependent with rivals. However, they ignore the impact of the interdependence of investment opportunities on the underinvestment issue, which could discourage derivative hedging.

36 The firm poor in cash discussed in Bolton and Scharfstein (1990) does not necessarily mean small amounts of cash holdings. "Poor in cash" indicates the limited ability to externally finance. Limited ability to externally finance because of the high sensitivity of refinancing decisions to a firm's performance determines the high predation risk the firm encounters.

Investment opportunities can be considered as potential investment projects with positive NPVs (Chi & Su, 2016; Haushalter et al., 2007; Yang & Zheng, 2017). Their values are determined by the likelihood that firms will exercise them optimally (Barclay & Smith, 1995; Krishnaswami et al., 1999; Myers, 1977). Interdependence of investment opportunities indicates the intensity of competition in exercising these investment opportunities. Competition in exercising investment opportunities could lead to either greater firm initial inputs or diluted future cash inflows, which decreases the value of investment opportunities in place or even causes investment opportunities to be abandoned. Shrunken investment opportunities weaken the influence of cash flow volatility on underinvestment (Froot et al., 1993). Therefore, it is not apparent that derivative hedging to solve the underinvestment problem must be strongly incentivised. Instead, using derivatives to time the market can possibly raise more cash funds, which could create competitive advantages in exercising interdependent investment opportunities (Mello & Ruckes, 2003; 2005).

In summary, the above discussion documents a different opinion on how derivative use could be affected by the interdependence of investment opportunities employed by Haushalter et al. (2007) as the proxy for predation risk. Interdependence of investment opportunities cannot differentiate firms encountering predation threat from firms that are expected to be the predators. Even if the degree of interdependence of investment opportunities indicates the intensity of the predation threat a firm could face, the predation risk to the firm that has interdependent investment opportunities with peers could still be low. According to the arguments in Bolton and Scharfstein (1990), only a cash poor firm will have high predation risk; a cash rich firm doesn’t. Furthermore, intensified interdependence of investment opportunities makes exercising interdependent investment opportunities more costly. In other words, it inevitably shrinks the value of exercising the investment opportunities that a firm being preyed upon has. Without having many valuable investment opportunities, the need to use derivatives to mitigate the underinvestment issue is expected to be discouraged. Taking into account the above arguments, the impact of the interdependence of investment opportunities on derivative hedges suggested in Haushalter et al. (2007) needs to be further investigated.

### 4.4.3 Verification of the independence of investment opportunity as a factor affecting corporate derivative use

Haushalter et al. (2007) claim that firms with more interdependence of investment opportunities are more likely to use derivatives to hedge against cash flow volatility. Dichotomous variables were employed by Haushalter et al. (2007) to represent the derivative hedge. Given that the dichotomous variables cannot reveal the extent of corporate derivative use, derivative holdings as continuous variables are more commonly employed in hedge and risk management studies (Borokhovich, Brunarski, Crutchley & Simkins, 2004; Gay & Nam, 1998; Guay & Kothari, 2003; Knopf et al., 2002). To verify Haushalter's et al. (2007) arguments, the explanatory power of interdependence of investment opportunities on derivative holdings is examined first.

Haushalter et al. (2007) focus on derivative hedges rather than specifically investigating selective hedging. Selective hedging is using derivatives to time the market to obtain extra returns (Glaum, 2002; Stulz, 1996). The timing and extent of derivative use are decided based on the manager's active market view (Brown et al., 2006; Loss, 2012). By conducting selective hedging behaviour, cash flow volatility because of the uncertainty of market movements is not necessarily mitigated, it could be enlarged. Therefore, the underinvestment problem as a consequence of uncontrolled cash flow volatility cannot be effectively solved by selective hedging. Haushlter et al. (2007) suggest a positive relationship between interdependence of investment opportunities and derivative hedging. As an inference, accordingly, if underinvestment brings greater concerns to a firm whose investment opportunities are more interdependent with competitors, the firm is expected to be less likely to conduct selective hedging. To further verify Haushalter et al.'s (2007) arguments indirectly, the effect of the interdependence of investment opportunities on selective hedging is tested.

### 4.4.4 Proxy variables for predation risk according to Haushalter (2008)

Haushalter et al. (2007) employ proxy variables of interdependence investment opportunities to represent predation risk. Haushalter et al.'s (2007) predation risk, focusing on the interdependence of investment opportunities, is different from the predation theory explained by Bolton and Scharfstein (1990). To verify how the predation risk argued in Haushalter et al. (2007) affects corporate derivative use, especially selective hedging, the proxy variables that were used to represent the interdependence of investment opportunities in past studies are used for further tests (Chi & Su, 2016; Haushalter et al., 2007)

#### *4.4.4.1 A measure of the covariance of firm growth opportunities with industry rivals (Corr)*

Given that a firm's share price is considered to mirror the present value of future cash flows, the company's stock price is more sensitive to its competitors if the firm shares more growth opportunities with its competitors (Chi & Su, 2016). Therefore, a firm's covariance of growth opportunity within the industry in which it operates is suggested as a proxy of the interdependence of investment opportunities (Chi & Su, 2016; Haushalter et al., 2007). The covariance of growth opportunity within the industry is calculated as the correlation of the firm's stock returns with the industry's stock returns (Haushalter et al., 2007; Parrino, 1997). We follow this method to regress the firm's monthly stock returns on both market returns and firms equally weighted industry returns. (Industry classification refers to the two-digit Standard Industrial Classification (SIC) codes.)

*4.4.4.2 A measure of similarity in business operations (K-L Distance)*

The capital-to-labour ratio, calculated as the net value of plant, property and equipment over the number of employees, indicates the production technology that determines the degree of production development in the industry (MacKay & Phillips, 2005). Closer to the industry mean capital-to-labour ratio represents more similar production technology captured by the firms in the industry, hence more similarity in business operations with competitors. Haushalter et al. (2007) suggest that the interdependence of investment opportunities is intensified as a result of higher similarity in business operations. Therefore, the absolute distance to the industry means the capital-to-labour ratio (K-L Distance) is used as a proxy of predation risk arising from the interdependence of investment opportunities (Haushalter et al., 2007). A negative sign is taken for variable K-L Distance for convenience of explanations, i.e., a higher value of K-L Distance represents a higher degree of interdependence of investment opportunities.

*4.4.4.3 A measure of industry structure (HHI & HHI4)*

A firm in a more concentrated industry has investment opportunities more interdependent with competitors (Haushalter et al., 2007). According to Haushalter et al.'s (2007) arguments, a firm with more interdependent investment opportunities faces a higher predation risk. Therefore, a measure of industry concentration is used to represent the predation risk in Haushalter et al. (2007). Measures of industry concentration are employed in this study to represent the degree of interdependence of investment opportunities (Haushalter et al., 2007; Valta, 2012). The degree of industry concentration is estimated using the Herfindahl-Hirschman Index (HHI) (Adam & Nain, 2013; DeFond & Park, 1999; Engel, Hayes & Wang, 2003). The HHI is calculated by summing the squares of market shares for all firms in the same industry. A lower value of the HHI indicates more intensive market competition.

The value of HHI relies on the number of firms and the variance of market shares for the firms in the same industry. Many studies on the issue of product market competition calculate HHI by summing the squares of market shares based on the total sales or revenue disclosed in the Compustat database (Giroud & Mueller, 2010; Hou & Robinson, 2006; Tirole, 1988; Valta, 2012). Compustat is criticised to some extent because it does not provide sales information for private companies. Though it may not completely reflect the variance of market share, HHI based on the Compustat database is far better than HHI sourced from the US Census Bureau to represent the industry structure in our study[37]. Hence, we use the 6-digit SIC HHI sourced from the Compustat database to measure industry concentration. Consistent with Haushalter et al. (2007), the concentration ratio based on the biggest four firms in the industry (HHI4) is also estimated.

*4.4.4.4 A measure of product fluidity (Fluidity)*

Hoberg et al. (2014) developed a text-based measure of product market threats, Fluidity, which captures word changes in competitors' disclosures relative to the firm's business description in the 10-k filings. Fluidity estimated by Hoberg et al. (2014) indicates how intensively the product markets change each year. Following Haushalter et al.'s (2007) arguments that investments are

37 Considering the weakness of HHI based on the Compustat database, some studies collect the data for HHI from the Census of Manufacturers by the US Census Bureau (Fresard, 2010; Grullon & Michaely, 2014; MacKay & Phillips, 2005). However, this HHI could also not be convincingly used for product market competition research because of its weakness. First, it calculates only the 50 largest firms in an industry. This calculation method reduces the number of firms in an industry and biases the variance of market share since only the largest companies are considered. Secondly, it can provide the HHI only for industries in the manufacturing sector (Grullon & Michaely, 2014); market competition in non-manufacturing industries cannot be measured. Thirdly, the concentration measures are issued only every five years which means the intensity of product market competition must be assumed to be maintained constantly. This is not realistic nor can it be used for short-term studies since there is no time-variant for product market competition. In addition, the latest census data are for 2007. Using lagged data for this study which samples from 2009 to 2014 can heavily bias the results.

more interdependent because of higher similarity in business operations, this dynamic measure of product similarity has been used in past studies to represent the competitive threat and the intensity of interdependence of investment opportunities (Chi & Su, 2016; Morellec et al., 2014).

### 4.4.5 The endogenous factor of industry structure

Industry structure proxied by HHI or HHI4 is widely used to represent the level of market power (Akdogu & MacKay, 2008; Ghosal, 1995; Ghosal & Lougani, 1996; Klepsch, 2016; Valta, 2012). Industry structure is also suggested as positively associated with predation threat (Grullon & Michaely, 2014; Kovenock & Philips, 1997; Valta, 2012; Zingales, 1998). Market power differs from predation threat although both are derived from market competition. The two are investigated separately in past studies for different issues of interest. For example, market power and the predatory threat from strategical investing are separately investigated in the literature about the effect of competition on option value of waiting to the investments (Cooper & Ejarque, 2001; Majd & Pindyck, 1987; McDonald & Siegel, 1986)[38]. Valta (2012) analysed the effect of competition on the cost of bank debt by separating predation threat from market power, although both are presented by an identical measure of industry concentration.

In addition to the market power and predation threat, the level of industry concentration can also indicate the difference in alleviating information asymmetry by competition. Allen and Gale (2000) argue that competition provides an effective corporate governance mechanism that is even better than corporate control and institutional monitoring. Information asymmetry is reduced by product market competition so that transparency of the firm's performance to investors is improved (Holmstrom, 1982; Shleifer, 1985). Anecdotal evidence shows that market competition improves

38 Where strategic interaction is concerned, the threat from strategic investing as a manner of predatory action is argued to be more prevalent for firms operatinhg in more concentrated industries (Ghosal & Loungani, 1996; Klepsch, 2016; Mello & Wang, 2012).

operating efficiency and reduces agency costs (Hart, 1983; Nalebuff & Stiglitz, 1983; Shleifer & Vishny, 1997).

When it comes to corporate derivative use, stories that explain the effects of industry structure unfolded differently. Considering market power as a “natural hedge”, firms in more concentrated industries have flexibility in passing off the cost shock to the output price. Hence, they are less incentivised to hedge the risk exposure by using derivatives (Allayannis & Ihrig, 2001; Allayannis & Weston, 1999, Mello & Ruckes, 2005; Mello & Wang, 2012). Past studies also regard the degree of industry concentration as an indicator of predation threat. Grullon and Michaely (2014) argue that there are no gains for predators to drive other firms out of the market if the competitors after predatory actions are still numerous. Besides, high barriers to entry in concentrated industries allow predators adequate time for recovery from the losses from predatory actions (Kovenock & Philips, 1997; Zingales, 1998). These studies highlight the competitive environment within which firms can take predatory action. However, a competitive environment does not necessarily raise the predation risk that a firm could encounter. In the spirit of Bolton and Scharfstein (1990), predation risk is the risk of being driven out of the market because of limited capacity to external financing. As argued by Bolton and Scharfstein (1990), concerns of agency problems because of information asymmetry constrain a firm’s ability to external financing, which induces a rival’s predatory actions. Therefore, *ceteris paribus*, firms in more concentrated industries that lack a mechanism to mitigate the information asymmetry by competition encounter higher predation risk. In addition, as claimed by Haushalter et al. (2007), firms in more concentrated industries have investment opportunities more interdependent with competitors. The degree of interdependence of investment opportunities indicates the intensity of predation risk that a firm could encounter (Haushalter et al., 2007). By employing measures of industry concentration as proxies for predation risk, Haushalter et al. (2007) find that firms in more concentrated industries are more likely to use derivatives to hedge. Haushalter et al.'s (2007) arguments are disputable in this study. This difference induces the further analysis of the endogeneity of industry concentration on the issue of corporate derivative use, specifically selective hedging behaviour.

As discussed above, corporate selective hedging can be affected by industry structure as the result of either indicated market power or embedded predation risk. To investigate if predation risk can explain the positive relationship between industry structure and corporate selective hedging, the factors of market power and predation risk are identified from industry structure. As far as predation risk is concerned, predation risk arising from the interdependence of investment opportunities argued in Haushalter et al. (2007) and predation risk because of information asymmetry discussed in Bolton and Scharfstein (1990) are differentiated.

To test what leads to the potential relationship between industry structure and corporate selective hedging, two-stage models are applied. The interdependence of investment opportunities is initially teased out by regressing the measure of industry structure (HHI) on the proxy variables of market power and predation risk suggested in Bolton and Scharfstein (1990). At the second stage, the standard deviation of residual derivative holdings is regressed on the residuals estimated at the first stage. Given that three proxy variables are used to represent predation risk in this study, the measures of industry structure are regressed on them separately and jointly with control of the market power at the first stage. A similar procedure is conducted when industry structure is proxied by HHI4.

To further test if the predation risk because of information asymmetry can explain the effect of industry structure on corporate selective hedging, the two-stage model is again employed. At the first stage, the measures of industry structure are regressed on proxy variables of market power and interdependence of investment opportunities. By focusing on the estimated residuals from the models at the first stage, the factors market power and interdependence of investment opportunities are excluded from the measure of industry structure. At the second stage, the standard deviation of residual derivative holdings is regressed on the estimated residuals from the models at the first stage. A similar procedure is also conducted when industry structure is proxied by HHI4.

Pursuant to the literature on industrial organisation, the factor market power is proxied by price-cost margin (Guiso & Parigi, 1999; Mello & Wang, 2012). Price-cost margin (PCM) measures the extent of product substitutability since it is defined as the negative reciprocal of the price elasticity of demand (Karuna, 2007; Nevo, 2001). Hence, a lower level of product substitutability indicates greater power a firm has to influence the market. The price-cost margin is calculated as operating income before depreciation divided by total sales (Morellec et al., 2014). To make the price-cost margin comparably reflect the market power for the firms in different industries, the excess price-cost margin (EPCM) is utilised by calculating the difference of a firm's PCM to the industry average PCM (Gaspar & Massa, 2006; Morellec et al., 2014; Nickell, 1996). The proxy variables, i.e., Corr, K-L Distance, and Fluidity, estimated by Hoberg et al. (2014), are used to represent the interdependence of investment opportunities (Chi & Su, 2016; Haushalter et al., 2007). Three proxy variables, MTB, Sd_ocf, and Dm3, are used to test how the predation risk explained in Bolton and Sharfstein (1990) affects corporate selective hedging behaviour.

## 4.5 Proxy Variables Used to Represent Board Gender Diversity

In this study, three proxies are used to represent board gender diversity. They are the number of female directors (Hutchinson et al., 2015; Sila et al., 2016), the percentage of female directors on the board (Baixauli-Soler et al., 2015; Levi et al., 2014) and the Blau's (1977) index (Campbell &

Minguez-Vera, 2008; He & Huang, 2011; Joecks et al., 2013). Blau's (1977) index is a measure of diversity for categorical variables. When gender diversity is measured, Blau's (1977) index for gender diversity is calculated as $1 - \sum_{c=1}^{2} G_c^2 . G_c$, which indicates the fraction of female/male directors on the board. The maximum value of Blau's (1977) index for gender diversity is 0.5, i.e., half of all board members are female. The minimum value of Blau's (1977) index for gender diversity is 0 when homogeneity of board members by gender is established.

Past studies focus on the phenomenon of tokenism and investigate the potential critical mass to explain corporate decision making and economic outcomes (Bear et al., 2010; Cook & Glass, 2015; Joecks et al., 2013; Kramer et al., 2006, Liu et al., 2014; Melero, 2011; Schwartz-Ziv, 2015). Most follow Kanter's (1977a, b) method to categorise the participation of female directors on boards as uniform, skewed, tilted and balanced board gender composition. Uniform boards are boards on which all directors are male. Whether the board is skewed or tilted is determined by the proportion of female directors. Skewed boards are the boards with up to 20% of female directors and tilted boards consist of 20%-40% female directors. When the proportion of female directors on a board is in the range of 40% to 60%, it is a balanced board according to Kanter's (1977a, b) categorisation. The critical mass of board gender diversity is also discussed with respect to the number of female directors on boards. Prior studies argue that "three" is the magic number; firms fully benefit from board gender diversity only if the number of female directors is three or more (Kramer et al., 2006; Liu, Wei & Xie, 2014; Schwartz-Ziv, 2015; Torchia et al., 2011). Therefore, whether a tilted board or three or more female directors on a board affects corporate selective hedging behaviour materially is tested. Two series of categorical variables are introduced. Board gender composition is initially described according to Kanter's (1977a, b) categories. Boards are also categorised into four groups; which include the boards with either 0, 1, 2, or 3 and more female directors.

## 4.6 Control Variables

The following determinants of corporate hedging policies analysed in previous studies are controlled in this study: firm size (Géczy et al., 1997; Mian, 1996; Tufano, 1996), debts-to-assets ratio (Bartram et al., 2009; Gay & Nam, 1998; Haushalter, 2000), institutional shareholdings (Haushalter, 2000; Knopf et al, 2002), tax loss carried forward (Gay & Nam, 1998; Géczy et al., 1997; Graham & Rogers, 2002), market-to-book value of assets (Knopf et al., 2002; Mian, 1996; Nance et al., 1993), and total cash compensation of CEO (Guay & Kothari, 2003; Knopf et al., 2002). Risk exposure is measured in prior studies by the amount of foreign sales (Bartram et al., 2009; Beber & Febbri, 2012; Kim et al., 2006). However, foreign currency risk exposure is derived not only from sales but also from investment expenditure (Froot et al., 1993) and is affected by market power and rivals' hedging behaviour (Adam et al., 2007; Allayannis & Ihrig, 2001; Mello & Wang, 2012). Hence, foreign currency risk exposure is proxied in this study by foreign operating income (Bartram et al., 2009; Fok, Carroll & Chiou, 1997; Géczy et al., 1997).

Past studies argue that market power provides firms flexibility in strategic pricing that can pass off the cost shock to the output price (Allayannis & Ihrig, 2001; Allayannis &Weston, 1999; Mello & Wang, 2012). Therefore, firms with market power do not have the incentive to use derivatives to hedge against cost shocks arising from instability in the foreign currency market. Using market power as a natural hedge to mitigate the downside risk enhances the probability of selective hedges to obtain extra returns. In this study, the price-cost margin (PCM) is used to represent the degree of market power (Allayannis & Weston, 1999). The price-cost margin is calculated as operating income before depreciation divided by total sales (Morellec et al., 2014). To make the price-cost margin reflect the market power for firms in different industries, the excess price-cost margin (EPCM) is used by calculating the difference of the firm's PCM to the industry average PCM (Gaspar & Massa, 2006; Morellec et al., 2014; Nickell, 1996).

According to Stulz (1996), selective hedging occurs under two conditions. One is the manager's belief in holding private information of market movements. A manager's belief in private market information is not observable. Stulz (1996) argues that firms could obtain private information on commodity price movements since they are the main market participants and dominate the market to some extent. However, the foreign currency market is enormous so no market participant can dominate it. Therefore, studies claim that the manager's belief in private information is derived from the manger's overconfidence or behavioural bias (Adam et al., 2015; Beber & Fabbri, 2012). In this study, apart from the CEO's cash compensation, the CEO's personal characteristics such as age, tenure and gender, are controlled.

The second condition to take the selective hedges is the adequate financial strength a firm has (Stulz, 1996). Without adequate financial strength, taking the risk of selective hedging could make the firm intolerant of potential losses. Though adequate financial strength is discussed as a condition in Stulz (1996), it doesn't explain the incentive to selectively hedge when firms are financially strong. After all, the purpose of selective hedging is to obtain extra returns. Taking into account the purpose of selective hedging, Stulz (1996) admits that firms in financial distress could also hedge selectively for extra returns. In this study, two variables, cash holdings and cash dividend payments are used to represent the degree of financial strength. It is expected that the total amount of cash holdings, which indicates the financial strength, is negatively associated with the time-series variation of residual derivative holdings. In addition, larger cash dividends indicate stronger financial strength. A financially weak firm is unlikely to pay large amounts of cash dividends.

To exclude other board factors from the impact of board gender diversity on corporate selective hedging behaviour, additional board-level factors are controlled. Appointed female directors could result in an enlarged board. To differentiate the potential impact of board size on corporate selective hedging behaviour, board size is controlled (Berger et al., 2014; Levi et al., 2014; Sila et al., 2016). Studies have found that appointed female directors are young and less experienced (Berger et al., 2014; Croson & Gneezy, 2009); without controlling this factor, how gender diversity affects corporate selective hedging behaviour cannot be clearly identified. Therefore, the directors' age and average tenure are controlled (Berger et al., 2014). The fraction of independent directors on boards is also controlled (Levi et al., 2014; Sila et al., 2016). Selective hedging needs professional knowledge of risk management, so the percentage of directors who are the financial experts is controlled. Group bias introduced in social identity theory could be generated not only by gender but also by other demographic attributes such as the age, tenure, and ethnicity. Conflicts in decision-making process because of self-identity or self-categorisation in age, tenure or ethnicity could also affect a firm's decisions on derivative use. Therefore, the standard deviation of board directors' ages, the standard deviation of board directors' tenure, and a dummy variable indicating racial minority are also controlled for robustness tests.

## 4.7 Data Collection

In this study, the year-end gross notional amount of derivatives used to mitigate foreign currency risk is required. However, to the best of my knowledge, no database currently provides this information. Therefore, the procedure applied by Beber and Fabbri (2012) and Graham and Rogers (2002) is followed. The data were manually collected from the 10-K files in EDGAR. The 10-K files were searched for the following keywords: 'risk management', 'financial instrument', 'derivative', 'hedg' (in order to capture hedge, hedges, hedging, hedged, etc.), 'forward', 'future' and 'option' to find the relevant paragraphs. When a firm claimed the use of derivatives but did not provide detailed disclosure in the 10-K file, the full annual report was searched. The gross notional amount of derivatives deflated by total assets (Beber & Fabbri, 2012; Guay & Kothari, 2003; Knopf et al., 2002) is used as the dependent variable in the baseline regressions.

All firms' financial characteristics were sourced from the Compustat Database. To estimate the correlation of a firm's stock returns with the industry's stock returns, all data of stock returns were collected from the Center for Research in Security Prices (CRSP). The product fluidity measure was collected from Hoberg and Phillips data library[39]. CEO's characteristics were sourced from the Compustat-Execucomp Database. Appendix 1 defines all variables used in this study.

## 4.8 Summary

This chapter provides an overview of the research design. Firms in S&P 500 using derivatives to manage foreign currency risk from 2009 to 2014 comprise the sample. Beber and Fabbri's (2012) model is employed and corporate selective hedging behaviour is identified by focusing on the standard deviation of residual derivative holdings on fundamental characteristics. Different proxy variables are used to represent predation risk and board gender diversity. After the introduction of the control variables, data sources are introduced. Based on the described research design, the test results and discussion are provided in the next chapter.

39 See http://hobergphillips.usc.edu/.

# CHAPTER FIVE: RESULTS AND DISCUSSIONS

## 5.1 Introduction

This chapter provides the test results for the impact of competitive environments on corporate selective hedging behaviour. Predation risk as a result of product market competition and board gender diversity are the focus. The descriptive statistics of the variables and correlation analysis are initially presented in sections 5.2 and 5.3, respectively. Section 5.4 reports the determinants of the derivatives used to hedge foreign currency risk. How predation risk affects corporate selective hedging behaviour is discussed in section 5.5. In section 5.6, the effect of board gender diversity is analysed. The findings are summarised in section 5.7. Figure 1 (page 78) shows how the main tabulated test results in this chapter are linked to support discussion of the developed hypotheses.

## 5.2 Descriptive Statistics

Table 5.1 summarises the statistics on derivative use. Panel A shows the summary statistics for full firm-year observations; the break-down of derivative use by sample years is reported in Panel B. Unbalanced panel data are employed since firms that did not use derivatives in the early years of the sample period are retained (Bebber & Fabbri, 2012; Guay, 1999). Panel C summarises the notional amount of derivative use for firms clustered by the 2-digit GIC industry codes. Firms in the information technology, healthcare, and telecommunication services industries enter into more derivative transactions against foreign currency risk whereas firms in the energy and consumer discretionary sectors use relatively fewer derivatives.

**Figure 5.1: The Relationships Between the Tabulated Test Results and the Developed Hypotheses**

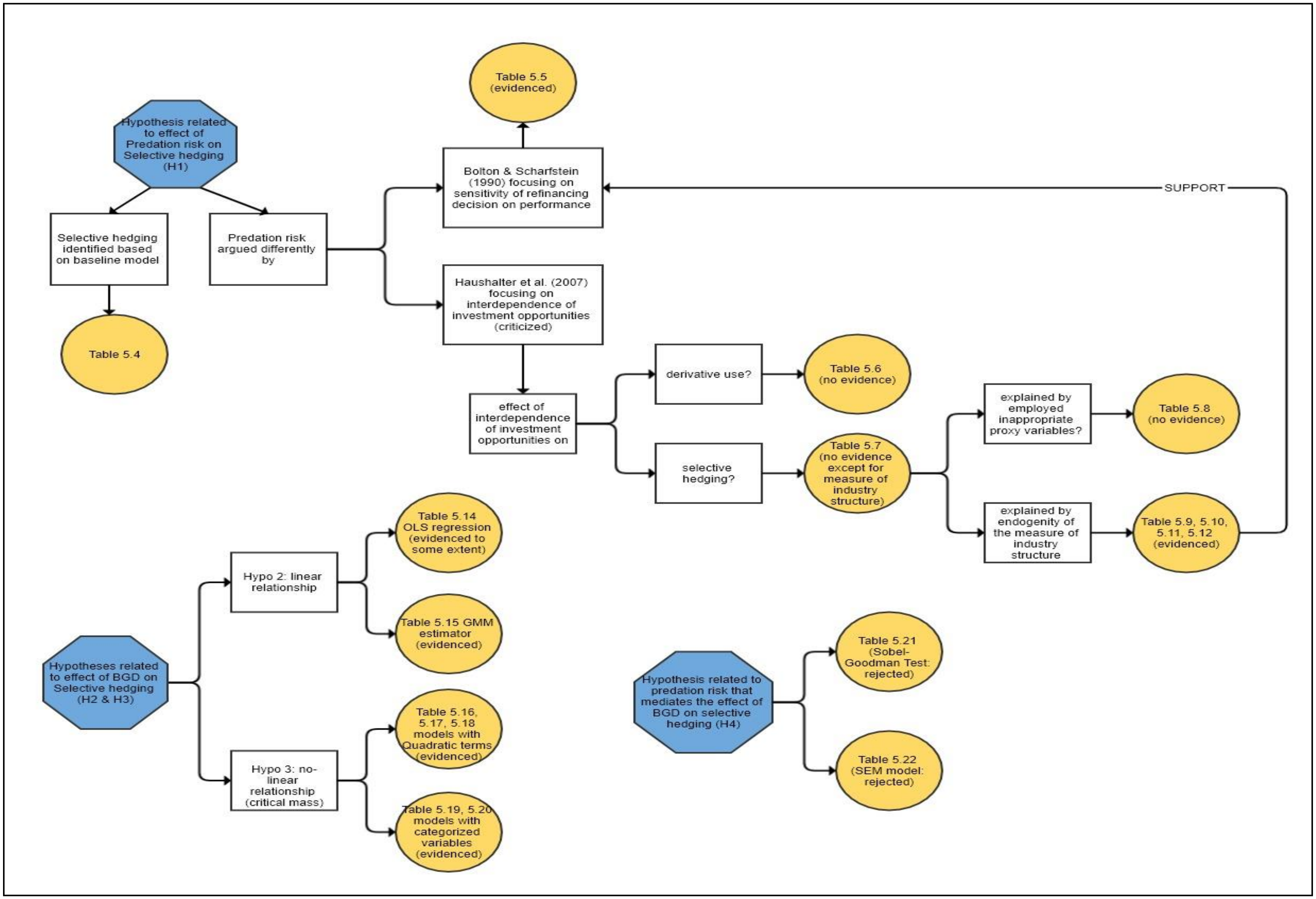

**Table 5.1: Summary of the Use of Foreign Currency Derivatives**

This table shows the summary statistics of currency derivative holdings. The currency derivative holdings are gross notional amounts of instruments at year's end. The data are manually collected from 10-k filings and annual reports. Panel A shows the summary statistics for full firm-year observations. The break-down of derivative use by sample years is reported in panel B. Panel C summarises the notional amounts of derivative use for firms clustered by the 2-digit GIC industry codes.

| FX Derivatives Use | Obs. | Mean | Std. Dev. | Min | p25 | p50 | p75 | Max |
|---|---|---|---|---|---|---|---|---|
| **Panel A: Full sample firms** | | | | | | | | |
| | 1312 | 2975.58 | 7033.77 | 0.00 | 184.75 | 643.25 | 2009.00 | 81455.00 |
| **Panel B: By years** | | | | | | | | |
| 2009 | 201 | 2334.88 | 5703.68 | 0.00 | 114.10 | 510.40 | 1900.00 | 50000.00 |
| 2010 | 213 | 2610.76 | 6087.22 | 0.00 | 147.00 | 520.00 | 1800.00 | 47600.00 |
| 2011 | 218 | 2886.50 | 6702.06 | 0.00 | 198.00 | 644.00 | 1957.00 | 48100.00 |
| 2012 | 223 | 3245.10 | 7589.74 | 0.00 | 225.00 | 685.00 | 2515.00 | 55373.00 |
| 2013 | 229 | 3180.32 | 7191.03 | 0.00 | 205.16 | 686.00 | 2000.00 | 51144.00 |
| 2014 | 228 | 3497.16 | 8388.35 | 0.00 | 231.85 | 670.45 | 2434.50 | 81455.00 |
| **Panel C: By industry (2-digit GIC)** | | | | | | | | |
| Energy (10) | 102 | 1036.83 | 1781.14 | 0.00 | 42.00 | 286.50 | 1002.00 | 7600.00 |
| Materials (15) | 123 | 2353.57 | 3968.63 | 0.00 | 442.00 | 1000.00 | 2000.00 | 20530.00 |
| Industrial (20) | 200 | 2457.15 | 5586.97 | 0.00 | 225.00 | 612.90 | 2573.50 | 43446.00 |
| Consumer Discretionary (25) | 245 | 1693.35 | 4267.65 | 0.00 | 200.40 | 556.00 | 1118.00 | 32867.00 |
| Consumer Staples (30) | 161 | 2722.92 | 4671.74 | 0.00 | 195.00 | 930.20 | 2500.00 | 23553.00 |
| Health Care (35) | 191 | 4673.51 | 9599.78 | 0.00 | 205.16 | 925.00 | 3873.00 | 50000.00 |
| Information Technology (45) | 272 | 4332.97 | 10158.06 | 0.00 | 152.00 | 540.05 | 2402.95 | 81455.00 |
| Telecommunication Services (50) | 18 | 5156.72 | 7524.72 | 0.00 | 0.00 | 857.00 | 7795.00 | 26505.00 |

The summary statistics on all variables used to investigate the impact of predation risk and board gender diversity on corporate selective hedging behaviour are presented in Table 5.2. The mean of deflated gross notional amounts of foreign currency derivatives (de_FX) is 0.1 and the average standard deviation of residual derivative holdings (sd_res) is 0.03. Compared with the mean, the maximum standard deviation of residual derivative holdings is much greater (0.41). This indicates that some firms use derivatives dramatically differently in some periods, which can hardly be explained by fundamental derivative hedging theories. Three proxy variables are used to represent predation risk, the mechanisms of which are explained in section 4.4.1. The market to book ratio of assets (MTB) is 2.23 and the mean of the standard deviation of operating cash flows is 772.20. The mean of Dm3 (the percentage of debts matured in no less than 3 years) is 0.69. To test the robustness, the percentage of debts matured in no less than 1, 2, 4, and 5 years are also employed. At any time, the debts matured in no less than t years covers the debts matured in year t and later years. As expected, the means of these variables (Dmt) are orderly reduced. In addition to the proxy variables used by Haushalter et al. (2007), the Fluidity measure (Fluidity) is employed to represent the interdependence of investment opportunities. The summary statistics of these variables are shown in Table 5.2. Variable HHI4 is estimated based on the largest four firms in the industry. Though both HHI and HHI4 represent the degree of industry concentration, the means of the two variables are very different. The mean of HHI4 (0.30) is approximately three times the mean of HHI (0.09).

**Table 5.2 Summary Statistics of the Investigated Variables**

| Variable | Obs | Mean | Std. | Min | Max | Variable | Obs | Mean | Std. | Min | Max |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **Dependent Variables:** | | | | | | **Independent Variables** | | | | | |
| de_FX | 1312 | 0.10 | 0.20 | 0.00 | 3.72 | **CEO Factors** | | | | | |
| sd_res | 227 | 0.03 | 0.04 | 0.00 | 0.41 | CEO_cashcomp | 1312 | 7.00 | 1.09 | 0.00 | 10.37 |
| | | | | | | CEO_age | 1312 | 56.40 | 6.06 | 36.00 | 83.00 |
| **Independent variables:** | | | | | | CEO_tenure | 1312 | 5.97 | 5.54 | 0.00 | 36.00 |
| **Variables related to predation risk** | | | | | | CEO_gender | 1312 | 0.04 | 0.2 | 0.00 | 1.00 |
| MTB | 1312 | 2.23 | 1.26 | 0.75 | 12.84 | | | | | | |
| Dm1 | 1195 | 0.85 | 0.19 | 0.00 | 1.00 | **Board Factors** | | | | | |
| Dm2 | 1096 | 0.77 | 0.22 | 0.00 | 1.00 | Board_size | 1243 | 10.66 | 1.88 | 5.00 | 19.00 |
| Dm3 | 1069 | 0.69 | 0.24 | 0.00 | 1.00 | Board_age | 1243 | 62.49 | 3.16 | 47.77 | 72.21 |
| Dm4 | 1032 | 0.60 | 0.25 | 0.00 | 1.00 | Board_tenure | 1243 | 8.25 | 2.90 | 0.45 | 19.42 |
| Dm5 | 991 | 0.51 | 0.25 | 0.00 | 1.00 | Board_indep | 1243 | 0.82 | 0.10 | 0.00 | 1.00 |
| Sd_ocf | 1312 | 772.20 | 1560.70 | 20.59 | 20164.00 | Board_outside | 1243 | 12.18 | 4.96 | 0.00 | 31.00 |
| Corr | 1305 | 0.75 | 1.39 | -4.61 | 7.68 | | | | | | |
| K-L Distance | 1312 | -0.09 | 0.13 | -0.88 | 0.00 | **Board diversity** | | | | | |
| Fluidity | 1286 | 5.83 | 2.91 | 0.63 | 21.59 | B_sd_age | 1243 | 7.12 | 2.01 | 2.36 | 14.82 |
| HHI | 1312 | 0.09 | 0.06 | 0.03 | 0.35 | B_sd_tenure | 1243 | 5.93 | 3.03 | 0.00 | 19.33 |
| HHI4 | 1312 | 0.30 | 0.05 | 0.25 | 0.57 | B_sd_cashcomp | 1311 | 32.05 | 30.57 | 0.00 | 680.25 |
| | | | | | | B_d_raceminority | 1243 | 0.75 | 0.43 | 0.00 | 1.00 |
| **Variables related to board gender diversity** | | | | | | B_pct_fi_expert | 1243 | 0.23 | 0.13 | 0.00 | 0.60 |
| B_d_female | 1243 | 0.92 | 0.27 | 0.00 | 1.00 | | | | | | |
| B_female | 1243 | 1.88 | 1.09 | 0.00 | 7.00 | **Firm Factors** | | | | | |
| B_pct_female | 1243 | 0.17 | 0.09 | 0.00 | 0.60 | MTB | 1312 | 2.23 | 1.26 | 0.75 | 12.84 |
| B_blau_index | 1243 | 0.27 | 0.12 | 0.00 | 0.50 | Fincome | 1312 | 0.65 | 3.02 | -18.31 | 73.00 |
| uniform_board | 1243 | 0.08 | 0.27 | 0.00 | 1.00 | Debt | 1312 | 0.24 | 0.15 | 0.00 | 0.89 |
| skewed_board | 1243 | 0.53 | 0.50 | 0.00 | 1.00 | Firmsize | 1312 | 10.01 | 1.06 | 7.24 | 13.35 |
| tilted_board | 1243 | 0.37 | 0.48 | 0.00 | 1.00 | Institutional | 1312 | 11.68 | 10.57 | 0.00 | 63.00 |
| balanced_board | 1243 | 0.02 | 0.14 | 0.00 | 1.00 | TaxlossCF | 1312 | 3.96 | 3.26 | 0.00 | 10.54 |
| fedir_0 | 1243 | 0.08 | 0.27 | 0.00 | 1.00 | CapEx | 1312 | 0.02 | 0.03 | 0.00 | 0.21 |
| fedir_1 | 1243 | 0.28 | 0.45 | 0.00 | 1.00 | CashDiv | 1312 | 0.02 | 0.03 | 0.00 | 0.29 |
| fedir_2 | 1243 | 0.40 | 0.49 | 0.00 | 1.00 | Cashholdings | 1312 | 0.16 | 0.14 | 0.00 | 0.84 |
| fedir_3 | 1243 | 0.23 | 0.42 | 0.00 | 1.00 | | | | | | |

As reported in Table 5.2, 92% of sample firms during the sample period have female participation on boards. The number of female directors on averages is 1.88 and the mean proportion of female directors is 17%. Given that the mean board size 10.66, the average number of female directors is rounded up to 2 (10.66*0.17%). The mean Blau's (1977) index for gender is 0.27. Most sample observations are firms with boards which are categorised as either skewed (53%) or tilted (37%) boards. Focusing on the number of female directors on boards, 23% of the sample firm-year observations have boards with three or more female directors. The percentage of boards with one and two female directors are 28% and 40%, respectively. Taking board members as a whole, the average age of the board members is 62.5 years (standard deviation 7.12), the average tenure is 8.25 years (standard deviation 5.93), and 82% of board directors are independent. The mean total holdings of outside directorships is 12.18. The standard deviation of board members' cash compensation is 32.05. Seventy-five per cent of the sampled firms have an ethnic minority of directors on the board. On average, the percentage of the directors who are financial experts is 23%.

## 5.3 Correlation Analysis of the Variables

Correlations of the variables are given in Table 5.3. Panel A indicates the correlation among the variables used in the baseline model and Panel B indicates the correlation among the variables used in the second stage regressions. For each firm, the mean values of all variables in time series are shown in Panel B. The variable Firmsize is positively correlated with variables Board_size and Board_outside. The correlations are 0.40. Variable Board_size is positively correlated with variable Board_outside (correlation = 0.58). These positive correlations indicate that board size is larger for larger firms. It is expected that there would be more board outside connections in firms with larger boards. In addition, the correlation between variables MTB and Cashholdings is 0.50, which implies that more cash funds are accumulated in the firms that have more investment opportunities. Though the P-values above are relatively high, there is no strong evidence to document the multicollinearity.

In Panel C Table 5.3, correlations among the proxy variables representing predation risk according to the arguments by Bolton and Scharfstein (1990) are reported. The market-to-book ratio of the assets is negatively correlated with all variables that represent the percentage of debt maturity. However, the standard deviation of operating cash flows within sample years is not significantly associated with the market-to-book ratio of the assets and is correlated only with the variables of the percentage of debt maturity no less than 4 and 5 years. As expected, all variables of the percentage of debt maturity are highly correlated, with coefficients estimated in the range 0.75 to 0.92. Panel D presents the correlations among the variables that indicate the degree of interdependence of investment opportunities. The variable of K-L Distance is negatively associated with HHI, HHI4 and the measure of product market fluidity estimated by Hoberg et al. (2014). Further, HHI4 is positively correlated with HHI but it is negatively associated with the measure of product market fluidity. Interestingly, none of these measures is correlated with the variable Corr. Panel E presents the correlations of proxy variables that indicate board gender composition. As shown in Panel E, three proxy variables, B_female, B_pct_female, and B_blau_index are highly correlated.

**Table 5.3 Correlations of Variables**

Correlations of the variables employed in the baseline and residual models. This table shows correlations of independent variables employed in two-stage model testing. Panel A shows the correlations between fundamental financial characteristics that are used to explain corporate derivative use. Panel B shows the correlations of control variables that represent the factors at different levels that possibly affect corporate selective hedging behaviour. Panels C and D show the correlations of proxy variables that represent both predation risk explained in Bolton and Scharfstein (1990) and the interdependence of investment opportunities analysed in Haushalter et al. (2007). Panel E shows the correlations of variables that represent board gender composition. All variables shown in Table 5.3 are defined in Appendix 1. Figures in bold indicate significant correlations at 1% level.

| **Panel A: Baseline Model** | | **1** | **2** | **3** | **4** | **5** | **6** | **7** |
|---|---|---|---|---|---|---|---|---|
| 1 | MTB | 1.00 | | | | | | |
| 2 | Fincome | 0.04 | 1.00 | | | | | |
| 3 | Debt | **-0.12** | -0.06 | 1.00 | | | | |
| 4 | Firmsize | 0.04 | 0.04 | 0.06 | 1.00 | | | |
| 5 | Institutional | **0.12** | -0.03 | 0.01 | **-0.33** | 1.00 | | |
| 6 | TaxlossCF | -0.03 | 0.05 | 0.01 | -0.02 | -0.05 | 1.00 | |
| 7 | CEO_cashcomp | **-0.16** | -0.01 | **0.15** | **0.08** | **-0.12** | 0.04 | 1.00 |

| **Panel B: Residual Model** | | **1** | **2** | **3** | **4** | **5** | **6** | **7** | **8** | **9** | **10** | **11** | **12** | **13** | **14** | **15** | **16** | **17** |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | MTB | 1.00 | | | | | | | | | | | | | | | | |
| 2 | Fincome | 0.06 | 1.00 | | | | | | | | | | | | | | | |
| 3 | Debt | **-0.14** | **-0.16** | 1.00 | | | | | | | | | | | | | | |
| 4 | Firmsize | -0.03 | 0.05 | 0.04 | 1.00 | | | | | | | | | | | | | |
| 5 | Institutional | **0.15** | **-0.07** | 0.00 | **-0.39** | 1.00 | | | | | | | | | | | | |
| 6 | TaxlossCF | -0.05 | 0.06 | -0.01 | -0.06 | -0.03 | 1.00 | | | | | | | | | | | |
| 7 | CEO_cashcomp | **-0.21** | -0.02 | **0.17** | **0.08** | **-0.16** | 0.06 | 1.00 | | | | | | | | | | |
| 8 | CEO_age | **-0.13** | -0.05 | **0.14** | **0.14** | -0.05 | -0.01 | **0.18** | 1.00 | | | | | | | | | |
| 9 | CEO_tenure | **0.11** | -0.02 | **-0.08** | 0.05 | 0.06 | -0.02 | **-0.11** | **0.34** | 1.00 | | | | | | | | |
| 10 | CEO_gender | -0.06 | **-0.09** | **0.09** | **0.09** | 0.00 | 0.05 | 0.02 | **-0.08** | **-0.12** | 1.00 | | | | | | | |
| 11 | Board_size | **-0.27** | 0.03 | **0.18** | **0.40** | **-0.09** | -0.02 | **0.22** | **0.17** | -0.02 | 0.07 | 1.00 | | | | | | |
| 12 | Board_age | **-0.09** | **-0.16** | **0.12** | **0.08** | -0.05 | -0.06 | **0.14** | **0.28** | **0.08** | **-0.07** | **0.13** | 1.00 | | | | | |
| 13 | Board_tenure | 0.02 | 0.04 | **-0.08** | -0.02 | **0.08** | -0.03 | **-0.12** | **0.13** | **0.39** | **-0.16** | 0.03 | **0.29** | 1.00 | | | | |
| 14 | Board_indep | **-0.14** | 0.05 | 0.05 | **0.09** | **-0.26** | 0.05 | **0.08** | 0.02 | **-0.14** | **0.12** | -0.03 | **0.12** | **-0.09** | 1.00 | | | |
| 15 | Board_outside | **-0.29** | 0.03 | **0.23** | **0.40** | **-0.20** | 0.05 | **0.29** | **0.11** | **-0.09** | 0.06 | **0.58** | **0.12** | **-0.20** | **0.20** | 1.00 | | |
| 16 | CashDiv | **0.20** | 0.01 | **0.21** | **0.21** | -0.05 | **-0.13** | **0.12** | **0.10** | **-0.09** | 0.04 | **0.18** | 0.05 | 0.01 | 0.03 | **0.11** | 1.00 | |
| 17 | Cashholdings | **0.50** | **0.10** | **-0.35** | 0.05 | **0.09** | 0.06 | **-0.33** | **-0.15** | **0.10** | **-0.10** | **-0.34** | **-0.08** | **0.15** | **-0.14** | **-0.28** | -0.02 | 1.00 |

Table 5.3 Correlations of Variables continued on next page

**Table 5.3 Correlations of Variables continued**

| **Panel C: Predation risk related variables** | | **1** | **2** | **3** | **4** | **5** | **6** | **7** |
|---|---|---|---|---|---|---|---|---|
| **1** | MTB | 1.00 | | | | | | |
| **2** | Sd_ocf | -0.05 | 1.00 | | | | | |
| **3** | Dm1 | **-0.17** | 0.03 | 1.00 | | | | |
| **4** | Dm2 | **-0.18** | 0.04 | **0.92** | 1.00 | | | |
| **5** | Dm3 | **-0.17** | 0.04 | **0.85** | **0.92** | 1.00 | | |
| **6** | Dm4 | **-0.18** | **0.06** | **0.78** | **0.85** | **0.91** | 1.00 | |
| **7** | Dm5 | **-0.21** | **0.06** | **0.75** | **0.80** | **0.84** | **0.91** | 1.00 |

| **Panel D: Variables of Interdependence of investment opportunities** | | **1** | **2** | **3** | **4** | **5** |
|---|---|---|---|---|---|---|
| **1** | Corr | 1.00 | | | | |
| **2** | K-L Distance | 0.00 | 1.00 | | | |
| **3** | Fluidity | 0.00 | **-0.12** | 1.00 | | |
| **4** | HHI | -0.01 | **-0.14** | -0.03 | 1.00 | |
| **5** | HHI4 | -0.01 | **-0.11** | **-0.06** | **0.65** | 1.00 |

| **Panel E: Variables of board gender diversity** | | **1** | **2** | **3** |
|---|---|---|---|---|
| **1** | B_female | 1.00 | | |
| **2** | B_pct_female | **0.95** | **1.00** | |
| **3** | B_blau_index | **0.92** | **0.97** | 1.00 |

## 5.4 Why Do Firms Use Derivatives to Hedge Foreign Currency Risk?

The gross notional amounts of derivatives deflated by the book value of total assets are initially regressed on the firm's fundamental financial characteristics according to the theories suggested by previous studies (see section 2.2.1). In Table 5.4, test results from OLS regressions with year-fixed effect are shown in the first two columns. Industry dummies are controlled in column 2. In addition to the basic OLS models applied, a panel regression is conducted with both firm and year-fixed effects. In the first three columns, the growth of investment opportunities is proxied by the market-to-book ratio of the assets. To verify the explanatory power that growth of investment opportunities has on corporate derivative hedging, the capital expenditure on property, plant, and equipment scaled by book value of total assets (CapEx) is employed to test robustness (Graham & Rogers, 2002; Haushalter, 2000). The test results from the OLS and panel regressions are shown in the last three columns. All analysis is conducted with robust standard errors.

As shown in Table 5.4 (page 88) the market-to-book ratio as a proxy for growth of investment opportunities is positively associated with the amounts of derivative holdings. When CapEx is alternatively employed, both the OLS regression with the year and industry dummies controlled (column 5) and panel data analysis (column 6) provide consistent findings. These findings support Froot et al.'s (1993) arguments that the more growth opportunities firms have, the more likely they will conduct derivative hedging. When OLS regressions are employed, firm size is positively associated with currency derivative holdings, which is consistent with past findings (Adam et al., 2017; Bartram Brown & Fehle, 2009; Kim et al., 2006; Nance et al., 1993). It could be a consequence of more sophisticated risk management expertise that large firms have or economies of scale in entering derivative transactions to reduce the transaction costs in large firms (Berkman & Bradbury, 1996; Glaum, 2002; Nance et al., 1993). When OLS regressions are employed, the coefficients of Debt are of negative significance, which appears to be inconsistent with the arguments of the cost of financial distress (Stulz, 1996; Smith & Stulz, 1985). However, Géczy et al. (2007) argue that a firm's optimal debt ratio does not indicate the level of financial distress. Leverage could also indicate the debt raising capacity instead of weak financial strength (Faulkender & Petersen, 2005; Fresard, 2010; Lemmon & Robert, 2010; Sufi, 2009). Firms with a larger debt-raising capacity would be less likely to have an underinvestment problem as the result of cash flow volatility. Hence, they are less likely to use derivatives to hedge. Though both variables Debt and Firmsize have significant coefficients in the OLS models, these two variables lose explanatory power when panel regressions are applied. These insignificant coefficients are consistent with Beber and Fabbri's (2012) findings. As shown in columns 3 and 6, Table 5.4, the deflated foreign income (Fincome) is negatively associated with gross notional amounts of derivative holdings when panel regressions are conducted. This implies that hedging against foreign currency risk exposure is not the only goal of corporate derivative use. In addition, the relatively low within r-squares indicate that fundamental financial characteristics can weakly explain the variability in the gross notional amounts of derivative holdings. This implies the probability of derivative use for market timing (Beber & Fabbri, 2012).

**Table 5.4 Baseline Regressions on Fundamental Financial Characteristics**

This table shows the results of regressing the notional amounts of foreign currency derivative holdings, deflated by the book value of total assets, on fundamental financial characteristics. The variables MTB and CapEx are employed to represent growth opportunities. Variable Fincome, Debt, Firmsize, Institutional, TaxlossCF, CEOcashcomp are employed as independent variables. Appendix 1 provides detailed information on the construction of variables. In columns 1, 2, 4 and 5, OLS regressions are reported with year-fixed effects. Industry dummies are additionally controlled in columns 2 and 5. Panel regressions are employed with both firm and year fixed effects, which are shown in columns 3 and 6. All analyses are conducted with robust standard errors.

| Dependent Variable: de_FX | (1) | (2) | (3) | (4) | (5) | (6) |
|---|---|---|---|---|---|---|
| | ols | ols | fe | ols | ols | fe |
| MTB | 0.0157*** | 0.0115*** | 0.0139*** | | | |
| | [0.000] | [0.000] | [0.001] | | | |
| CapEx | | | | 0.0436 | 0.2927** | 0.2643** |
| | | | | [0.639] | [0.012] | [0.023] |
| Fincome | 0.0002 | 0.0003 | -0.0005* | 0.0004 | 0.0002 | -0.0005* |
| | [0.737] | [0.613] | [0.087] | [0.503] | [0.659] | [0.052] |
| Debt | -0.0711*** | -0.0703*** | -0.0075 | -0.0874*** | -0.0901*** | -0.0218 |
| | [0.003] | [0.007] | [0.794] | [0.000] | [0.001] | [0.458] |
| Firmsize | 0.0134*** | 0.0219*** | -0.0123 | 0.0147*** | 0.0234*** | 0.003 |
| | [0.000] | [0.000] | [0.252] | [0.000] | [0.000] | [0.770] |
| Institutional | -0.0001 | 0.0002 | 0.0001 | 0.0001 | 0.0004 | 0.0001 |
| | [0.674] | [0.413] | [0.803] | [0.609] | [0.166] | [0.621] |
| TaxlossCF | -0.0002 | -0.001 | -0.0006 | -0.0003 | -0.0011 | -0.0008 |
| | [0.879] | [0.361] | [0.596] | [0.743] | [0.303] | [0.472] |
| CEOcashcomp | -0.0016 | 0.0013 | 0.0022 | -0.0040* | 0.0001 | 0.0015 |
| | [0.533] | [0.636] | [0.434] | [0.090] | [0.980] | [0.526] |
| No. obs. | 1312 | 1312 | 1312 | 1312 | 1312 | 1312 |
| r2 | 0.059 | 0.131 | | 0.032 | 0.124 | |
| Within R-squared | | | 0.029 | | | 0.021 |
| Firm fixed effects | N | N | Y | N | N | Y |
| Year Dummies | Y | Y | Y | Y | Y | Y |
| Industry Dummies | N | Y | N | N | Y | N |
| Robust Std. Err. | Y | Y | Y | Y | Y | Y |

***, **, * denotes statistical significance at the 1%, 5%, and 10% levels, respectively. P-values are reported in parentheses.

## 5.5 The Results and Discussion of the Effects of Predation Risk on Derivative Use and Corporate Selective Hedging Behaviour

Three proxy variables of predation risk are used to investigate the effect of predation risk on corporate selective hedging behaviour. These proxy variables are employed according to the defined predation risk in Bolton and Scharfstein (1990). Haushalter et al. (2007) examine how predation risk affects corporate derivative use by focusing on the degree of interdependence of investment opportunities. Whether interdependence of investment opportunities can represent predation risk is further investigated.

### 5.5.1 Does predation risk explain selective hedging?

Following Beber and Fabbri (2012), a measure of selective hedging is constructed by calculating the standard deviation of the residual derivative holdings on fundamental financial characteristics. The residuals are estimated from the panel regression model with firm and year fixed effects shown in column 3, Table 5.4[40]. Using cross-sectional analysis, whether predation risk explains the standard deviation of residual derivative holdings is investigated. Three proxies are used to represent predation risk. They are the market-to-book ratio of the assets (MTB), standard deviation of cash flows from operating activities (Sd_ocf) and the percentage of interest-bearing debts to mature in 3 or more years (Dm3). If firms use derivatives for hedging purposes only, rather than speculation, none of the proxies should have significant coefficients.

40 The test results are consistent in OLS regressions with year and industry dummies controlled. If the mark-to-book value ratio is replaced by CapEx, the results are not significantly changed.

**Table 5.5 Estimator Comparison for Regressions of Standard Deviation of Residuals on Proxy Variables of Predation Risk**
Estimator comparison for regressions of standard deviation of residuals on proxy variable of predation risk. This table presents the results of OLS regressions with the standard deviation of residual derivative holdings as dependent variables. The residuals are estimated from the panel regression model with firm and year fixed effects shown in column 3, Table 5.4. In this table, predation risk is represented by the market-to-book ratios (MTB), standard deviation of cash flow generated from operating activities, and percentage of interest-bearing debt to mature in three or more years. In columns 1, 3, and 5, only independent variables employed in baseline models are controlled. Additional control variables are added in columns 2, 4, and 6. They are the proxy variables of financial strength, i.e., Cashholdings and CashDiv and the proxy variables of managers' personal characteristics, i.e., CEO_age, CEO_tenure, and CEO_gender. In column 5, all variables that represent either financial strength or a manger's personal characteristics are jointly controlled. In all models, EPCM as a proxy of market power is also controlled. Appendix 1 provides detailed information on the construction of variables. All models are analysed with industry fixed effect and robust standard errors.

| Dep. Var: sd of residuals | (1) | (2) | (3) | (4) | (5) | (6) |
|---|---|---|---|---|---|---|
| MTB | 0.0033* | 0.0044** | | | | |
| | [0.086] | [0.039] | | | | |
| Sd_ocf | | | 0.0279*** | 0.0262*** | | |
| | | | [0.002] | [0.001] | | |
| Dm3 | | | | | -0.0310*** | -0.0280*** |
| | | | | | [0.001] | [0.002] |
| EPCM | -0.0080 | -0.0011 | 0.0035 | 0.0063 | 0.0133 | 0.0155 |
| | [0.570] | [0.941] | [0.809] | [0.685] | [0.384] | [0.352] |
| Fincome | 0.0008 | 0.0009 | 0.0009 | 0.0009 | 0.0011 | 0.0011 |
| | [0.375] | [0.302] | [0.270] | [0.249] | [0.169] | [0.126] |
| Debt | -0.0120 | -0.0109 | -0.0150 | -0.0114 | -0.0146 | -0.0094 |
| | [0.326] | [0.377] | [0.228] | [0.369] | [0.334] | [0.516] |
| Firmsize | 0.0013 | 0.0028* | -0.0013 | 0.0002 | 0.0004 | 0.0020 |
| | [0.370] | [0.072] | [0.474] | [0.903] | [0.797] | [0.198] |
| Institutional | 0.0004 | 0.0004 | 0.0004 | 0.0004 | 0.0004 | 0.0004 |
| | [0.174] | [0.138] | [0.154] | [0.124] | [0.196] | [0.128] |
| TaxlossCF | 0.0010* | 0.0009* | 0.0010* | 0.0010* | 0.0008 | 0.0007 |
| | [0.091] | [0.091] | [0.087] | [0.085] | [0.181] | [0.194] |
| CEOcashcomp | 0.0012 | 0.0016 | 0.0021 | 0.0027 | 0.0008 | 0.0015 |
| | [0.456] | [0.363] | [0.230] | [0.117] | [0.592] | [0.376] |
| CashDiv | | -0.1804* | | -0.1408 | | -0.1558 |
| | | [0.099] | | [0.220] | | [0.188] |
| Cashholding | | -0.0093 | | 0.0144 | | 0.0082 |
| | | [0.675] | | [0.488] | | [0.708] |
| CEO_gender | | 0.0010 | | 0.0013 | | -0.0095 |
| | | [0.917] | | [0.895] | | [0.274] |
| CEO_tenure | | -0.0005 | | -0.0004 | | -0.0002 |
| | | [0.196] | | [0.286] | | [0.666] |
| CEO_age | | -0.0001 | | -0.0002 | | -0.0003 |
| | | [0.703] | | [0.522] | | [0.451] |
| No. obs. | 227 | 227 | 227 | 227 | 212 | 212 |
| r2 | 0.1585 | 0.1837 | 0.1581 | 0.1771 | 0.1947 | 0.2109 |
| Industry Dummies | Y | Y | Y | Y | Y | Y |
| Robust Std. Err. | Y | Y | Y | Y | Y | Y |

***, **, * denotes statistical significance at the 1%, 5%, and 10% levels, respectively. P-values are reported in parentheses.

In Table 5.5, columns one, three and five indicate the test results for the regressions with control variables that are used only in the baseline model. To exclude the effects of the factors claimed in Stulz (1996) on selective hedging, additional control variables are added. Adequate financial strength (argued in Stulz (1996)) is controlled by total cash holdings (Cashholding) and cash dividend payments (CashDiv). Personal factors, such as gender, tenure and age, which could possibly affect the CEO's overconfidence, are also taken as control variables. To avoid bias as a result of the industry-oriented difference in derivative applications, industry dummies are controlled. All models in Table 5.5 are analysed with robust standard errors.

As shown in Table 5.5, both variables MTB and Sd_ocf are positively associated with the standard deviation of residual derivative holdings on fundamentals. This indicates that firms with higher market-to-book ratio and greater standard deviation of operating cash flows are more likely to hedge selectively. Variable Dm3 has negative coefficients, which implies that firms with shorter debt maturity are more likely to hedge selectively. The coefficients on variables Sd_ocf and Dm3 are significant at the 1% level. The test results remain the same when Stulz's (1996) arguments are taken into account by adding additional control variables into the models. The results described above strongly support the association between predation risk and corporate selective hedging behaviour. In the models where the proxy variables of MTB and Sd_ocf are used, the variable tax losses carried forward (TaxlossCF) has positive coefficients with significance at the 10% level. This is consistent with arguments in past studies that firms close to financial distress have an incentive to time the market (Adam et al., 2017; Stulz, 1996). Additionally, in model two, there are significant coefficients on both variables Firmsize and CashDiv. The explanatory power of firm size (Firmsize) can be explained by the informational advantages that large firms have in predicting market movements (Stulz, 1996). The informational advantages could arise from more professional expertise that large firms have or a deeper involvement in foreign currency derivative transactions. The explanatory power of cash dividend payment (CashDiv) indicates that firms paying more cash dividend are less likely to hedge selectively. This makes sense since selectively taking the risk to hedge for extra returns is not necessary if the firm already has the capacity to pay larger amounts of cash for the dividend.

### 5.5.2 Does interdependence of investment opportunities explain corporate derivative use and corporate selective hedging behaviour?

Haushalter et al. (2007) claim that interdependence of investment opportunities as a proxy for predation risk is positively related to derivative hedging. To verify the explanatory power of interdependence of investment opportunities on corporate derivative use, similar tests to those in Haushalter et al. (2007) are conducted. Because of the weakness in using dichotomous dependent variables for testing as in Haushalter et al. (2007), the gross notional amounts of derivatives is the focus. In section 4.4.2, the inappropriateness of using the degree of interdependence of investment opportunities to represent the predation risk that a firm encounters is discussed. To support the arguments in section 4.4.2, further tests are conducted to investigate if interdependence of investment opportunities affects derivative use, specifically, corporate selective hedging behaviour.

#### *5.5.2.1 The effect of the interdependence of investment opportunities on corporate derivative holdings*

The test results are shown in Table 5.6. Three proxy variables are used to represent the interdependence of investment opportunities as in Haushalter et al. (2007). They are industry stock Beta (Corr), the absolute value of industry demeaned capital-to-labour ratio (K-L Distance), and a measure of industry concentration (HHI). In this study, all these proxy variables are used. Both

OLS and panel regressions are conducted with robust standard errors. The year and industry dummies are controlled in the OLS models and panel regressions are applied with firm and year fixed-effects.

As shown in Table 5.6 (page 94), except for the panel regression with interdependence of investment opportunities represented by the variable Corr, the coefficients of the three proxies are not statistically significant. In addition, the coefficients' signs lack consistency. This inconsistency exists regardless of the proxy variables and models used. Based on the findings, there is no evidence to support Haushalter's et al. (2007) arguments. The relationship between the interdependence of investment opportunities and corporate derivative use is not clear.

Though explanatory power of the interdependence of investment opportunities on corporate derivative use is not found, market-to-book ratios (MTB) are positively associated with the amount of derivative holdings. The coefficients of market-to-book ratio are significant at the 1% level in all models. The test results strongly support the arguments in Froot et al. (1993) that firms with more investment opportunities are more likely to use derivative hedging to mitigate underinvestment problems. The variable foreign income (Fincome) has negative coefficients in panel regressions when firm-year fixed effects are controlled. Since the variable Fincome reflects the extent of foreign currency risk exposure, the test results indicate that firms with larger risk exposure are less likely to conduct derivative hedging. This is consistent with arguments in past studies for the existence of corporate selective hedging behaviour (Adam & Fernando, 2006; Bodnar et al., 1998; Brown et al., 2006; Faulkender, 2005; Glaum, 2002). In addition, the significant coefficients of the variables Debt and Firmsize in the OLS models disappear when panel regressions are conducted, which is consistent with the findings in Table 5.4.

**Table 5.6 Baseline Regressions on Interdependence of Investment Opportunities**

This table shows the results of regressing the gross notional amounts of foreign currency derivative holdings, deflated by the book value of total assets, on the interdependence of investment opportunities. Three variables are used to represent the interdependence of investment opportunities. They are Corr, K-L Distance, and HHI. Variables MTB, Fincome, Debt, Firmsize, Institutional, TaxlossCF, CEOcashcomp are used as controls. Appendix 1 provides detailed information on the construction of the variables. In columns 1, 3, and 5, OLS regressions are conducted with year and industry fixed effects. Panel regressions, conducted with both firm and year fixed effects,are shown in columns 2, 4, and 6. All analyses are conducted with robust standard errors.

| **Dep. Var: de_FX** | **(1)** | **(2)** | **(3)** | **(4)** | **(5)** | **(6)** |
|---|---|---|---|---|---|---|
| | **ols** | **fe** | **ols** | **fe** | **ols** | **fe** |
| Corr | 0.0027 | 0.0024** | | | | |
| | [0.204] | [0.035] | | | | |
| K-L Distance | | | -0.0002 | 0.0161 | | |
| | | | [0.992] | [0.564] | | |
| HHI | | | | | 0.0831 | -0.0483 |
| | | | | | [0.332] | [0.788] |
| MTB | 0.0114*** | 0.0135*** | 0.0115*** | 0.0137*** | 0.0109*** | 0.0138*** |
| | [0.000] | [0.001] | [0.000] | [0.001] | [0.001] | [0.002] |
| Fincome | 0.0002 | -0.0005* | 0.0003 | -0.0005* | 0.0003 | -0.0005* |
| | [0.699] | [0.052] | [0.613] | [0.085] | [0.647] | [0.085] |
| Debt | -0.0712*** | -0.0104 | -0.0703*** | -0.0074 | -0.0723*** | -0.0072 |
| | [0.006] | [0.711] | [0.007] | [0.794] | [0.004] | [0.801] |
| Firmsize | 0.0222*** | -0.0116 | 0.0219*** | -0.0122 | 0.0215*** | -0.0122 |
| | [0.000] | [0.274] | [0.000] | [0.256] | [0.000] | [0.257] |
| Institutional | 0.0002 | 0.0000 | 0.0002 | 0.0001 | 0.0002 | 0.0001 |
| | [0.407] | [0.894] | [0.413] | [0.844] | [0.428] | [0.807] |
| TaxlossCF | -0.0012 | -0.0007 | -0.0010 | -0.0006 | -0.0010 | -0.0006 |
| | [0.280] | [0.559] | [0.369] | [0.595] | [0.318] | [0.600] |
| CEOcashcomp | 0.0015 | 0.0021 | 0.0013 | 0.0023 | 0.0012 | 0.0022 |
| | [0.596] | [0.452] | [0.641] | [0.415] | [0.641] | [0.446] |
| No. obs. | 1305 | 1305 | 1312 | 1312 | 1312 | 1312 |
| r2 | 0.132 | | 0.131 | | 0.132 | |
| Within R-squared | | 0.033 | | 0.029 | | 0.029 |
| Firm fixed effects | N | Y | N | Y | N | Y |
| Year Dummies | Y | Y | Y | Y | Y | Y |
| Industry Dummies | Y | N | Y | N | Y | N |
| Robust Std. Err. | Y | Y | Y | Y | Y | Y |

***, **, * denotes statistical significance at the 1%, 5%, and 10% levels, respectively. P-values are reported in parentheses.

*5.5.2.2 The effect of the interdependence of investment opportunities on explaining the variation of residual derivative holdings*

To test if the interdependence of investment opportunities can explain corporate selective hedging, the proxy variables of the interdependence of investment opportunities used in Haushalter et al. (2007) are employed. These proxy variables are Corr, K-L Distance, HHI, and HHI4. To test the effect on corporate selective hedging behaviour, the standard deviation of residual derivative holdings on fundamental factors that explain derivative hedging is the focus (Beber & Fabbri, 2012). For the tests on the interdependence of investment opportunities represented by each proxy variable, the control variables introduced in the baseline model (see Table 5.4) are initially used. According to the arguments in previous studies, the factors of adequate financial strength and manager's personal characteristics are taken into account as controls, which are shown in columns 2, 4, 6, and 8. All regressions are conducted with robust standard error and industry fixed effects. Table 5.7 (page 97) shows the test results.

When interdependence of investment opportunities is represented by proxy variables Corr and K-L Distance, there is no significant effect on the standard deviation of residual derivative holdings. Adding the controls of financial strength and CEO's personal characteristics does not change the result. In addition, the signs lack consistency. However, when the measure of industry structure, i.e., HHI, is used, the coefficients are positively significant at the 1% level regardless of the financial strength and the CEO's personal characteristics. When industry structure is measured by taking into account only the biggest 4 firms in the industry (HHI4), the statistical significance of the coefficient of HH4 remains the same. The results indicate that firms operating in more concentrated industries are more likely to selectively hedge foreign currency risks. According to the test results summarised above, there is no consistent evidence to support the explanatory power of the interdependence of investment opportunities on corporate derivative use, specifically selective hedging behaviour.

The test results show a positive relationship between the measure of industry structure and the standard deviation of residual derivative holdings. However, when the variables Corr and K-L Distance are used, the relationship is not statistically significant. The inconsistency of the test results is explained as follows. First, the proxy variables employed by Haushalter et al. (2007) are not appropriate to represent the level of interdependence of investment opportunities. Secondly, the measure of industry structure is endogenous. Industry structure represents factors other than the interdependence of investment opportunities that could possibly affect corporate selective hedging behaviour.

To verify if interdependence of investment opportunities affects corporate derivative use and selective hedging behaviour, an additional proxy variable of interdependence of investment opportunities, i.e. a measure of product fluidity (Fluidity), is used. Both OLS and panel regressions are conducted with settings like those in the tests reported in Table 5.6. In these tests, gross notional amounts of derivative holdings are used as dependent variables (see columns 1 and 2, Table 5.8 (page 98)). Regressions are also conducted with settings like those in the test results shown in Table 5.7. In these regressions, the standard deviations of residual derivative holdings are used as dependent variables, which specifically addresses the corporate selective hedging behaviour (see columns 3 and 4, Table 5.8). If interdependence of investment opportunities has explanatory power on corporate derivative use and selective hedging behaviour, significant coefficients of the variable Fluidity are expected. However, as shown in Table 5.8, except for the OLS regression in column 1, the test results are all insignificant.

**Table 5.7 Estimator Comparison for Regressions of Standard Deviation of Residual Derivative Holdings on the Interdependence of Investment Opportunities**

Estimator comparison for regressions of standard deviation of residuals on variables of Corr, K-L Distance, HHI and HHI4. This table presents the results of OLS regressions with the standard deviation of residual derivative holdings as dependent variables. The residuals are estimated from the panel regression model with firm and year fixed effects shown in column 3, Table 5. 4. In this table, the interdependence of investment opportunities is represented by variables of Corr, K-L Distance, HHI and HHI4. Variable EPCM and all independent variables used in the baseline models are controlled. The proxy variables of financial strength, i.e., Cashholdings and CashDiv, and the proxy variables of managers' personal characteristics, i.e., CEO_age, CEO_tenure, and CEO_gender, are then added to the model as shown in columns 2, 4, 6, 8. Appendix 1 provides detailed information on the construction of variables. Industry dummy is controlled in all models. All models are analysed with robust standard errors.

| Dep. Var: sd of residuals | (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) |
|---|---|---|---|---|---|---|---|---|
| Corr | 0.0006 | 0.0009 | | | | | | |
| | [0.826] | [0.764] | | | | | | |
| K-L Distance | | | -0.0173 | -0.0185 | | | | |
| | | | [0.349] | [0.308] | | | | |
| HHI | | | | | 0.1492*** | 0.1479*** | | |
| | | | | | [0.010] | [0.010] | | |
| HHI4 | | | | | | | 0.1325** | 0.1288** |
| | | | | | | | [0.036] | [0.040] |
| EPCM | 0.0076 | 0.0072 | 0.0036 | 0.0032 | -0.0003 | 0.0001 | -0.0053 | -0.0052 |
| | [0.623] | [0.649] | [0.830] | [0.850] | [0.986] | [0.993] | [0.712] | [0.727] |
| Fincome | 0.0009 | 0.0008 | 0.001 | 0.0009 | 0.0005 | 0.0004 | 0.0003 | 0.0002 |
| | [0.218] | [0.297] | [0.175] | [0.236] | [0.501] | [0.583] | [0.660] | [0.767] |
| Debt | -0.0126 | -0.0135 | -0.0135 | -0.0146 | -0.0168 | -0.018 | -0.0139 | -0.0149 |
| | [0.331] | [0.295] | [0.283] | [0.242] | [0.174] | [0.140] | [0.260] | [0.229] |
| Firmsize | 0.0023 | 0.0027* | 0.0019 | 0.0022 | 0.0012 | 0.0015 | 0.0021 | 0.0025 |
| | [0.149] | [0.087] | [0.233] | [0.167] | [0.431] | [0.322] | [0.176] | [0.112] |
| Institutional | 0.0004 | 0.0004 | 0.0004 | 0.0004 | 0.0003 | 0.0004 | 0.0004 | 0.0004 |
| | [0.138] | [0.118] | [0.147] | [0.128] | [0.182] | [0.159] | [0.164] | [0.142] |
| TaxlossCF | 0.0008 | 0.0008 | 0.0009 | 0.0010* | 0.0007 | 0.0008 | 0.0008 | 0.0008 |
| | [0.156] | [0.139] | [0.103] | [0.089] | [0.159] | [0.138] | [0.150] | [0.128] |
| CEOcashcomp | 0.0017 | 0.0016 | 0.0018 | 0.0017 | 0.0014 | 0.0013 | 0.0019 | 0.0018 |
| | [0.372] | [0.385] | [0.329] | [0.348] | [0.434] | [0.495] | [0.308] | [0.344] |
| CashDiv | | -0.1532 | | -0.1425 | | -0.1465 | | -0.1292 |
| | | [0.186] | | [0.223] | | [0.158] | | [0.241] |
| Cashholding | | 0.0125 | | 0.0108 | | 0.0008 | | 0.0035 |
| | | [0.557] | | [0.620] | | [0.964] | | [0.852] |
| CEO_gender | | 0.0003 | | 0.0011 | | 0.0014 | | -0.0017 |
| | | [0.979] | | [0.913] | | [0.879] | | [0.851] |
| CEO_tenure | | -0.0005 | | -0.0004 | | -0.0005 | | -0.0004 |
| | | [0.258] | | [0.277] | | [0.213] | | [0.251] |
| CEO_age | | -0.0003 | | -0.0003 | | -0.0002 | | -0.0002 |
| | | [0.483] | | [0.483] | | [0.687] | | [0.602] |
| No. obs. | 227 | 227 | 227 | 227 | 227 | 227 | 227 | 227 |
| r2 | 0.1557 | 0.1662 | 0.159 | 0.1693 | 0.1895 | 0.1984 | 0.1777 | 0.1861 |
| Industry Dummies | Y | Y | Y | Y | Y | Y | Y | Y |
| Robust Std. Err. | Y | Y | Y | Y | Y | Y | Y | Y |

***, **, * denotes statistical significance at the 1%, 5%, and 10% levels, respectively. P-values are reported in parentheses.

**Table 5.8 Estimator Comparison for Baseline Regressions and Regressions of Std. Deviaion of Residuals on Variables of Fluidty**

This table shows the effect of interdependence of investment opportunities proxied by the variable Fluidity on gross derivative holdings and the standard deviation of residual derivative holdings. In columns 1 and 2, gross notional amounts of foreign currency derivative holdings deflated by the book value of total assets are regressed on fundamental financial characteristics. Both OLS and Panel regressions are applied. Columns 3 and 4 show the test results of OLS regressions with standard deviation of residual derivative holdings as dependent variables. The observations collected for each independent variable used in columns 3 and 4 are set on average for each firm over the sample period. Appendix 1 provides detailed information on the construction of variables.

| Dep. Var: | (1) | (2) | (3) | (4) |
|---|---|---|---|---|
| | **de_FX** | **de_FX** | **Sd of residuals** | **Sd of residuals** |
| Fluidity | -0.0023** | -0.0002 | -0.001 | -0.0013 |
| | [0.036] | [0.832] | [0.180] | [0.108] |
| MTB | 0.0122*** | 0.0141*** | | |
| | [0.000] | [0.001] | | |
| EPCM | | | 0.0101 | 0.010 |
| | | | [0.509] | [0.526] |
| Fincome | 0.0002 | -0.0004 | 0.0007 | 0.0006 |
| | [0.718] | [0.102] | [0.370] | [0.439] |
| Debt | -0.0757*** | -0.0089 | -0.015 | -0.0158 |
| | [0.005] | [0.758] | [0.252] | [0.220] |
| Firmsize | 0.0232*** | -0.0125 | 0.0028* | 0.0031** |
| | [0.000] | [0.253] | [0.077] | [0.049] |
| Institutional | 0.0003 | 0.0001 | 0.0004 | 0.0004 |
| | [0.215] | [0.659] | [0.137] | [0.121] |
| TaxlossCF | -0.0008 | -0.0007 | 0.0008 | 0.0009 |
| | [0.443] | [0.562] | [0.136] | [0.118] |
| CEOcashcomp | 0.002 | 0.0022 | 0.002 | 0.0019 |
| | [0.455] | [0.430] | [0.267] | [0.290] |
| CashDiv | | | | -0.1894 |
| | | | | [0.124] |
| Cashholding | | | | 0.0157 |
| | | | | [0.455] |
| CEO_gender | | | | 0.0005 |
| | | | | [0.959] |
| CEO_tenure | | | | -0.0004 |
| | | | | [0.269] |
| CEO_age | | | | -0.0002 |
| | | | | [0.544] |
| No. obs. | 1286 | 1286 | 227 | 227 |
| r2 | 0.134 | | 0.1619 | 0.1711 |
| Within R-squared | | 0.03 | | |
| Firm fixed effects | N | Y | | |
| Year Dummies | Y | Y | | |
| Industry Dummies | Y | N | Y | Y |
| Robust Std. Err. | Y | Y | Y | Y |

***, **, * denotes statistical significance at the 1%, 5%, and 10% levels, respectively. P-values are reported in parentheses.

### 5.5.3 How can the relationship between industry structure and selective hedging be explained?

The tests conducted above provide evidence that interdependence of investment opportunities has no explanatory power on corporate derivative use and selective hedging behaviour. However, why industry structure significantly affects selective hedging behaviour is not clear. Whether it results from factors other than interdependence of investment opportunities is now further investigated.

Table 5.9 (page 100) shows the results when the interdependence of investment opportunities is teased out from the measure of industry structure. All control variables are fully maintained from the models shown in Table 5.7. The regression results of first stages are shown in the first five columns. All three proxy variables separately representing predation risk at the first stage are significantly associated with industry structure (HHI). In addition, the measure of market power, i.e., EPCM, shows explanatory power in columns 2 and 3. When the three proxy variables of predation risk are jointly added into the model, the variables MTB and Sd_ocf have significant coefficients. Additional control of market power does not affect the significance. At the second stage, the coefficients of the residuals estimated from the models shown in columns 6-8 reveal statistical significance. However, the economic significance is reduced when compared with the coefficient of HHI (0.1479) in column 6, Table 5.7. Especially when variables MTB and Dm3 are used in the models at the first stage, the coefficients of estimated residuals in the models at the second stage are reduced by around 30%. Interestingly, when all three variables of predation risk are jointly controlled at the first stage, the estimated residual in the model at the second stage loses the explanatory power. The additional control of market power at the first stage does not change the insignificance.

**Table 5.9 Effects of Market Concentration (HHI) on the Standard Deviation of Residual Derivative Holdings by Teasing out Interdependence of Investment Opportunities**
Further discussion of the effects of market structure (HHI) by teasing out market power and predation risk argued in Bolton & Scharfstein (1990). This table shows the results of two-stage regression models. At the first stage, OLS regressions are conducted with industry structure as dependent variables. Industry structure is represented by variable HHI. As regressors, market power is proxied by variable EPCM and predation risk is represented by variables of MTB, Sd_ocf and Dm3 separately and jointly. The test results are shown in columns 1-5. The residuals estimated from first-stage regressions are the variable of interest at the second stage. Test results for the regressions at the second stage are shown in columns 6-10. At the second stage, the dependent variables are the standard deviation of residual derivative holdings. All the control variables including the proxy variables of financial strength and managers' personal characteristics are maintained from column 2, Table 5.7. Appendix 1 provides detailed information on the construction of variables. Industry dummy is controlled in all models. All models are analysed with robust standard errors.

| Dep. Var: HHI/ sd of residuals | (1) stage 1 | (2) stage 1 | (3) stage 1 | (4) stage 1 | (5) stage 1 | (6) stage 2 | (7) stage 2 | (8) stage 2 | (9) stage 2 | (10) stage 2 |
|---|---|---|---|---|---|---|---|---|---|---|
| MTB | 0.0134*** | | | 0.0160*** | 0.0145*** | | | | | |
| | [0.002] | | | [0.000] | [0.002] | | | | | |
| Sd_ocf | | 0.0222* | | 0.0360*** | 0.0313*** | | | | | |
| | | [0.098] | | [0.000] | [0.001] | | | | | |
| Dm3 | | | -0.0300*** | -0.0124 | -0.0144 | | | | | |
| | | | [0.009] | [0.320] | [0.254] | | | | | |
| EPCM | 0.0415 | 0.0858*** | 0.0937*** | | 0.036 | | | | | |
| | [0.117] | [0.003] | [0.001] | | [0.192] | | | | | |
| r_hhi_1 | | | | | | 0.1078* | | | | |
| | | | | | | [0.052] | | | | |
| r_hhi_2 | | | | | | | 0.1372** | | | |
| | | | | | | | [0.013] | | | |
| r_hhi_3 | | | | | | | | 0.1036* | | |
| | | | | | | | | [0.072] | | |
| r_hhi_4 | | | | | | | | | 0.0648 | |
| | | | | | | | | | [0.272] | |
| r_hhi_5 | | | | | | | | | | 0.0684 |
| | | | | | | | | | | [0.245] |
| No. obs. | 228 | 228 | 220 | 220 | 220 | 227 | 227 | 220 | 220 | 220 |
| r2 | 0.1145 | 0.0435 | 0.0681 | 0.139 | 0.1441 | 0.1824 | 0.1935 | 0.1768 | 0.1672 | 0.1678 |
| Controls | n/a | n/a | n/a | n/a | n/a | Y | Y | Y | Y | Y |
| Industry Dummies | Y | Y | Y | Y | Y | Y | Y | Y | Y | Y |
| Robust Std. Err. | Y | Y | Y | Y | Y | Y | Y | Y | Y | Y |

***, **, * denotes statistical significance at the 1%, 5%, and 10% levels, respectively. P-values are reported in parentheses.

**Table 5.10 Effects of Market Concentration (HHI4) on the Standard Deviation of Residual Derivative Holdings by Teasing out Interdependence of Investment Opportunities**

This table shows the results of two-stage regression models. At the first stage, OLS regressions are conducted with industry structure as dependent variables. Industry structure is represented by variable HHI4. As regressors, market power is proxied by variable EPCM and predation risk is represented by variables of MTB, Sd_ocf and Dm3 separately and jointly. The test results are shown in columns 1-5. The residuals estimated from first-stage regressions are the variable of interest at the second stage. Test results for the regressions at the second stage are shown in columns 6-10. At the second stage, the dependent variables are the standard deviation of residual derivative holdings. All the control variables including the proxy variables of financial strength and managers' personal characteristics are maintained from column 2, Table 5.7. Appendix 1 provides detailed information on the construction of variables. Industry dummy is controlled in all models. All models are analysed with robust standard errors.

| Dep. Var: HHI4/ sd of residuals | (1) stage 1 | (2) stage 1 | (3) stage 1 | (4) stage 1 | (5) stage 1 | (6) stage 2 | (7) stage 2 | (8) stage 2 | (9) stage 2 | (10) stage 2 |
|---|---|---|---|---|---|---|---|---|---|---|
| MTB | 0.0108** | | | 0.0137*** | 0.0102** | | | | | |
| | [0.015] | | | [0.007] | [0.039] | | | | | |
| Sd_ocf | | -0.0083 | | 0.0116 | 0.0003 | | | | | |
| | | [0.631] | | [0.446] | [0.984] | | | | | |
| Dm3 | | | -0.0318** | -0.0152 | -0.0201* | | | | | |
| | | | [0.011] | [0.224] | [0.095] | | | | | |
| EPCM | 0.0840*** | 0.1256*** | 0.1207*** | | 0.0856*** | | | | | |
| | [0.009] | [0.000] | [0.001] | | [0.008] | | | | | |
| r_hhi4_1 | | | | | | 0.0944 | | | | |
| | | | | | | [0.110] | | | | |
| r_hhi4_2 | | | | | | | 0.1293** | | | |
| | | | | | | | [0.034] | | | |
| r_hhi4_3 | | | | | | | | 0.0682 | | |
| | | | | | | | | [0.258] | | |
| r_hhi4_4 | | | | | | | | | 0.0376 | |
| | | | | | | | | | [0.527] | |
| r_hhi4_5 | | | | | | | | | | 0.0478 |
| | | | | | | | | | | [0.427] |
| No. obs. | 228 | 228 | 220 | 220 | 220 | 227 | 227 | 220 | 220 | 220 |
| r2 | 0.1273 | 0.0774 | 0.1058 | 0.1119 | 0.1429 | 0.1754 | 0.1857 | 0.1665 | 0.1628 | 0.1636 |
| Controls | n/a | n/a | n/a | n/a | n/a | Y | Y | Y | Y | Y |
| Industry Dummies | Y | Y | Y | Y | Y | Y | Y | Y | Y | Y |
| Robust Std. Err. | Y | Y | Y | Y | Y | Y | Y | Y | Y | Y |

***, **, * denotes statistical significance at the 1%, 5%, and 10% levels, respectively. P-values are reported in parentheses.

Further tests are conducted using the two-stage models when the industry structure is represented by the variable HHI4. As shown in Table 5.10 (page 101), variables MTB and DM3 are significantly associated with variable HHI4. When the three variables of predation risk suggested by Bolton and Scharfstein (1990) are jointly controlled at the first stage, variable MTB has significant coefficients. With additional control of market power, the coefficient of variable Dm3 is significant at the 10% level. In all models in columns 1-3 and 5, the test results show that variable EPCM is significantly associated with variable HHI4. At the second stage, except for the model in column 7, the estimated residuals from the models at the first stage lose explanatory power on the standard deviation of residual derivative holdings.

According to the test results shown in Tables 5.9 and 5.10, the findings are summarised. First, regarding industry structure as an endogenous variable, the test results at the first stage indicate that the level of industry concentration denotes not only the market power but also the predation risk explained by Bolton and Scharfstein (1990). Secondly, the test results at the second stage indicate that the residuals estimated from the first stage lose explanatory power when market power and predation risk because of information asymmetry are excluded from the measure of industry structure. There is no evidence to support the negative relationship between interdependence of investment opportunities and the standard deviation of residual derivative holdings. Lastly, when all the variables of predation risk because of information asymmetry are included in the models at the first stage, the coefficients of estimated residuals in the models at the second stage are insignificant. Without controlling market power at the first stage as shown in column 4, Tables 5.9 and 5.10, the estimated residuals from the first stage do not show significant coefficients. These findings indirectly support the argument in this study that the predation risk because of information asymmetry suggested by Bolton and Scharfstein (1990) affects corporate selective hedging.

Table 5.11 (page 105) shows the results when predation risk is teased out of the measure of industry structure. All control variables are fully maintained from the models in Table 5.7. In Table 5.11, industry structure is measured by the variable HHI. At the first stage, in the models with market power controlled, the variable EPCM is positively associated with variable HHI. This indicates that firms in more concentrated industries have more market power. When interdependence of investment opportunities is represented by the variable Fluidity as shown in column 3, Table 5.11, the fluidity coefficient is significant at 10% level with a negative sign. However, the coefficients of variables Corr and K-L Distance lack significance when they are used. Variable K-L Distance is negatively associated with variable HHI when the three proxy variables of the interdependence of investment opportunities are all controlled in the model at the first stage. However, when market power is additionally controlled, as shown in column 5, Table 5.11, the coefficients of all proxy variables of the interdependence of investment opportunities are not significant. At the second stage, all the residuals estimated from the models shown in columns 1-3 have explanatory power on the standard deviation of residual derivative holdings. Even if all proxy variables of the interdependence of investment opportunities are simultaneously controlled, the explanatory power of estimated residuals is maintained. Compared with the coefficient of HHI (0.1479) in column 6, Table 5.7, the coefficients of estimated residuals are only slightly reduced.

Further tests using the two-stage models when the industry structure is represented by variable HHI4 are conducted. As shown in Table 5.12, the relationship between the variables EPCM and HHI4 is always significantly positive at the 1% level. The coefficients of variable Fluidity are negative when it is controlled as a proxy for the interdependence of investment opportunities in the models at the first stage. The residuals estimated from the models in columns 1-5 have the explanatory power to explain the standard deviation of residual derivative holdings. The coefficients of estimated residuals are only slightly reduced compared with the coefficient of HHI4 (0.1288) in column 8, Table 5.7.

As shown in columns 1-5 in Tables 5.11 and 5.12, the positive relationship between industry concentration and market power is further established. Firms in more concentrated industries have more market power. In addition, all residuals estimated from the models at the first stage have significant coefficients in second-stage regressions. This indicates that industry structure can explain corporate selective hedging behaviour when the factors of market power and interdependence of investment opportunities are excluded from the measure of industry structure. The test results in Tables 5.11 and 5.12 verify the possibility that predation risk because of information asymmetry can explain the positive relationship between industry structure and corporate selective hedging behaviour. This questions the effect of industry structure as a proxy for the interdependence of investment opportunities on corporate selective hedging.

**Table 5.11 The Effects of Market Concentration (HHI) on the Standard Deviation of Residual Derivative Holdings by Teasing out the Predation Risk Argued in Bolton and Scharfstein (1990)**

This table shows the results of two-stage regression models. At the first stage, OLS regressions are conducted with industry structure as dependent variables. Industry structure is represented by variable HHI. As regressors, market power is proxied by variable EPCM and interdependence of investment opportunities is represented by the variables Corr, K-L Distance and Fluidity separately and jointly. The test results are shown in columns 1-5. The residuals estimated from first-stage regressions are the variable of interest at the second stage. Test results for the regressions at the second stage are shown in columns 6-10. At the second stage, the dependent variables are the standard deviation of residual derivative holdings. All the control variables including the proxy variables of financial strength and managers' personal characteristics are maintained from column 2, Table 5.7. Appendix 1 provides detailed information on the construction of variables. Industry dummy is controlled in all models. All models are analysed with robust standard errors.

| Dep. Var: HHI/ sd of residuals | (1) stage 1 | (2) stage 1 | (3) stage 1 | (4) stage 1 | (5) stage 1 | (6) stage 2 | (7) stage 2 | (8) stage 2 | (9) stage 2 | (10) stage 2 |
|---|---|---|---|---|---|---|---|---|---|---|
| Corr | 0.0012 | | | -0.0014 | -0.0007 | | | | | |
| | [0.785] | | | [0.754] | [0.874] | | | | | |
| K-L Distance | | -0.0463 | | -0.0810** | -0.0498 | | | | | |
| | | [0.215] | | [0.014] | [0.187] | | | | | |
| Fluidity | | | -0.0026* | -0.0014 | -0.0026 | | | | | |
| | | | [0.096] | [0.367] | [0.105] | | | | | |
| EPCM | 0.0917*** | 0.0745** | 0.1094*** | | 0.0918** | | | | | |
| | [0.001] | [0.035] | [0.000] | | [0.012] | | | | | |
| r_hhi_1 | | | | | | 0.1415** | | | | |
| | | | | | | [0.012] | | | | |
| r_hhi_2 | | | | | | | 0.1323** | | | |
| | | | | | | | [0.016] | | | |
| r_hhi_3 | | | | | | | | 0.1294** | | |
| | | | | | | | | [0.015] | | |
| r_hhi_4 | | | | | | | | | 0.1192** | |
| | | | | | | | | | [0.031] | |
| r_hhi_5 | | | | | | | | | | 0.1174** |
| | | | | | | | | | | [0.027] |
| No. obs. | 227 | 227 | 227 | 227 | 227 | 227 | 227 | 227 | 227 | 227 |
| r2 | 0.0404 | 0.048 | 0.0532 | 0.03 | 0.0619 | 0.196 | 0.1924 | 0.1913 | 0.189 | 0.188 |
| Controls | n/a | n/a | n/a | n/a | n/a | Y | Y | Y | Y | Y |
| Industry Dummies | Y | Y | Y | Y | Y | Y | Y | Y | Y | Y |
| Robust Std. Err. | Y | Y | Y | Y | Y | Y | Y | Y | Y | Y |

***, **, * denotes statistical significance at the 1%, 5%, and 10% levels, respectively. P-values are reported in parentheses.

**Table 5.12 The Effects of Market Concentration (HHI4) on Standard Deviation of Residual Derivative Holdings by Teasing out the Predation Risk Argued in Bolton and Scharfstein (1990)**

This table shows the results of two-stage regression models. At the first stage, OLS regressions are conducted with industry structure as dependent variables. Industry structure is represented by variable HHI4. As regressors, market power is proxied by variable EPCM and interdependence of investment opportunities is represented by variables Corr, K-L Distance and Fluidity separately and jointly. The test results are shown in columns 1-5. The residuals estimated from first-stage regressions are the variables of interest at the second stage. Test results for the regressions at the second stage are shown in columns 6-10. At the second stage, the dependent variables are the standard deviation of residual derivative holdings. All the control variables including the proxy variables of financial strength and managers' personal characteristics are maintained from column 2, Table 5.7. Appendix 1 provides detailed information on the construction of variables. Industry dummy is controlled in all models. All models are analysed with robust standard errors.

| Dep. Var: HHI4/ sd of residuals | (1) stage 1 | (2) stage 1 | (3) stage 1 | (4) stage 1 | (5) stage 1 | (6) stage 2 | (7) stage 2 | (8) stage 2 | (9) stage 2 | (10) stage 2 |
|---|---|---|---|---|---|---|---|---|---|---|
| Corr | 0.0031 | | | -0.0001 | 0.0011 | | | | | |
| | [0.471] | | | [0.991] | [0.815] | | | | | |
| K-L Distance | | -0.0105 | | -0.0632* | -0.0124 | | | | | |
| | | [0.785] | | [0.098] | [0.748] | | | | | |
| Fluidity | | | -0.0041*** | -0.0022* | -0.0041*** | | | | | |
| | | | [0.001] | [0.061] | [0.001] | | | | | |
| EPCM | 0.1249*** | 0.1200*** | 0.1527*** | | 0.1489*** | | | | | |
| | [0.000] | [0.002] | [0.000] | | [0.000] | | | | | |
| r_hhi4_1 | | | | | | 0.1226** | | | | |
| | | | | | | [0.042] | | | | |
| r_hhi4_2 | | | | | | | 0.1246** | | | |
| | | | | | | | [0.041] | | | |
| r_hhi4_3 | | | | | | | | 0.1045* | | |
| | | | | | | | | [0.059] | | |
| r_hhi4_4 | | | | | | | | | 0.1019* | |
| | | | | | | | | | [0.090] | |
| r_hhi4_5 | | | | | | | | | | 0.1011* |
| | | | | | | | | | | [0.067] |
| No. obs. | 227 | 228 | 228 | 227 | 227 | 226 | 227 | 227 | 226 | 226 |
| r2 | 0.0785 | 0.0773 | 0.1112 | 0.0255 | 0.1129 | 0.1847 | 0.1842 | 0.1789 | 0.18 | 0.179 |
| Controls | n/a | n/a | n/a | n/a | n/a | Y | Y | Y | Y | Y |
| Industry Dummies | Y | Y | Y | Y | Y | Y | Y | Y | Y | Y |
| Robust Std. Err. | Y | Y | Y | Y | Y | Y | Y | Y | Y | Y |

***, **, * denotes statistical significance at the 1%, 5%, and 10% levels, respectively. P-values are reported in parentheses.

### 5.5.4 Robustness tests

One proxy variable used in this study to represent the predation risk because of information asymmetry suggested in Bolton and Scharfstein (1990) is the percentage of debts that will mature in 3 or more years (DM3). Considering the arbitrary choice of 3 years, robustness tests are conducted by choosing the percentage of debts maturing in no less than 1, 2, 4 and 5 years (Barclay & Smith, 1995). The test results are shown in Appendix 2. The coefficient of Dm1 is not significant at the 10% level (P-value= 0.103) when the CEO's personal characteristics are not additionally controlled. Except for this, all proxy variables reveal significant coefficients with negative signs. The additional controls of financial strength and CEO's personal characteristics do not affect the significance of coefficients of the proxy variables.

Corporate selective hedging is identified by calculating the standard deviation of the residual derivative holdings on fundamentals (Beber & Febbri, 2012). To examine what affects the standard deviation of the residual derivative holdings in the sample period, the variables of interest are set on average over the sample period (Beber & Febbri, 2012). However, the value on average cannot indicate how the change of variables of interest affect the test results. To examine if variation in the variables of interest in time series significantly affects the test results, changes in the variables of interest are further controlled. For all proxy variables of interest, dummy variables are set according to whether the value of variables is continuously increased, decreased or fluctuating during the sample period. Summaries of the standard deviations of the residual derivative holdings by changes of variables of interest are shown in Appendixes 3 and 4. As shown in Appendix 5, the explanatory power of proxy variables that are used for predation risk because of information asymmetry suggested by Bolton and Scharfstein (1990) is not significantly changed. In the models shown in Appendix 6, the effects of the interdependence of investment opportunities on corporate selective hedging are further tested. The test results indicate that no proxy variable of the interdependence of investment opportunities has significant coefficients. When the measures of industry structure are used, both HHI and HHI4 have significant coefficients with positive signs (see Appendix 7). In summary, the test results are not significantly changed by taking into account variation in the variables of interest in time series.

Following Beber and Fabbri's (2012) procedure, corporate selective hedging is identified as the standard deviation of the residual derivative holdings in this study. Panel regressions are conducted to estimate the residual derivative holdings. The factors that were discussed in prior studies to explain why firms use derivatives to hedge are considered as independent variables. Focusing on the standard deviation of residuals, Beber and Fabbri's (2012) method makes sure that the variation is most likely to be attributable to derivative speculation rather than a derivative hedge. To test for the robustness of the explanatory power of predation risk on corporate selective hedging, OLS regressions are conducted with the standard deviation of derivative holdings as the dependent variable. As shown in Appendix 8, the standard deviation of derivative holdings is regressed on three proxy variables of predation risk with robust standard errors. In addition to the firm's fundamental characteristics, then variables representing financial strength and the CEO's personal characteristics are also controlled. Both proxy variables, Sd_ocf and Dm3, are significantly associated with the standard deviation of derivative holdings. The significance of the coefficients of both proxy variables is at the 1% level. The P-value for the coefficient of variable MTB is slightly higher than 10%. This could be because of the dual representation of MTB for both investment opportunities and information asymmetry.

The results are further checked for robustness in the following ways. First, the gross notional amounts of derivatives by total sales and foreign sales are normalised. Secondly, a natural logarithm function is taken for the normalised gross notional amounts of derivatives. Thirdly, in the tests Corr is calculated based on returns for 24 months instead of 12 months. Fourthly, the balanced panel data excluding firms that did not use derivatives in the early years of the sample period are used. Lastly, the residual derivative holdings are estimated from the baseline OLS model with the year and industry dummies controlled. The above robustness tests provide consistency in indicating the effect of predation risk on corporate selective hedging behaviour. In addition, the interdependence of investment opportunities is not significantly associated with the standard deviation of residual derivative holdings. The conclusions are not significantly altered based on the above un-tabulated tests.

## 5.6 The Results and Discussion of the Effects of Board Gender Diversity on Corporate Selective Hedging Behaviour

First, using Beber and Fabbri's (2012) method to identify corporate selective hedging behaviour, the linear relationship between board gender diversity and corporate selective hedging behaviour is investigated. Taking into account the potential of critical mass that focuses on the dynamic change of female directors, the test for the non-linear relationship between board gender diversity and selective hedging is then further conducted. Lastly, the mediation function of predation risk that links both board gender diversity and corporate selective hedging is discussed.

### 5.6.1 Does board gender diversity explain corporate selective hedging behaviour?

To investigate the effect of board gender diversity on corporate selective hedging behaviour, selective hedging is identified based on the residual model used in Beber and Fabbri (2012). Panel regressions are conducted at the first stage. In these regressions, the gross notional amounts of derivatives are used as the dependent variables. The different financial characteristics discussed to explain derivative use in prior studies are controlled. The residuals estimated from the first-stage model indicate the extent of derivative hedges that cannot be explained by fundamental theories. By excluding factors that possibly result in a derivative hedge, the standard deviation of residuals estimated in the second-stage model indicates the extent of market timing, i.e., selective hedging. The results from baseline regressions on fundamental financial characteristics are shown in Table 5.4 and discussed in section 5.4. When panel regressions are used with industry-fixed effect, it is documented that firms with more investment opportunities are more likely to use derivatives to hedge. Further, using derivatives to hedge seems not to be preferred by firms that are heavily exposed to foreign currency risks. This test result indirectly indicates the possibility of derivative use for timing the market.

Table 5.13 (page 111) summarises the statistics of the standard deviations of residuals by board gender composition. For the total sample, as shown in Panel A, the standard deviation of residuals at the mean is 0.0332. Panel B describes the standard deviation of residuals for the sample firms categorised by the number of female directors on the board. This standard deviation of residuals is largest for firms with only one female director on board. On increased female participation on boards, the standard deviations of residuals are orderly reduced. When the number of female directors increases from one to three, and even more, the standard deviation of residuals for the firms with three or more female directors is reduced by approximately 40%. Panel C reports the summary statistics for firms categorised by the fraction of female directors on the board. The means of the standard deviations of residuals are also orderly reduced for the boards with female directors, which is consistent with the results in Panel B. Compared with the skewed group, the mean standard deviations of residuals for both tilted and balanced boards are reduced by 25% and 40%, respectively. Though the number of firms that have no females on the board is small, eight firms, the standard deviation of residuals for the firms with no female directors is smallest regardless of the board gender category. According to the summary statistics in Panels B and C, it appears that, prima facie, there is a bell-shaped relationship between board gender diversity and the standard deviations of residual derivative holdings.

**Table 5.13 Summary Statistics of the Standard Deviation of Residual Derivative Holdings by Board Gender Composition**
This table summarises the standard deviations of residual derivative holdings by board gender composition. Panel A indicates the summary for all sampled firms. Panel B indicates the standard deviations of residual derivative holdings for the firms categorised by the number of female directors on the board. Panel C indicates the standard deviations of residual derivative holdings for the firms categorised by fractions of female directors on the board according to Kanter's (1977a, b) categorisation method.

| Variable | Obs. | Mean | Std. Dev. | Min | Max |
|---|---|---|---|---|---|
| Panel A: total | | | | | |
| | 227 | 0.0332 | 0.0378 | 0.0011 | 0.4135 |
| Panel B: By No. of fe_dir | | | | | |
| 0 | 8 | 0.0161 | 0.0132 | 0.0034 | 0.0388 |
| 1 | 68 | 0.0431 | 0.0581 | 0.0063 | 0.4135 |
| 2 | 90 | 0.0315 | 0.0261 | 0.0050 | 0.1329 |
| 3 | 61 | 0.0268 | 0.0195 | 0.0011 | 0.1076 |
| Panel C: By %fe_dir | | | | | |
| uniformed | 8 | 0.0161 | 0.0132 | 0.0034 | 0.0388 |
| skewed | 138 | 0.0372 | 0.0450 | 0.0053 | 0.4135 |
| tilted | 79 | 0.0281 | 0.0221 | 0.0011 | 0.1076 |
| balanced | 2 | 0.0224 | 0.0137 | 0.0127 | 0.0321 |

A linear relationship between board gender diversity and corporate selective hedging behaviour is investigated first. The dependent variables are the standard deviations of residual derivative holdings. Table 5.14 (page 113) shows the test results with board gender diversity represented separately by three different proxy variables. These proxy variables are: number of female directors on a board, the proportion of female directors on a board, and the Blau's (1977) index by gender of board members. The dependent variable is the standard deviation of the residual derivative holdings which is estimated by the baseline panel regression (see column 3, Table 5.4). For models with each proxy variable of board gender diversity, a firm's fundamental financial characteristics that explain derivative use in the first-stage model are considered as control variables. To isolate the gender effect from other board factors that could possibly affect corporate selective hedging behaviour, additional board-level factors are controlled. From the literature, these board factors are the board size, the fraction of independent directors on boards, the total number of external board seats held by all directors, the average age of board members, and the average tenure of board members (Baixauli-Soler et al., 2015; Berger et al., 2014; Levi et al., 2014; Sila et al., 2016).

Based on the arguments in Stulz (1996), two conditions need to be satisfied for a firm to hedge selectively. One is adequate financial strength; the other is the manager's belief in holding private information about market movements. Considering the gigantic size of the currency market that no market participants can dominate, timing the market by truly obtaining private information is not profitably sustainable (Adam & Fernando, 2006; Beber & Fabbri, 2012; Brown et al., 2006). Accordingly, studies argue that corporate selective hedging behaviour based on the manager's belief in holding private information results from overconfidence (Adam et al., 2007; Adam et al., 2015; Beber & Fabbri, 2012). Therefore, like the tests conducted for the issue of predation risk in section 5.5, additional variables are controlled for the two factors discussed in Stulz (1996) in columns 2, 4, and 6. Both cash dividends and firm cash holdings are used to control for financial strength and CEO's age, tenure, and gender are all controlled to differentiate the degree of manager overconfidence.

As shown in Table 5.14, all proxy variables of board gender diversity are negatively associated with variations of derivative holdings. The coefficients of variable B_Female are statistically significant at the 10% level. The significance remains when additional controls are added into model 2. The result indicates that a firm with more female directors on the board is less likely to

**Table 5.14 OLS Regressions of the Standard Deviation of Residual Derivative Holdings on Board Gender Diversity**
This table indicates the test results of OLS regressions on the proxy variables of board gender diversity, i.e., B_Female, B_pct_Female and B_blau_index. The dependent variables are the standard deviations of residual derivative holdings. The residual derivative holdings are estimated from baseline penal regression model shown in column 3, Table 5.4. All models shown in this table are analysed with industry dummies and robust standard errors. All variables are defined in Appendix 1.

| **Dep. Var: Sd of Residuals** | **(1)** | **(2)** | **(3)** | **(4)** | **(5)** | **(6)** |
|---|---|---|---|---|---|---|
| B_Female | -0.0069* | -0.0072* | | | | |
| | [0.084] | [0.096] | | | | |
| B_pct_Female | | | -0.0701* | -0.0734 | | |
| | | | [0.094] | [0.105] | | |
| B_blau_index | | | | | -0.0479 | -0.0483 |
| | | | | | [0.192] | [0.222] |
| MTB | 0.0036 | 0.0049* | 0.0035 | 0.0048* | 0.0035 | 0.0048* |
| | [0.143] | [0.096] | [0.152] | [0.092] | [0.152] | [0.094] |
| Fincome | 0.0007 | 0.0008 | 0.0007 | 0.0007 | 0.0009 | 0.0009 |
| | [0.396] | [0.395] | [0.426] | [0.421] | [0.299] | [0.303] |
| Debt | -0.0295** | -0.0292* | -0.0292** | -0.0288* | -0.0284* | -0.0278* |
| | [0.046] | [0.063] | [0.049] | [0.068] | [0.055] | [0.078] |
| Firmsize | 0.0011 | 0.0019 | 0.0011 | 0.0019 | 0.001 | 0.0019 |
| | [0.628] | [0.435] | [0.637] | [0.438] | [0.660] | [0.447] |
| Institutional | 0.0005 | 0.0005 | 0.0005 | 0.0005 | 0.0005 | 0.0005 |
| | [0.163] | [0.154] | [0.168] | [0.159] | [0.167] | [0.154] |
| TaxlossCF | 0.0011 | 0.0011 | 0.0011 | 0.0011 | 0.0011 | 0.0011 |
| | [0.108] | [0.115] | [0.109] | [0.116] | [0.112] | [0.117] |
| CEO_cashcomp | -0.0001 | 0.0001 | -0.0001 | 0.0001 | -0.0002 | 0.0001 |
| | [0.966] | [0.945] | [0.953] | [0.950] | [0.930] | [0.965] |
| Board_size | -0.0017 | -0.0017 | -0.0029 | -0.0029 | -0.0028 | -0.0028 |
| | [0.330] | [0.347] | [0.104] | [0.107] | [0.115] | [0.118] |
| Board_age | 0.0002 | 0.0003 | 0.0002 | 0.0003 | 0.0003 | 0.0004 |
| | [0.793] | [0.691] | [0.791] | [0.688] | [0.723] | [0.625] |
| Board_tenure | -0.0013* | -0.0008 | -0.0013* | -0.0009 | -0.0013* | -0.0009 |
| | [0.084] | [0.313] | [0.079] | [0.285] | [0.077] | [0.264] |
| Board_indep | 0.0327 | 0.0302 | 0.0319 | 0.0296 | 0.0303 | 0.0285 |
| | [0.204] | [0.232] | [0.210] | [0.238] | [0.251] | [0.276] |
| Board_outside | 0.001 | 0.001 | 0.001 | 0.001 | 0.001 | 0.001 |
| | [0.193] | [0.210] | [0.193] | [0.210] | [0.213] | [0.236] |
| CEO_age | | 0.0054 | | 0.0053 | | 0.0021 |
| | | [0.605] | | [0.619] | | [0.842] |
| CEO_tenure | | -0.0003 | | -0.0003 | | -0.0003 |
| | | [0.591] | | [0.596] | | [0.613] |
| CEO_gender | | -0.0004 | | -0.0004 | | -0.0004 |
| | | [0.457] | | [0.448] | | [0.461] |
| CashDiv | | -0.0874 | | -0.0894 | | -0.0946 |
| | | [0.439] | | [0.435] | | [0.415] |
| Cashholdings | | -0.0157 | | -0.0152 | | -0.0154 |
| | | [0.585] | | [0.596] | | [0.595] |
| No. obs. | 227 | 227 | 227 | 227 | 227 | 227 |
| r2 | 0.1541 | 0.1632 | 0.1532 | 0.1624 | 0.149 | 0.1577 |
| Industry Dummies | Y | Y | Y | Y | Y | Y |
| Robust Std. Err. | Y | Y | Y | Y | Y | Y |

***, **, * denotes statistical significance at the 1%, 5%, and 10% levels, respectively. P-values are reported in parentheses use derivatives to time the market. When variable B_pct_Female is used in the model with added additional controls, the P-value is 0.105. The statistical significance of the coefficient disappears, but the P-value is slightly higher at the 10% level. With the employed variable of the B_blau_index, significant effects of board gender diversity on the standard deviations of residual derivative holdings are not found. According to the above test results, there is no consistent evidence to support the negative relationship between board gender diversity and corporate selective hedging behaviour. Based on the test results shown in Table 5.14, variable Debt is negatively associated with variations of derivative use, which is consistent with findings by Glaum (2002). If the variable Debt indicates a firm's debt raising capacity (Faulkender & Petersen, 2005; Fresard, 2010; Lemmon & Robert, 2010; Sufi, 2009), the findings are consistent with the arguments on the issue of predation risk in section 5.5. That is, greater debt raising capacity mitigates the predation risk that a firm could encounter so that the firm is less likely to use elective hedging for extra funds to deal with the predation risk. Further, the significance of the coefficients of the variable Board_tenure to some extent indicates that a firm with more aged board members is less likely to use derivatives to time the market. In addition, when additional controls are added into the regressions, the coefficients of the variable MTB is positively significant, which is consistent with the findings discussed in section 5.5.

Prior studies argue that female directors are not randomly appointed (Baixauli-Soler et al., 2015; Huang & Kisgen, 2013; Sila et al., 2016). Whether female directors are appointed could depend on a firm's risk-taking propensity. In addition, the possible existence of female self-selection could also explain the negative relationship between board gender diversity and corporate risk-taking behaviour. Therefore, without taking into account possible reverse causality, how board gender diversity affects corporate risk, cannot be truly examined. To further investigate the causality between board gender diversity and corporate selective hedging behaviour, the generalized method of moments (GMM) estimation is applied (Baixauli-Soler et al., 2015) to solve the endogeneity problem. As argued in Adams and Ferreira (2009), the lack of social connections with potential candidates of female directorship determines that fewer females are appointed as directors on boards. Therefore, if male directors have more female connections on outside boards this can enhance female participation in directorship. Accordingly, the fraction of male directors who have female connections on outside boards over total directors (B_pct_maledir_outfelink) is used as an instrument variable (Adams & Ferreira, 2009; Levi et al., 2014). In addition, instead of focusing on the number of male directors, the fraction of outside female connections that male directors have over total outside directorships (B_maledir_pct_outfelink) is also employed (Adams & Ferreira, 2009; Sila et al., 2016). The model is over-identified by employing the above two instruments[41]. The correlation between these two instrument variables is 0.2815.

The test results of the GMM estimation are shown in Table 5.15 (page 117). The extent of board gender diversity is represented by three proxies. In the models with different proxies of board gender diversity, both firm fundamental financial characteristics and board characteristics are controlled. Additionally, the CEO's personal traits and a firm's financial strength are also controlled for robustness testing. All regressions are conducted with industry dummies and robust standard errors. As shown in Table 5.15, the F-statistics for the first stage models are between 40 and 55, which indicates that these two instruments are jointly not weak instruments. The Hansen's J statistics for most of the models are over 0.70 and the minimum Hansen's J statistic is 0.5686, which indicates that the employed instruments are valid and the models are correctly specified.

41 Exactly identified model is not employed according to the arguments in Sila et al. (2016) that Hansen test for instrument exogeneity requires larger number of instruments than the number of endogenous variables.

According to the test results, the three proxies of board gender diversity are all negatively associated with the standard deviations of residual derivative holdings with significance at the 10% level. These consistent test results document that firms with more female directors on the board are less likely to use derivatives to time the market. Like the test results from OLS regressions shown in Tables 5.14, the variable Debt in Table 5.15 is negatively associated with the dependent variable. Further, the coefficients of variable MTB are positively significant. The signs and significance are not changed by the employed proxies of board gender diversity. This supports the arguments about the impact of predation risk on corporate selective hedging behaviour. The variable TaxlossCF is also positively associated with the standard deviations of the residual derivative holdings. This implies that firms suffering more losses have stronger incentives to time the market for extra returns, which is consistent with arguments on the effect of profitability in Glaum (2002).

**Table 5.15 GMM Estimator Comparison for Regressions of the Standard deviation of Residual Derivative Holdings on Proxy Variables of Board Gender Diversity**

This table indicates the test results of instrumental variables estimator implemented using the Generalized Method of Moments (GMM). The models are over-identified by employing two instruments. One is the fraction of male directors who have female connections on outside boards over total directors (B_pct_maledir_outfelink). The other is the fraction of outside female connections that male directors have over total outside directorships (B_maledir_pct_outfelink). The dependent variables are the standard deviations of residual derivative holdings. The residual derivative holdings are estimated from baseline penal regression model in column 3, Table 5.4. The board gender diversity is proxied by three variables, i.e., number of female directors on board (B_Female), the fraction of female directors on board (B_pct_Female) and Blau's (1977) index by gender (B_blau_index). All models shown in this table are analysed with industry dummies and robust standard errors. The factors at different levels are controlled. All variables are defined in Appendix 1.

| Dep. Var: Sd of Residuals | (1) | (2) | (3) | (4) | (5) | (6) |
|---|---|---|---|---|---|---|
| B_Female | -0.0101* | -0.0104* | | | | |
| | [0.057] | [0.083] | | | | |
| B_pct_Female | | | -0.1001* | -0.1024* | | |
| | | | [0.057] | [0.082] | | |
| B_blau_index | | | | | -0.0785* | -0.0798* |
| | | | | | [0.060] | [0.084] |
| MTB | 0.0058** | 0.0079** | 0.0057** | 0.0077** | 0.0057** | 0.0077** |
| | [0.030] | [0.020] | [0.031] | [0.020] | [0.031] | [0.020] |
| Fincome | 0.0003 | 0.0004 | 0.0003 | 0.0004 | 0.0005 | 0.0005 |
| | [0.721] | [0.671] | [0.737] | [0.681] | [0.573] | [0.534] |
| Debt | -0.0359** | -0.0364** | -0.0357** | -0.0359** | -0.0349** | -0.0349** |
| | [0.015] | [0.016] | [0.015] | [0.017] | [0.018] | [0.020] |
| Firmsize | 0.0009 | 0.0018 | 0.0009 | 0.0018 | 0.0009 | 0.0019 |
| | [0.669] | [0.444] | [0.691] | [0.450] | [0.679] | [0.431] |
| Institutional | 0.0006* | 0.0006* | 0.0006 | 0.0006* | 0.0006 | 0.0006* |
| | [0.099] | [0.089] | [0.106] | [0.096] | [0.109] | [0.098] |
| TaxlossCF | 0.0012* | 0.0012* | 0.0012* | 0.0012* | 0.0012* | 0.0012* |
| | [0.075] | [0.077] | [0.076] | [0.079] | [0.082] | [0.086] |
| CEO_cashcomp | 0.0001 | 0.0004 | 0.0001 | 0.0004 | -0.0002 | 0.0002 |
| | [0.990] | [0.836] | [0.986] | [0.819] | [0.910] | [0.902] |
| Board_size | -0.0012 | -0.0012 | -0.0030* | -0.0030* | -0.0027 | -0.0028 |
| | [0.550] | [0.563] | [0.094] | [0.088] | [0.128] | [0.123] |
| Board_age | 0.0002 | 0.0003 | 0.0002 | 0.0003 | 0.0002 | 0.0003 |
| | [0.834] | [0.749] | [0.810] | [0.710] | [0.795] | [0.713] |
| Board_tenure | -0.0008 | -0.0002 | -0.0008 | -0.0003 | -0.0008 | -0.0003 |
| | [0.274] | [0.764] | [0.241] | [0.680] | [0.248] | [0.674] |
| Board_indep | 0.0423 | 0.04 | 0.0403 | 0.0384 | 0.0407 | 0.0394 |
| | [0.111] | [0.117] | [0.116] | [0.122] | [0.118] | [0.122] |
| Board_outside | 0.0013* | 0.0013 | 0.0012* | 0.0013 | 0.0012 | 0.0012 |
| | [0.096] | [0.102] | [0.095] | [0.103] | [0.107] | [0.116] |
| CEO_age | | 0.0108 | | 0.0101 | | 0.0074 |
| | | [0.371] | | [0.399] | | [0.520] |
| CEO_tenure | | -0.0003 | | -0.0002 | | -0.0003 |
| | | [0.632] | | [0.646] | | [0.603] |
| CEO_gender | | -0.0003 | | -0.0003 | | -0.0003 |
| | | [0.547] | | [0.520] | | [0.589] |
| CashDiv | | -0.1429 | | -0.1484 | | -0.1526 |
| | | [0.193] | | [0.183] | | [0.180] |
| Cashholdings | | -0.0205 | | -0.0193 | | -0.0196 |
| | | [0.443] | | [0.467] | | [0.466] |
| No. obs. | 225 | 225 | 225 | 225 | 225 | 225 |
| r2 | 0.1593 | 0.1708 | 0.1598 | 0.1714 | 0.1537 | 0.1644 |
| First stage F | 41.4507 | 41.0082 | 47.6822 | 41.0082 | 54.2941 | 51.6650 |
| Hansen's J chi2 | 0.8969 | 0.7281 | 0.8249 | 0.7281 | 0.7787 | 0.5686 |
| Industry Dummies | Y | Y | Y | Y | Y | Y |
| Robust Std. Err. | Y | Y | Y | Y | Y | Y |

***, **, * denotes statistical significance at the 1%, 5%, and 10% levels, respectively. P-values are reported in parentheses.

In summary, to test how board gender diversity affects corporate selective hedging behaviour, different proxies are used to represent the extent of female participation on boards. In addition to the factors at the firm and board levels, CEO personal traits and firm financial strength are jointly and separately controlled for robustness tests. Both OLS and GMM estimations are used. After conducting OLS regressions, Variable B_female is negatively associated with the standard deviations of residual derivative holdings. Though the coefficients of B_pct_Female and B_blau_index are insignificant to some extent, the signs of these two proxies of board gender diversity are all negative. GMM models are used to deal with the issue of reverse causality. The test results support the negative impact of board gender diversity on corporate selective hedging behaviour.

### 5.6.2 Does critical mass exist to explain the effect of board gender diversity on corporate selective hedging behaviour?

According to the test results discussed above, board gender diversity is negatively associated with the standard deviations of residual derivative holdings. This negative relationship indicates that firms with more gender diversified boards are less likely to conduct selective hedging behaviour. Though the negative impact can be explained by female directors' risk aversion, the linear relationship cannot clarify if female participation on boards can create an in-group bias and result in conflicts in different domains of foreign currency risk management. Social identity and self-categorisation theories support conflict in board decision processes because of in-group bias by gender. Conflict in the board decision making process could be an impediment in the effectiveness of corporate foreign currency risk management, which impairs the stability of derivative use. The weakened stability of derivative use can be reflected in the enlarged standard deviations of residual derivative holdings. Therefore, a negative linear relationship could indicate a greater effect of female risk aversion than in-group bias and inter-group conflict on corporate selective hedging behaviour. Prior studies argue that female directors, as a symbolic presence on boards, make no significant change in board decision making (Joecks et al., 2013; Kanter, 1977; Kramer et al., 2006). Board decision making takes no account of female risk aversion once female directors are regarded as tokens. However, being a token does not necessarily indicate assimilation into all domains of foreign currency risk management. If a critical mass of female participation on boards exists in deciding board risk propensity, a non-linear relationship between board gender diversity and corporate selective hedging could be identified.

To test the existence of a board critical mass of female participation that significantly affects corporate selective hedging behaviour, the squared proxies of board gender diversity are added into the model. Table 5.16 (page 120) shows the test results of OLS regressions with an added variable of squared Blau's (1977) index by gender. In column 1, the standard deviations of residual derivative holdings is regressed on fundamental financial characteristics. In addition to the fundamental financial characteristics, board factors such as size, board directors' average age, board directors' average tenure, the percentage of independent directors on boards, and the total amounts of board directors' outside connections are controlled for the model shown in column 2. In columns 3, 4 and 5, Table 5.16, the CEO'S personal traits such as age, tenure and gender, and proxies for financial strength such as amount of cash dividends and cash holdings are separately and jointly controlled. All regressions are conducted with robust standard errors and controlled industry dummies. As shown in Table 5.16, the coefficients of variable $B\_blau\_index^2$ are all negatively significant but the variable B_blau_index loses explanatory power with positive signs in all models. The negative significant coefficients of variables $B\_blau\_index^2$ imply a bell-shaped relationship between board gender diversity and corporate selective hedging behaviour. In addition, except for the first column, variable Debt is negatively associated with the standard deviation of residual derivative holdings in all models. However, in unreported tables, when board gender diversity is represented by either variable B_female or variable B_pct_female, neither single factors nor quadratic functions have explanatory power.

**Table 5.16 Estimator Comparison for Regressions of the Standard Deviation of Residual Derivative Holdings on Variable of B_Blau_index with both Linear and Quadratic Terms**

This table indicates the test results of OLS regressions on Blau's (1977) index by gender. In addition to the single term, the quadratic function of Blau's (1977) index by gender is added into the model. The dependent variables are the standard deviation of residual derivative holdings. The residual derivative holdings are estimated from baseline penal regression model shown in column 3, Table 5.4. All models shown in this table are analysed with industry dummies and robust standard errors. The factors at different levels are controlled as shown in Table 5.14. All variables are defined in Appendix 1.

| Dep. Var: Sd of Residuals | (1) | (2) | (3) | (4) | (5) |
|---|---|---|---|---|---|
| B_blau_index | 0.0785 | 0.0939 | 0.1046 | 0.095 | 0.1038 |
| | [0.334] | [0.287] | [0.258] | [0.275] | [0.259] |
| B_blau_index^2 | -0.2518* | -0.3000** | -0.3299** | -0.3007** | -0.3274** |
| | [0.060] | [0.033] | [0.025] | [0.031] | [0.026] |
| MTB | 0.0043* | 0.0034 | 0.0034 | 0.0048* | 0.0048 |
| | [0.050] | [0.159] | [0.171] | [0.098] | [0.114] |
| Fincome | 0.0005 | 0.0006 | 0.0006 | 0.0006 | 0.0006 |
| | [0.546] | [0.500] | [0.514] | [0.441] | [0.483] |
| Debt | -0.0168 | -0.0302** | -0.0299** | -0.0304** | -0.0303** |
| | [0.194] | [0.032] | [0.038] | [0.034] | [0.040] |
| Firmsize | 0.0007 | 0.0014 | 0.0019 | 0.0018 | 0.0022 |
| | [0.724] | [0.534] | [0.427] | [0.457] | [0.375] |
| Institutional | 0.0004 | 0.0006 | 0.0006 | 0.0006 | 0.0006 |
| | [0.221] | [0.114] | [0.115] | [0.110] | [0.111] |
| TaxlossCF | 0.0011 | 0.0011 | 0.0011 | 0.001 | 0.001 |
| | [0.134] | [0.124] | [0.129] | [0.133] | [0.135] |
| CEO_cashcomp | 0.0011 | -0.0001 | 0.0001 | 0.0001 | 0.0001 |
| | [0.536] | [0.971] | [0.944] | [0.992] | [0.953] |
| No. obs. | 227 | 227 | 227 | 227 | 227 |
| r2 | 0.1299 | 0.1625 | 0.1692 | 0.1666 | 0.1728 |
| Controls for board characters | N | Y | Y | Y | Y |
| Controls for CEO's characters | N | N | Y | N | Y |
| Controls for financial strength | N | N | N | Y | Y |
| Industry Dummies | Y | Y | Y | Y | Y |
| Robust Std. Err. | Y | Y | Y | Y | Y |

***, **, * denotes statistical significance at the 1%, 5%, and 10% levels, respectively. P-values are reported in parentheses.

By employing different proxies to represent the board gender diversity, not all the quadratic functions of the proxies have significant coefficients. To investigate the inconsistency, the correlations of proxy variables and their quadratic functions are summarised in Table 5.17. As shown in Table 5.17, the correlation between variable B_female and variable $B\_female^2$ is 0.92.

The correlation between variable B_pct_female and its quadratic function is 0.94. The correlation between variable B_Blau_index and its quadratic function is 0.96. The extremely high correlations between proxies of board gender diversity and their quadratic functions could possibly explain the inconsistent results because of bias arising from the issue of multicollinearity.

**Table 5.17 Correlation of Variables that Represent the Board Gender Composition**
Correlation of variables that represent the board gender composition. This table indicates the correlations of variables that include three proxies of board gender diversity (B_pct_female, B_female, and B_blau_index) and the quadratic functions of these proxies.

| Correlations | B_pct _female | B_pct _female ^2 | B_female | B_female^2 | B_Blau _index | B_Blau _index^2 |
|---|---|---|---|---|---|---|
| B_pct_female | 1.00 | | | | | |
| B_pct_female$^2$ | 0.94 | 1.00 | | | | |
| B_female | 0.95 | 0.89 | 1.00 | | | |
| B_female$^2$ | 0.84 | 0.91 | 0.92 | 1.00 | | |
| B_Blau_index | 0.97 | 0.83 | 0.92 | 0.74 | 1.00 | |
| B_Blau_index$^2$ | 0.99 | 0.93 | 0.93 | 0.84 | 0.96 | 1.00 |

**Table 5.18 Estimator Comparison for Regressions of the Standard Deviation of Residual Derivative Holdings on Quadratic Terms of Proxies of Board Gender Composition**

This table indicates the test results of OLS regressions on quadratic functions of board gender diversity that is proxied by three variables (i.e., B_pct_female, B_female, and B_blau_index). The dependent variables are the standard deviations of residual derivative holdings. The residual derivative holdings are estimated from baseline penal regression model shown in column 3, Table 5.4. All models shown in this table are analysed with industry dummies and robust standard errors. The factors at different levels are controlled as shown in Table 14. All variables are defined in Appendix 1.

| Dep. Var: Sd of Residuals | (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) | (9) |
|---|---|---|---|---|---|---|---|---|---|
| B_female² | -0.0008** | -0.0009** | -0.0009** | | | | | | |
| | [0.022] | [0.035] | [0.039] | | | | | | |
| B_pct_female² | | | | -0.1014** | -0.1260** | -0.1398** | | | |
| | | | | [0.026] | [0.013] | [0.011] | | | |
| B_blau_index² | | | | | | | -0.0623* | -0.0788* | -0.0830* |
| | | | | | | | [0.092] | [0.054] | [0.062] |
| MTB | 0.0028 | 0.0025 | 0.003 | 0.0030* | 0.0023 | 0.0029 | 0.0030* | 0.0023 | 0.0029 |
| | [0.109] | [0.202] | [0.167] | [0.088] | [0.225] | [0.185] | [0.091] | [0.234] | [0.184] |
| Fincome | 0.0009 | 0.0009 | 0.0009 | 0.0007 | 0.0007 | 0.0007 | 0.0008 | 0.0008 | 0.0009 |
| | [0.198] | [0.224] | [0.184] | [0.344] | [0.372] | [0.324] | [0.229] | [0.244] | [0.215] |
| Debt | -0.0158 | -0.0243** | -0.0229** | -0.0153 | -0.0246** | -0.0234** | -0.015 | -0.0241** | -0.0230* |
| | [0.132] | [0.031] | [0.050] | [0.147] | [0.030] | [0.048] | [0.157] | [0.034] | [0.054] |
| Firmsize | 0.0007 | 0.0007 | 0.0014 | 0.0003 | 0.0008 | 0.0015 | 0.0005 | 0.001 | 0.0017 |
| | [0.651] | [0.710] | [0.491] | [0.842] | [0.649] | [0.455] | [0.770] | [0.583] | [0.406] |
| Institutional | 0.0003 | 0.0004 | 0.0004 | 0.0003 | 0.0004 | 0.0004 | 0.0003 | 0.0004 | 0.0004 |
| | [0.218] | [0.132] | [0.125] | [0.257] | [0.140] | [0.136] | [0.254] | [0.137] | [0.130] |
| TaxlossCF | 0.0010* | 0.0009* | 0.0009* | 0.0009* | 0.0009* | 0.0009* | 0.0009* | 0.0009 | 0.0009 |
| | [0.075] | [0.086] | [0.093] | [0.085] | [0.088] | [0.097] | [0.096] | [0.101] | [0.111] |
| CEO_cashcomp | 0.0013 | 0.0005 | 0.0008 | 0.0012 | 0.0004 | 0.0007 | 0.001 | 0.0002 | 0.0005 |
| | [0.389] | [0.751] | [0.583] | [0.432] | [0.786] | [0.620] | [0.486] | [0.882] | [0.741] |
| No. obs. | 227 | 227 | 227 | 227 | 227 | 227 | 227 | 227 | 227 |
| r2 | 0.1438 | 0.1721 | 0.1827 | 0.1412 | 0.1754 | 0.1868 | 0.1401 | 0.1741 | 0.1841 |
| Controls for Board characters | N | Y | Y | N | Y | Y | N | Y | Y |
| Controls for CEO's characters | N | N | Y | N | N | Y | N | N | Y |
| Controls for financial strength | N | N | Y | N | N | Y | N | N | Y |
| Industry Dummies | Y | Y | Y | Y | Y | Y | Y | Y | Y |
| Robust Std. Err. | Y | Y | Y | Y | Y | Y | Y | Y | Y |

***, **, * denotes statistical significance at the 1%, 5%, and 10% levels, respectively. P-values are reported in parentheses.

Table 5.18 shows the test results for quadratic functions of all three proxies of board gender diversity. When the single factors are dropped from the models, the quadratic functions of proxy variables of board gender diversity are all negatively associated with the standard deviations of residual derivative holdings. In columns 1, 4, and 7, fundamental financial characteristics are controlled. Board level factors are controlled in columns 2, 5, and 8. In columns 3, 6, and 9, additional factors of CEO's personal traits and proxies for a firm's financial strength are additionally controlled. The additional control variables did not significantly affect the test results. The negative significance of the coefficients of quadratic function supports the bell-shaped relationship found in Table 5.16. When few female directors are appointed to boards, increased female participation on the board makes firms more likely to use derivatives to time the market in foreign currency risk management. However, given that more women are nominated as board directors, firms are less likely to use selective hedging. The relationship between board gender diversity and corporate selective hedging behaviour is shown in Appendix 9, the Graphs of linear, quadratic and fractional polynomial fit plots. In Table 5.18, both variables Debt and TaxlossCF show a significant impact of the standard deviation of derivative use to some extent, which is consistent with the test results shown in Table 5.15.

To specifically investigate how corporate selective hedging behaviour could be affected by the dynamic change in the number of female directors, the categorical variables are set up to reflect the fraction of female directors on boards. Dummy variables are created based upon Kanter's (1977a, b) method. Accordingly, boards are categorised as uniform, skewed, tilted or balanced boards. The tilted board is considered as the base group. Table 5.19 (page 125) presents the test results when board gender diversity is proxied by categorical variables. All other settings are maintained from the models shown in Tables 5.14-5.16. The estimates for the three dummy categorical variables measure the proportionate difference in the effect on the standard deviation of residual derivative holdings relative to the firms with tilted boards. As shown in Table 5.19, compared with constants, the coefficients of the variable skewed_board are significantly larger whereas the coefficients of the variable uniform_board are significantly smaller. The coefficients of the variable balanced_board are not significantly different from the coefficients of the constants. The test results indicate that female participation does not reduce the standard deviation of residual derivative holdings until a tilted board is established. Selective hedging is most frequently adopted when the fraction of female directors on board is less than 20%. However, more female participation on boards results in firms being less likely to selectively hedge against foreign currency risk. The extent of selective hedging is not significantly different for the firms with balanced boards relative to the firms with tilted boards. Further, *ceteris paribus*, firms without female participation on the board are least likely to use derivatives to time the market.

According to the findings above, the implications consistent with the developed hypotheses are summarised as follows. Though female directors' risk aversion can impede selective hedging behaviour, conflicts in decision-making process because of in-group bias by gender make foreign currency risk ineffectively managed. These conflicts could occur in decisions on different domains of derivative use, which is reflected in the amplified standard deviations of residual derivative holdings. The impact of in-group bias by gender arising from female participation on boards is stronger than the impact of female directors' risk aversion in deciding corporate selective hedging behaviour when female directors are treated as tokens.

Being tokens of decision making on derivative use implies that females hide their true thoughts and pretend no difference in risk preference from dominant male counterparts. In such a

**Table 5.19 Estimator Comparison for Regressions of the Standard Deviation of Residual Derivative Holdings on Categorised Variables of Board Gender Composition by Fractions of Female Directors**

This table indicates the test results of OLS regressions on categorical variables of board gender. The board gender composition is categorised according to Kanter's (1977) categorisation method. Firms with tilted boards are regarded as the base group. The dependent variables are the standard deviations of residual derivative holdings. The residual derivative holdings are estimated from baseline penal regression model shown in column 3, Table 5.4. All models shown in this table are analysed with industry dummies and robust standard errors. The factors at different levels are controlled as shown in Table 14. All variables are defined in Appendix 1.

| Dep. Var: Sd of Residuals | (1) | (2) | (3) | (4) | (5) |
|---|---|---|---|---|---|
| uniform_board | -0.0144** | -0.0149*** | -0.0144*** | -0.0165*** | -0.0160*** |
| | [0.011] | [0.007] | [0.009] | [0.003] | [0.005] |
| skewed_board | 0.0114** | 0.0131** | 0.0133*** | 0.0130** | 0.0133** |
| | [0.017] | [0.010] | [0.009] | [0.013] | [0.013] |
| balanced_board | -0.0125 | -0.0059 | -0.0097 | -0.0041 | -0.0074 |
| | [0.123] | [0.667] | [0.542] | [0.754] | [0.618] |
| MTB | 0.0046** | 0.0033 | 0.0033 | 0.0050* | 0.0049* |
| | [0.036] | [0.160] | [0.177] | [0.087] | [0.100] |
| Fincome | 0.0007 | 0.0011 | 0.0011 | 0.0012 | 0.0011 |
| | [0.381] | [0.165] | [0.188] | [0.114] | [0.148] |
| Debt | -0.015 | -0.0278** | -0.0272* | -0.0280** | -0.0276* |
| | [0.227] | [0.045] | [0.052] | [0.046] | [0.053] |
| Firmsize | 0.001 | 0.0024 | 0.0028 | 0.0029 | 0.0033 |
| | [0.629] | [0.314] | [0.253] | [0.249] | [0.208] |
| Institutional | 0.0005 | 0.0007* | 0.0007* | 0.0007* | 0.0007* |
| | [0.166] | [0.090] | [0.093] | [0.087] | [0.091] |
| TaxlossCF | 0.0008 | 0.0008 | 0.0008 | 0.0008 | 0.0008 |
| | [0.229] | [0.210] | [0.208] | [0.228] | [0.222] |
| CEO_cashcomp | 0.0015 | 0.0005 | 0.0007 | 0.0006 | 0.0007 |
| | [0.393] | [0.768] | [0.668] | [0.756] | [0.683] |
| _cons | -0.0212 | -0.0404 | -0.0271 | -0.0475 | -0.0358 |
| | [0.416] | [0.429] | [0.596] | [0.370] | [0.499] |
| No. obs. | 227 | 227 | 227 | 227 | 227 |
| r2 | 0.1393 | 0.1706 | 0.1758 | 0.1763 | 0.1809 |
| Controls for Board characters | N | Y | Y | Y | Y |
| Controls for CEO's characters | N | N | Y | N | Y |
| Controls for financial strength | N | N | N | Y | Y |
| Industry Dummies | Y | Y | Y | Y | Y |
| Robust Std. Err. | Y | Y | Y | Y | Y |

***, **, * denotes statistical significance at the 1%, 5%, and 10% levels, respectively. P-values are reported in parentheses.

circumstance, female directors avoid being considered risk averse and are possibly as risk-prone as dominant male peers. However, when the number of females on a board increases to the critical mass, the voice coming from females' risk aversion is more likely to be heard and their token image is accordingly alleviated. In this case, though the effect of female directors' risk aversion cannot completely neutralize the effect of in-group bias by gender, the positive impact of in-group bias by gender on the standard deviation of residual derivative holdings can be offset to some extent. Therefore, beyond the critical mass of female participation, firms with more gender diversified boards conduct selective hedging behaviour more conservatively. It makes sense that firms with no female directors on boards use derivatives least to time the market since both effects discussed above on corporate selective hedging behaviour disappear.

To further test the critical mass of female occupants on boards with which firms effectively reduce selective hedging behaviour, the number of female directors on boards is particularly focused (Kramer et al., 2006; Liu, Wei & Xie, 2014; Schwartz-Ziv, 2015; Torchia et al., 2011). As shown in Table 5.20 (page 127), boards are categorised based on the number of female directors on the board. Boards with two female directors are set as the base group. The variables fedir_0, fedir_1 and fedir_3 are dummy variables that indicate a board with no female director, one female director and three or more female directors, respectively. All other settings are maintained from the models shown in Table 5.14. Table 5.20 shows that both dummy variables fedir_0 and fedir_3 have negative coefficients. The significance of the estimates is maintained for these two variables in all models regardless of the diversified settings of the controls. These results indicate how the standard deviations of residual derivative holdings are affected by the dynamic change of female directors on boards. Relative to the firms with two female directors on boards, the standard deviation of residual derivative holdings for the firms with only one female director on boards is not significantly different. However, when the number of female directors on a board is either increased to three and more or reduced to zero, the standard deviations of residual derivative holdings are significantly mitigated. The results imply that a bell-shaped relationship is formed

**Table 5.20 Estimator Comparison for Regressions of the Standard Deviation of Residual Derivative Holdings on Categorised Variables of Board Gender Composition by Number of Female Directors**

This table indicates the test results of OLS regressions on categorical variables of board gender. The board gender composition is categorised to be either none, one, two or three or more female directors on boards. Firms with two female directors on boards are regarded as the base group. The dependent variables are the standard deviations of residual derivative holdings. The residual derivative holdings are estimated from baseline penal regression model shown in column 3, Table 5.4. All models shown in this table are analysed with industry dummies and robust standard errors. The factors at different levels are controlled as shown in Table 14. All variables are defined in Appendix 1.

| Dep. Var: Sd of Residuals | (1) | (2) | (3) | (4) | (5) |
|---|---|---|---|---|---|
| fedir_0 | -0.0207*** | -0.0209*** | -0.0205*** | -0.0226*** | -0.0220*** |
| | [0.000] | [0.000] | [0.000] | [0.000] | [0.000] |
| fedir_1 | 0.0093 | 0.0086 | 0.009 | 0.0082 | 0.0087 |
| | [0.215] | [0.268] | [0.262] | [0.282] | [0.271] |
| fedir_3 | -0.0104** | -0.0114*** | -0.0115*** | -0.0114** | -0.0113** |
| | [0.012] | [0.008] | [0.009] | [0.012] | [0.014] |
| MTB | 0.0038* | 0.0032 | 0.0032 | 0.0048* | 0.0047 |
| | [0.069] | [0.165] | [0.187] | [0.085] | [0.103] |
| Fincome | 0.0004 | 0.0007 | 0.0007 | 0.0007 | 0.0007 |
| | [0.650] | [0.456] | [0.481] | [0.386] | [0.439] |
| Debt | -0.0174 | -0.0299** | -0.0293** | -0.0302** | -0.0298** |
| | [0.158] | [0.034] | [0.041] | [0.036] | [0.044] |
| Firmsize | 0.0021 | 0.0022 | 0.0027 | 0.0026 | 0.003 |
| | [0.295] | [0.336] | [0.262] | [0.288] | [0.234] |
| Institutional | 0.0005 | 0.0006* | 0.0006* | 0.0006* | 0.0006* |
| | [0.157] | [0.096] | [0.098] | [0.094] | [0.095] |
| TaxlossCF | 0.0009 | 0.001 | 0.001 | 0.0009 | 0.0009 |
| | [0.167] | [0.151] | [0.150] | [0.160] | [0.157] |
| CEO_cashcomp | 0.0013 | 0.0001 | 0.0003 | 0.0002 | 0.0003 |
| | [0.424] | [0.947] | [0.850] | [0.930] | [0.860] |
| _cons | -0.0233 | -0.0474 | -0.0355 | -0.0525 | -0.0416 |
| | [0.381] | [0.362] | [0.494] | [0.335] | [0.443] |
| No. obs. | 227 | 227 | 227 | 227 | 227 |
| r2 | 0.1497 | 0.1754 | 0.1805 | 0.1801 | 0.1847 |
| Controls for Board characters | N | Y | Y | Y | Y |
| Controls for CEO's characters | N | N | Y | N | Y |
| Controls for financial strength | N | N | N | Y | Y |
| Industry Dummies | Y | Y | Y | Y | Y |
| Robust Std. Err. | Y | Y | Y | Y | Y |
| Wald test: fedir_0 =fedir_3 | 0.051 | 0.112 | 0.145 | 0.056 | 0.079 |

***, **, * denotes statistical significance at the 1%, 5%, and 10% levels, respectively. P-values are reported in parentheses.

between the dynamic change of female directors on boards and corporate selective hedging behaviour. Using derivatives to time the market is not mitigated until there are at least three females appointed as directors. Wald tests are conducted to estimate if coefficients of variables of fedir_0 and fedir_3 are significantly different. The P-value of the Wald test in the model with only fundamental financial characteristics controlled is 0.051. Though the P-values in column 3 are greater than 10%, once additional factors are controlled, the P-values for the model shown in columns 4 and 5 are 0.056 and 0.079, respectively. Therefore, by focusing on the dynamic change in the number of female directors on boards, the test results generally support that firms with no female directors on boards use derivatives least to time the market.

In summary, to test for the existence of a critical mass in female participation on boards that significantly affects corporate selective hedging behaviour, the models with quadratic functions are first applied. The bell-shaped relationship between board gender diversity and corporate selective hedging behaviour is found based on the negative coefficients of quadratic functions. Secondly, dummy variables for multiple categories are used to represent the dynamic change of female participation on boards. Female participation on boards is not only categorised by the fraction of female directors on board but also by the number of female directors. The test results consistently indicate a bell-shaped relationship between board gender diversity and corporate selective hedging behaviour. Once female directors are appointed, corporate selective hedging behaviour is conducted less for firms with tilted boards or boards with three or more female directors. Hence, the third hypothesis is supported.

### 5.6.3 Robustness tests and discussion

In section 5.5, the effect of predation risk on corporate selective hedging behaviour is discussed. To examine how corporate selective hedging behaviour is affected by board gender diversity, the variable MTB, which represents predation risk, is controlled in all the tests conducted above. To test for results that could possibly be biased by the chosen measure of predation risk, both variables Dm3 and Sd_ocf are used to control the effect of predation risk. Appendixes 11 and 12 give the results of GMM estimation of board gender diversity with predation risk represented by either Dm3 or Sd_ocf. The GMM model is over-identified by employing two instrument variables. One is the fraction of male directors who have female connections on outside boards over total directors. The other is the fraction of outside female connections that male directors have over total outside directorships. In Appendix 11, three proxy variables of board gender diversity are used. The regressions are conducted with industry dummies and robust standard errors. For the regressions with board gender diversity represented by each proxy, a firm's fundamental financial characteristics and board level factors are first controlled. Then the CEO's personal traits and measures of corporate financial strength are also controlled. The F-statistics for the first stage models are between 35 and 40, which indicates that the two instruments are jointly not weak instruments. The Hansen's J statistics for all models are over 0.49, which indicates that the instruments used are valid and the models are correctly specified. As shown in Appendix 11, all proxies of board gender diversity are negatively associated with standard deviations of residual derivative holdings. The negative significance is maintained when the additional factors of CEO personal traits and measures of corporate financial strength are controlled. Variable Dm3, which represents predation risk, has negative coefficients in all regressions with a significance statistic at the 1% level. These test results show that both board gender diversity and predation risk have effects on corporate selective hedging behaviour. When all model settings are maintained, Appendix 12 shows the test results with predation risk represented by the variable Sd_ocf. The effects of both board gender diversity and predation risk on corporate selective hedging behaviour are not significantly altered.

Beber and Febbri's (2012) method is used to identify corporate selective hedging behaviour in this study. By adopting this method, the focus is on the standard deviation of residual derivative holdings on fundamental characteristics. To investigate how corporate selective hedging behaviour is affected, all independent variables including female board participation, are estimated on average over the sample period (Beber & Febbri, 2012). The proxies estimated at the mean for female board participation represent the static board gender diversity but not dynamic changes in board gender composition. To further examine if the dynamic changes in board gender composition in time series significantly affect the test results, three dummy variables are generated. These dummy variables are generated according to changes of proxies of board gender diversity to be continuously increased (Fe_dir_X0), decreased (Fe_dir_0Y) or fluctuated (Fe_dir_XY) during the sample period. The summary of changes and frequency of changes in board gender composition during the sample period is shown in Appendix 13. As shown in Panel A, Appendix 13, during the sample period, 127 firms had new appointments of female directors (Fe_dir increased), of which 78 firms had continuously increased female directors. During the sample period, 85 firms had a decreasing number of female directors (Fe_dir decreased), of which 36 firms had continuously reduced the number of female directors. Though there were 64 firms with an unchanged number of female directors on boards, female directors were on and off boards during the sample period in 49 sample firms. Sample firms had nominated an average of 1.2 female directors and, on average, 1.08 female directors had left each sampled firm. The maximum number of female directors appointed to a board during the sample period was three and the maximum number of female directors who left during the sample period was two. The columns with headings of "inc_" or "dec_" report the number of sample firms with a different frequency of female directors. The following numbers indicate how often female directors are either increased or decreased. Of the firms with an increased number of female directors, 105 firms appointed female directors once, 19 firms appointed female directors twice and 3 firms appointed female directors three times during the sample period. Of the firms with a decreased number of female directors, 78 firms signed off a female director once and only 7 firms signed off a female director twice. The frequency of female directorship change is also reported for the sub-sample groups, i.e., Fe_dir_X0, Fe_dir_0Y, and Fe_dir_XY. Panels B and C, Appendix 13, report the changes and frequency of changes of both the fraction of female directors on boards (Fe_dir%) and Blau's (1977) index by gender (Bindex) during the sample period. Given that these two proxies of board gender diversity are estimated by percentage and taking into account the factor of board size, the changes in board gender composition are more diversified. For example, the maximum number of times that both Fe_dir% and Bindex increased is five whereas the maximum times that both Fe_dir% and Bindex decreased is four. In addition, both Fe_dir% and Bindex are increased approximately 1.8 times during the sample period, and they are decreased by approximately 1.6 times, on average.

Based on the four different types of change in board gender composition (i.e., continuously increased, continuously decreased, fluctuated and unchanged), the summary of the standard deviations of residual derivative holdings is reported in Appendix 14. Panel A reports for the total sample and Panels B, C, D report for the different types of change in board gender composition, which is proxied by B_female, B_pct_female and B_blau_index, respectively. As shown in Appendix 14, the standard deviation of residual derivative holdings is greatest for the firms where female directors were on and off the boards during the sample period. However, when the number of female directors or the fraction of female directors on boards is unchanged, the variation of residual derivative holdings is narrowest.

To test how the dynamic changes of female directors on boards affect corporate selective hedging behaviour, the categorical variables for the different types of change in board gender composition are added to the models. All the model settings are maintained from Table 5.18. Boards with fluctuating changes in the number of female directors are regarded as the base group to avoid the issue of perfect collinearity. Variables Fdir_X0, Fdir_0Y and Fdir_00 represent the other three types of change in the nomination of female directors. These changes are measured for each proxy of board gender diversity. Appendix 15 shows the results. The number of female directors is focused on in the first three columns. Compared with the boards where female directors changed back and forth (base group), the standard deviation of residual derivative holdings is significantly reduced in the firms with other types of change in board gender composition. In the models with static board gender diversity proxied by the fraction of female directors on boards and Blau's (1977) index by gender, the coefficients of both Fdir_X0 and Fdir_0Y are not significant but, generally, the coefficients of Fidr_00 are negatively significant. These results indicate that controlling the dynamic changes in board gender composition does not affect the explanatory power of board gender diversity on corporate selective hedging behaviour. The bell-shaped relationship is verified according to the significant coefficients of all squared proxies of board gender diversity with negative signs. Firms with unchanged female directors on the board are less likely to use the derivatives to time the market.

A sub-sample analysis is conducted to test the existence of a critical mass of female participation on boards materially affecting corporate selective hedging behaviour. First, the sample firms are grouped by the number of female directors on the board. Appendix 16 shows the test results when different level factors are all controlled. Both the fraction of female directors on the board and Blau's (1977) index by gender are used to represent the degree of board gender diversity. There are only 10 firms with no female participation on the board. Regressions cannot be conducted because of a smaller number of observations than independent variables. Alternatively, firms with one or fewer female directors on the board are grouped and shown in columns 2 and 6 ("fedir=3" indicates the firms with three and more female directors on boards). According to the results in

Appendix 16, female participation on boards has no effect on corporate selective hedging behaviour until there are at least three women directors. When the number of female directors is beyond three, firms with more female directors on the board are less likely to selectively hedge foreign currency risk. The sub-sample analysis is also conducted with sample firms grouped according to Kanter's (1977a, b) method. Considering the limited observations grouped as uniform or balanced boards, firms with uniform and skewed boards are sub-sampled together and firms with tilted and balanced boards are sub-sampled together. As shown in Appendix 17, for sample firms with less than 20% of female directors on the board (%fe_dir <=skewed), all proxies of board gender diversity have no explanatory power on corporate selective hedging behaviour. However, for the sample firms with tilted or balanced boards, the coefficients of all proxy variables of board gender diversity are negatively significant. The results indicate that corporate selective hedging behaviour is not significantly influenced by female participation on boards until at least tilted boards are formed. Once the fraction of female directors on a board is beyond 20%, with an increasing number of female directors on the board, corporate selective hedging behaviour will be conducted more conservatively. In summary, all subsample analysis above supports the existence of a critical mass of female participation on boards to affect corporate selective hedging behaviour.

## 5.7 Does Predation Risk Mediate the Effect of Board Gender Diversity on Corporate Selective Hedging Behaviour?

In this study, it is argued that both board gender diversity and predation risk affect corporate selective hedging behaviour. Sobel-Goodman mediation tests are conducted to verify the mediation effect of predation risk on this relationship. The tests are conducted when predation risk is measured by different proxies. The results are shown in Table 5.21 (page 136). Predation risk is measured by four proxies as discussed before. They are market to book ratio of assets (MTB), the percentage of debts matured in no less than three years (Dm3), the standard deviation of operating cash flow during the sample period (Sd_ocf), and a concentration measure based on market share (HHI). Board gender diversity is represented by three proxy variables, i.e., B_Female, B_pct_Female and B_blau_index. As shown in Table 5.21, Path c is tested by conducting a simple regression analysis with board gender diversity predicting corporate selective hedging behaviour. Path a is tested by conducting a simple regression analysis with board gender diversity predicting predation risk. Paths b and c' are analysed in the models with corporate selective hedging regressed on both intervening variables of predation risk and the independent variable of board gender diversity. Indirect effect designates how board gender diversity affects corporate selective hedging behaviour through the measures of predation risk. The results consistently indicate that board gender diversity has no effect on the measures of predation risk regardless of the proxies used to represent both predation risk and board gender diversity. In Panels A and B, regression analysis on path b provides positive coefficients of variable MTB and negative coefficients of variable Dm3. These coefficients with a statistic of significance consistently support the explanatory power of predation risk on the standard deviation of residual derivative holdings. However, when predation risk is measured by variables of Sd_ocf and HHI in Panels C and D, a significant impact of predation risk on corporate selective hedging behaviour is not found. Though the direct effect of board gender diversity on corporate selective hedging is documented in all panels, an indirect effect through predation risk is not found.

To rule out the possibility of the effect of board gender diversity on corporate selective hedging behaviour through mediation function of predation risk, structural equation modelling (SEM) is also used. Predation risk and board gender diversity are measured by different proxies as well as

Sobel-Goodman mediation tests. The fundamental financial characteristics that are used for baseline regressions (shown in Table 5.4) are controlled for SEM estimation.

The results in Table 5.22 (page 137) indicate both board gender diversity (P-value =0.072) and predation risk (P-value =0.058) have explanatory power on the standard deviation of residual derivative holdings. However, board gender diversity has no effect on predation risk (P-value =0.666). The diagram of the structural equation model is shown in Appendix 10. Structural equation modelling cannot find an indirect effect of predation risk on the relationship between board gender diversity and corporate selective hedging behaviour.

These tests rule out an indirect effect of board gender diversity on corporate selective hedging behaviour through the mediation function of predation risk. Combining the results from the Sobel-Goodman mediation tests and structural equation modelling, the fourth hypothesis is rejected.

**Table 5.21 Sobel-Goodman Test for the Mediation Function of Predation Risk in Explaining the Effects of Board Gender Diversity on the Standard Deviation of Residual Derivative Holdings (**σres)

This table indicates the results of Sobel-Goodman mediation tests of whether the effect of board gender diversity on corporate selective hedging behaviour is mediated by predation risk. Sobel_Goodman mediation tests are conducted orderly with predation risk proxied by four variables respectively, i.e., MTB, Dm3, Sd_ocf and HHI. Board gender diversity is represented by three proxies. They are the number of female directors on boards (B_Female), the fraction of female directors on boards (B_pct_Female) and the Blau's (1977) index by gender (B_blau_index).

| **Panel A: Mediation= MTB** | **B_Female** | **B_pct_Female** | **B_blau_index** | **Panel B: Mediation= Dm3** | **B_Female** | **B_pct_Female** | **B_blau_index** |
|---|---|---|---|---|---|---|---|
| σres ← BGD (path c) | -0.0047* | -0.0504* | -0.0385 | σres ← BGD (path c) | -0.0056** | -0.0589* | -0.0433* |
| | [0.060] | [0.093] | [0.103] | | [0.040] | [0.064] | [0.078] |
| MTB ← BGD (path a) | -0.0680 | 0.1041 | -0.0670 | Dm3 ← BGD (path a) | 0.0101 | 0.0001 | 0.0754 |
| | [0.396] | [0.913] | 0929 | | [0.650] | [0.999] | [0.707] |
| σres ← MTB, BGD (path b) | 0.0046** | 0.0048** | 0.0048** | σres ← Dm3, BGD (path b) | -0.0138* | -0.0143* | -0.0139* |
| | [0.028] | [0.021] | [0.022] | | [0.094] | [0.083] | [0.091] |
| σres ← MTB, BGD (path c') | -0.0044* | -0.0509* | -0.0382 | σres ← Dm3, BGD (path c') | -0.0055** | -0.0589* | -0.0422* |
| | [0.077] | [0.087] | [0.103] | | [0.044] | [0.062] | [0.084] |
| Indirect effect | -0.0003 | 0.0005 | -0.0003 | Indirect effect | -0.0001 | -0.0001 | -0.0011 |
| | [0.427] | [0.9127] | [0.929] | | [0.661] | [0.999] | [0.7134] |
| Direct effect | -0.0044* | -0.0509* | -0.0382 | Direct effect | -0.0055** | -0.0589* | -0.0422* |
| | [0.076] | [0.092] | [0.101] | | [0.043] | [0.061] | [0.076] |
| **Panel C: Mediation= Sd_ocf** | **B_Female** | **B_pct_Female** | **B_blau_index** | **Panel D: Mediation= HHI** | **B_Female** | **B_pct_Female** | **B_blau_index** |
| σres ← BGD (path c) | -0.0047* | -0.0504*** | -0.0385 | σres ← BGD (path c) | -0.0047* | -0.0504* | -0.0385 |
| | [0.060] | [0.009] | [0.103] | | [0.060] | [0.093] | [0.103] |
| Sd_ocf ← BGD (path a) | 0.0084 | 0.0904 | 0.0938 | HHI ← BGD (path a) | 0.0032 | 0.0485 | 0.0232 |
| | [0.417] | [0.461] | [0.331] | | [0.389] | [0.264] | [0.498] |
| σres ← Sd_ocf, BGD (path b) | 0.0114 | 0.0110 | 0.0114 | σres ← HHI, BGD (path b) | 0.0697 | 0.0707 | 0.0680 |
| | [0.486] | [0.499] | [0.484] | | [0.129] | [0.125] | [0.139] |
| σres ← Sd_ocf, BGD (path c') | -0.0048* | -0.0514* | -0.0396* | σres ← HHI, BGD (path c') | -0.0050** | -0.0538* | -0.0401* |
| | [0.056] | [0.088] | [0.095] | | [0.049] | [0.073] | [0.089] |
| Indirect effect | 0.0001 | 0.0010 | 0.0011 | Indirect effect | 0.0002 | 0.0034 | 0.0016 |
| | [0.597] | [0.618] | [0.5693] | | [0.453] | [0.365] | [0.537] |
| Direct effect | -0.0048* | -0.0514* | -0.0396* | Direct effect | -0.0050** | -0.0538* | -0.0401* |
| | [0.059] | [0.086] | [0.093] | | [0.048] | [0.072] | [0.088] |

***, **, * denotes statistical significance at the 1%, 5%, and 10% levels, respectively. P-values are reported in parentheses.

**Table 5.22 Structural Equation Modelling for Testing the Mediation Function of Predation Risk in Explaining the Effects of Board Gender Diversity on the Standard Deviation of Residual Derivative Holdings (**σres)

This table indicates the test results of structural equation modelling of whether the effect of board gender diversity on corporate selective hedging behaviour is mediated by predation risk. Predation risk is proxied by four variables respectively, i.e., MTB, Dm3, Sd_ocf and HHI. Board gender diversity is represented by three proxies. They are the number of female directors on boards (B_Female), the fraction of female directors on boards (B_pct_Female) and the Blau's (1977) index by gender (B_blau_index). The fundamental financial characteristics that are shown in column 3, Table 5.4 are controlled.

| SEM Estimation | Coef. | z | P>\|z\| |
|---|---|---|---|
| **Structural** | | | |
| σres ← | | | |
| Predation risk | 0.1863 | 1.90 | 0.058 |
| Fincome | 0.0243 | 0.85 | 0.393 |
| Debt | -0.0056 | -0.11 | 0.914 |
| Firmsize | 0.0225 | 0.44 | 0.658 |
| Institutional | 0.1023 | 1.53 | 0.125 |
| TaxlossCF | 0.1096 | 2.25 | 0.025 |
| CEO_cashcomp | 0.0103 | 0.23 | 0.816 |
| BGD | -0.1092 | -1.80 | 0.072 |
| Predation risk ← | | | |
| BGD | 0.0401 | 0.43 | 0.666 |
| **Measurement** | | | |
| Predation Risk | | | |
| MTB ← | 0.7961 | 4.13 | 0.000 |
| Dm3 ← | -0.3769 | -4.25 | 0.000 |
| Sd_ocf ← | 0.0262 | 0.29 | 0.771 |
| HHI ← | 0.4421 | 3.55 | 0.000 |
| BGD | | | |
| B_female ← | 0.9499 | 106.85 | 0.000 |
| B_pct_female ← | 0.9981 | 393.12 | 0.000 |
| B_blau_index ← | 0.9778 | 156.01 | 0.000 |

***, **, * denotes statistical significance at the 1%, 5%, and 10% levels, respectively. P-values are reported in parentheses.

## 5.8 Summary

In this chapter, the effect of predation risk because of information asymmetry on corporate selective hedging behaviour is initially investigated. According to the arguments in Bolton and Scharfstein (1990) on predation theory, three proxy variables are used to represent the predation risk. The test results indicate that all three proxy variables are significantly associated with the standard deviation of residual derivative holdings. Furthermore, the inappropriateness of interdependence of investment opportunities that was used in previous studies to represent the predation risk is discussed. The empirical results do not find an effect of the interdependence of investment opportunities on corporate derivative use. Industry structure as an indicator of predation risk is also analysed. Industry competition as a governance mechanism to alleviate information asymmetry explains the positive relationship between industry structure and corporate selective hedging. However, there is no evidence to support the explanatory power of interdependence of investment opportunities on this relationship. Robustness tests provide consistent findings to support this conclusion.

The effect of board gender diversity on corporate selective hedging is also discussed in this chapter. The analysis based on OLS regressions finds that a firm with more females on the board conduct corporate selective hedging behaviour more conservatively. Over-identified GMM models are used with test results consistently supporting the above findings. To further test the existence of a critical mass, with the expectation of a non-linear relationship between board gender diversity and corporate selective hedging, different methods are applied. The estimations based on both models with quadratic functions and models with categorical variables to indicate board gender composition are conducted. A bell-shaped relationship between board gender composition and corporate selective hedging is found, which is also supported by sub-sample analysis. Additional control of dynamic changes in board gender composition during the sample period does not significantly affect the results. By conducting the Sobel-Goodman tests and structural equation modelling, board gender diversity does not affect corporate selective hedging through the mediation effect of predation risk.

# CHAPTER SIX: CONCLUSIONS

## 6.1 Introduction

This study investigated how corporate selective hedging behaviour is affected by competitive environments. Both predation risk as a result of product market competition and diversified board gender composition are considered. This study is summarised in section 6.2. In section 6.3 knowledge contributions are outlined, followed by the research limitations in section 6.4. Finally, suggestions for future research are provided in section 6.5 and a concluding statement is in 6.6.

## 6.2 Research Summary

Derivatives are widely used to time the market based on a decision maker's active view (Bodnar et al., 1998; Brown, 2001; Brown et al., 2006; Faulkender, 2005; Glaum, 2002; Loss, 2012; Wojakowsk, 2012). Because of a lack of disclosure on why and how derivatives are actually used, the risks embedded in corporate derivative use are not sufficiently brought to the forefront in investors' decision making. Derivatives can be used to hedge the risks as the result of market fluctuation but they can also be used to obtain extra returns. The opportunities to obtain extra returns could form a strategic advantage in intensive competition. For firms that adopt selective hedging behaviour, balancing both the hedging and speculating functions of derivatives is an important corporate decision. This study analyses both market and board factors to investigate how corporate selective hedging behaviour is affected by the competitive environments in which firms are involved. Beber and Fabbri's (2012) two-stage model is applied to identify corporate selective hedging behaviour. In the first stage, the gross notional amounts of derivatives that manage foreign currency risk are initially regressed on firms' fundamental characteristics as determinants of derivative hedges. The standard deviation of residual derivative holdings that cannot be explained by fundamental characteristics at the first stage represents corporate selective hedging behaviour.

To examine how external market factors affect corporate selective hedging behaviour, the predation risk because of product market competition is considered. Three different proxies are used to represent predation risk. The results provide consistent support for the explanatory power of predation risk on corporate selective hedging behaviour. Interdependence of investment opportunities is suggested in Haushalter et al. (2007) to indicate the extent of predation risk. They argue that firms encounter higher predation risk if their investment opportunities are more interdependent with peers. Haushalter et al. (2007) claim that, based on the link between predation risk and interdependence of investment opportunities, firms encountering higher predation risk are more likely to use derivatives to hedge. In other words, selective hedging to time the market is not encouraged for firms encountering predation risk. In order to verify Haushalter et al.'s (2007) arguments, the effect of the interdependence of investment opportunities on derivative use and corporate selective hedging behaviour is examined. However, no significant association between these two was consistently found. When measures of market structure (HHI & HHI4) are the focus, the results support the effect of product market competition on corporate selective hedging behaviour. This effect is explained by the mechanism of product market competition on reducing information asymmetry and improving transparency rather than an indication of the interdependence of investment opportunities that firms encounter. The findings support the criticisms of the relationships claimed by Haushalter et al. (2007) among the interdependence of investment opportunities, predation risk and corporate derivative use.

To examine how internal board factors affect corporate selective hedging behaviour, board gender diversity is considered. Three proxy variables are used to represent board gender composition: the number of female directors on the board, the fraction of female directors, and Blau's (1977) index by gender. OLS regressions provide findings with negative associations between board gender diversity and corporate selective hedging behaviour. The findings are consistently significant when over-identified GMM estimators are used to mitigate the endogeneity problem arising from reversal causality. To further test the non-linear relationship between board gender diversity and corporate selective hedging behaviour, models with quadratic functions and categorical proxy variables are used. The categorical variables are set by both the number of female directors on the board and the fraction of female directors as in Kanter's (1977a, b) method. The results indicate a bell-shaped relationship that reflects how board gender composition affects the standard deviation of residual derivative holdings. This bell-shaped relationship confirms the existence of a critical mass of female directors on a board to explain corporate selective hedging behaviour. Both female risk-aversion and intergroup bias supported by social identity and self-categorisation theories jointly explain the phenomenon. The Sobel-Goodman mediation test and structural equation modelling (SEM) are used to test whether predation risk mediates the effect of board gender diversity on corporate selective hedging behaviour. Mediation effect of predation risk is not found.

In summary, both predation risk arising from product market competition and board gender diversity affect corporate selective hedging behaviour. Firms encountering higher predation risk are more likely to selectively hedge foreign currency risk. Where board gender composition is concerned, firms with more female directors on the board are less likely to hedge selectively. This phenomenon does not appear unless female directors express their real risk propensity other than act as tokens in making corporate risk-taking decisions. The condition under which female directors are prevented from being regarded as tokens is participation on boards beyond a critical mass (at least three female directors or over 20% of directorship occupied by women). By focusing on both predation risk and board gender composition, this study found that corporate selective hedging behaviour is affected by both the external and internal competitive environments in which the firms are involved.

The hypotheses test results are summarised in Table 6.1.

**Table 6.1 Summary of Hypothesis Tests**

| | Hypotheses | Results |
|---|---|---|
| H1: | Firms encountering higher predation risk are more likely to hedge selectively. | Supported |
| H2: | Board gender diversity affects corporate selective hedging behaviour. | Supported |
| H3: | A critical mass exists for the effect of board gender diversity on corporate selective hedging behaviour. | Supported |
| H4: | Predation risk that a firm encounter mediates the effect of board gender diversity on corporate selective hedging behaviour. | Rejected |

## 6.3 Contributions

This study makes several contributions to knowledge:

1) By aiming at both external and internal competitive environments in which firms are involved, this study accumulates knowledge on how derivatives are used to manage foreign currency risk. A suggested answer to the question about what could affect corporate decisions on balancing derivatives' functions of hedging and speculating is provided. Previous studies investigate corporate selective hedging behaviour by focusing on isolated factors such as managerial compensation (Beber & Fabbri, 2012; Brown et al., 2006; Géczy et al., 2007), earnings management (Chernenko & Faulkender, 2011), overconfidence and mental accounts (Adam et al., 2007; Adam et al., 2015; Beber & Fabbri, 2012). This study provides evidence on how competitive environments at both industry and board levels could make firms selectively hedge foreign currency risk.

2) The relationship among predation risk, strategic investing, the interdependence of investment opportunities and corporate derivative use is reconsidered. In Haushalter et al. (2007), the

predation risk that a firm encounters is represented by the degree of interdependence of investment opportunities that a firm has with peers. This study criticises the arguments in Haushalter et al. (2007) and provides comments on the identification of predation risk according to the predation theory explained in Bolton and Scharfstein (1990). This will benefit subsequent studies of predation risk.

3) Industry structure proxied by industry concentration measures (HHI & HHI4) is widely used to represent the level of market power in prior studies (Akdogu & MacKay, 2008; Klepsch, 2016; Valta, 2012). These measures are also employed to indicate the degree of interdependence of investment opportunities (Chi & Su, 2016; Haushalter et al., 2007). This study analyses how product market competition that is represented by competition measures affects corporate selective hedging behaviour. The explanatory power of product market competition on corporate selective hedging behaviour is solely attributable to its function in alleviating information asymmetry and improving transparency. Considering the endogeneity issue of industry concentration measures, this study reminds us to be cautious of interpretations of industry concentration in related empirical studies.

4) Prior studies examine the effects of board gender diversity from different perspectives such as corporate performance (Adams & Ferreira, 2009; Ali et al., 2014; Liu et al., 2014), corporate reputation (Bear et al., 2010; Miller & Triana, 2009), CSR and corporate philanthropy (Boulouta, 2013; Landry et al., 2016; Liao et al., 2015; Post et al., 2011), capital market reaction (Gul et al., 2011; Kang et al., 2010), and earnings management (Srinidhi et al., 2011). The effects on different corporate risks are also investigated such as risk in innovation and R&D (Chen et al., 2016; Loukil & Yousfi, 2013; Miller & Triana, 2009), risk in M&A (Levi et al., 2014), and equity risk (Loukil & Yousfi, 2013; Sila et al., 2016). However, how board gender

diversity affects risk in using derivatives is seldom investigated. Taking into account corporate selective hedging as risk-taking behaviour, this study contributes to the literature on the economic outcomes of board gender diversity.

5) Past studies provide evidence of the existence of tokens on boards of directors (Joecks et al., 2013; Konrad et al., 2008; Kramer et al., 2006; Liu et al., 2014). The impact of board gender diversity on economic outcomes could be distorted if board members of minorities act as tokens. By conducting the analysis of the non-linear relationship between board gender diversity and corporate selective hedging behaviour, this study highlights the applicability of critical mass theory in explaining the economic outcomes of dynamic changes in board gender composition.

## 6.4 Limitations

The findings in this study should be interpreted in line with the following limitations. This study follows Beber and Fabbri's (2012) procedure to identify corporate selective hedging behaviour by focusing on the variation of total gross notional amounts of derivatives. For foreign currency risk management, forwards, options and swaps are the derivatives most commonly used by sample firms. However, because of the lack of consistent disclosure, different types of derivatives that firms choose to manage foreign currency risk cannot be further analysed. Though most studies in the field of corporate hedging and risk management focus on the gross notional amounts of derivatives, without further investigation on the different use of derivatives among firms could possibly affect the results.

Firms in S&P 500 from 2009 to 2014 are sampled. Before 2009, a large number of firms did not disclose the gross notional amounts of derivatives that were used to manage market risks. However, disclosure of the gross notional amounts of derivatives has improved since SFAS No.

161 (“Disclosures about Derivative Instruments and Hedging Activities, an amendment of FASB Statement No. 133”) was issued in March 2008. SFAS No. 161 has been effective since the third quarter of the 2009 fiscal year. Though the disclosure of gross notional amounts of derivatives was still not compulsory, most firms provide such information in annual reports and 10-k filings. Because of the limited disclosure in public databases providing the gross notional amounts of derivatives, data were manually collected for firms in S&P 500 from 2009 to 2014. In this study, variation in derivative use is used to represent market timing when factors that explain derivative hedges are excluded. Variation in derivative use over longer periods could better reflect market timing by the uncertainty of derivative use, thus making the results more persuasive.

## 6.5 Future Research

This study focusing on foreign currency risk investigates the effects of the competitive environments in which firms are involved on corporate selective hedging behaviour. The competitive environments that firms encounter in managing different market risks could be different. It would be interesting to further test if and how the competitive environments affect corporate selective hedging behaviour against interest rate risk or risk derived from the movements of commodity prices.

Board gender diversity is a focus in this study investigating the effect of the internal competitive environment on corporate selective hedging behaviour. Apart from board gender composition, other board directors’ characteristics such as age, educational background, and ethnicity could also be factors affecting corporate risk management. If the critical mass theory is valid, it could possibly explain how corporate selective hedging behaviour is non-linearly affected by these different board characteristics; further investigation is needed. In addition, since board functions are generally conducted by board committees, how the composition of board committees affects corporate selective hedging behaviour could be of interest for future research.

## 6.6 Concluding Comments

This study highlights how important contextual environments are in affecting corporate decision making on derivative use. Taking a risk to time the derivative market is affected by other potential risks that decision makers, or the firms that they represent, could encounter. These risks not only come from aggressive external competition but also from internal competitive conflicts in group decision making processes. In addition, decision makers' individual risk preferences cannot be ignored. A comprehensive understanding of corporate risk-taking behaviour cannot be truly obtained without taking above those into account and balancing the risks (or risk preferences) that exist in individual, group and industry perspectives. This study provides an insight into decision making process to explain how risks are dealt with in competitive environments.

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# Appendix

**Appendix 1: Description of the Variables**

| Variables | Description |
|---|---|
| de_FX | Gross notional amounts of foreign currency derivatives deflated by total assets |
| sd_res | Standard deviation of residuals estimated in baseline models |
| MTB | (Total assets – BV of equity + MV of equity)/ Total assets |
| Sd_ocf | The standard deviation of cash flow from operating activities during sample years |
| Dm1 | Percentage of interest-bearing debts with maturity >= 1 year over total interest-bearing debts |
| Dm2 | Percentage of interest-bearing debts with maturity >= 2 years over total interest-bearing debts |
| Dm3 | Percentage of interest-bearing debts with maturity >= 3 years over total interest-bearing debts |
| Dm4 | Percentage of interest-bearing debts with maturity >= 4 years over total interest-bearing debts |
| Dm5 | Percentage of interest-bearing debts with maturity >= 5 years over total interest-bearing debts |
| Corr | Covariance of a firm's stock returns with industry's stock return |
| K-L Distance | the absolute value of the difference between a firm's capital-to-labour ratio and industry mean |
| Fluidity | a text-based measure of product fluidity by Hoberg et al. (2014) |
| HHI | Sum of the squares of market shares for the firms in the industry classified by 6-digit GIC codes |
| HHI4 | Sum of the squares of market shares for the biggest 4 firms in the industry classified by 6-digit |
| MTB | (Total assets – BV of equity + MV of equity)/Total assets |
| EPCM | Excess price-cost margin: operating income before depreciation/total assets |
| B_Female | The number of female directors on a board |
| B_pct_Female | The proportion of female directors on a board |
| B_blau_index | The Blau's (1977) index by gender of the board directors |
| Uniform_board | The boards on which all directors are male |
| Skewed_board | The boards on which female directors are less than 20% |
| Tilted_board | The boards on which female directors are 20% or more, but less than 40% |
| Balanced_board | The boards on which female directors are 40% or more |
| CapEx | Capital expenditure |
| Fincome | Foreign income |
| Debt | Debts to assets ratio |
| Firmsize | Ln (MV of equity plus book value of debts) |
| Institutional | Number of block holders of shares that are greater than 5% |
| TaxlossCF | Tax loss carry forward |
| CashDiv | Cash dividend over total assets |
| Cashholdings | Total cash holdings deflated by total assets |
| CEO_cashcomp | CEO total current compensation (salary + bonus) |
| CEO_age | CEO's age |
| CEO_tenure | CEO's tenure |
| CEO_gender | CEO's gender |
| B_sd_age | The standard deviation of ages of board directors |
| B_sd_tenure | The standard deviation of tenures of board directors |
| B_sd_cashcomp | The standard deviation of cash compensation of board directors |
| B_d_raceminority | Dummy variable if at least one director of race minority exists |
| B_pct_fi_expert | The fraction of board directors who are a financial expert |

**Appendix 2: Robustness Tests for Effect of Debts Maturity on the Standard Deviation of Residual Derivative Holdings**
Estimator Comparison for Regressions of Std. Deviation of Residuals on variables of Dm1, Dm2, Dm4 and Dm5 respectively. This table presents the results of OLS regressions with the standard deviation of residual derivative holdings as dependent variables. The residuals are estimated from the panel regression model with firm and year fixed effects shown in column 3, table 5.4. In this table, predation risk is represented by the percentage of debts matured no less than one, two, four and five years, i.e., Dm1, Dm2, Dm4, and Dm5. All independent variables employed in baseline models are controlled. The proxy variables of financial strength, i.e., Cashholdings and CashDiv are added to the model shown in models 1, 4, 7, and 10. The proxy variables of managers' personal characteristics, i.e., CEO_age, CEO_tenure, and CEO_gender are added to the model shown in models 2, 5, 8, and 11. In models 3, 6, 9, 12, all variables that represent for either financial strength or manger's personal characteristics are jointly controlled. In all models, EPCM as a proxy of market power is also controlled. Appendix 1 provides detailed information on the construction of variables. Industry dummy is controlled in all models. All models are analysed with robust standard errors.

| **Dep. Var: sd of residuals** | **(1)** | **(2)** | **(3)** | **(4)** | **(5)** | **(6)** |
|---|---|---|---|---|---|---|
| Dm1 | -0.0213 | -0.0247* | -0.0212* | | | |
| | [0.103] | [0.060] | [0.091] | | | |
| Dm2 | | | | -0.0239** | -0.0273*** | -0.0237** |
| | | | | [0.017] | [0.007] | [0.017] |
| No. obs. | 222 | 222 | 222 | 215 | 215 | 215 |
| r2 | 0.1757 | 0.1748 | 0.1858 | 0.1895 | 0.1843 | 0.1958 |
| **Dep. Var: sd of residuals** | **(7)** | **(8)** | **(9)** | **(10)** | **(11)** | **(12)** |
| Dm4 | -0.0283*** | -0.0313*** | -0.0286*** | | | |
| | [0.001] | [0.000] | [0.001] | | | |
| Dm5 | | | | -0.0220** | -0.0233** | -0.0223** |
| | | | | [0.020] | [0.013] | [0.020] |
| No. obs. | 207 | 207 | 207 | 194 | 194 | 194 |
| r2 | 0.2191 | 0.2144 | 0.2262 | 0.1999 | 0.2 | 0.2028 |
| Control for Fundamental Financial Characteristics | Y | Y | Y | Y | Y | Y |
| Additional Controls of Financial Strength | Y | N | Y | Y | N | Y |
| Additional Controls of CEO's Characteristics | N | Y | Y | N | Y | Y |
| Industry Dummies | Y | Y | Y | Y | Y | Y |
| Robust Std. Err. | Y | Y | Y | Y | Y | Y |

***, **, * denotes statistical significance at the 1%, 5%, and 10% levels respectively. P-values are reported in parentheses.

**Appendix 3: Summary Statistics of the Std. Deviation of Residual Derivative Holdings by Changes of the Proxies of Predation Risk**

Summary statistics of the standard deviation of residual derivative holdings by changes of the proxies of predation risk. This table shows summary statistics on the standard deviation of residual derivative holdings. The residual derivative holdings are estimated from the panel regression model with firm and year fixed effects shown in column 3, table 5.4. Panel A shows the summary statistics for full sample firm observations. Panel B indicates the summary statistics of the standard deviation of residual derivative holdings categorised by the changes of variable MTB. Panel C indicates the summary statistics of the standard deviation of residual derivative holdings categorised by the changes of variable Sd_ocf. Panel D indicate the summary statistics of the standard deviation of residual derivative holdings categorised by the changes of variable Dm3. The prefix "Inc_" indicates that the value of the variables continuously increases during the sample period. The prefix "Dec_" indicates that the value of the variables continuously decreases during the sample period. The prefix "Var_" indicates that the value of the variables fluctuates during the sample period.

| Variables | Obs | Mean | Std. Dev. | Min | Max |
|---|---|---|---|---|---|
| Panel A: Total | | | | | |
| sd_res | 227 | 0.0269 | 0.0271 | 0.0011 | 0.2458 |
| Panel B: By MTB | | | | | |
| Inc_F_Q | 27 | 0.0208 | 0.0143 | 0.0015 | 0.0497 |
| Dec_F_Q | 2 | 0.0439 | 0.0037 | 0.0413 | 0.0465 |
| Var_F_Q | 198 | 0.0276 | 0.0284 | 0.0011 | 0.2458 |
| Panel C: By Sd_ocf | | | | | |
| Inc_OCF | 27 | 0.0356 | 0.0279 | 0.0051 | 0.1136 |
| Dec_OCF | 11 | 0.0144 | 0.0083 | 0.0015 | 0.0268 |
| Var_OCF | 189 | 0.0264 | 0.0274 | 0.0011 | 0.2458 |
| Panel D: By Dm3 | | | | | |
| Inc_dm3_d | 5 | 0.0156 | 0.0192 | 0.0051 | 0.0497 |
| Dec_dm3_d | 6 | 0.0247 | 0.0102 | 0.0074 | 0.0366 |
| Var_dm3_d | 201 | 0.0273 | 0.0276 | 0.0011 | 0.2458 |

**Appendix 4: Summary Statistics of the Std. Deviation of Residual Derivative Holdings by Changes of the Proxies of Interdependence of Investment Opportunities**

Summary statistics of the standard deviation of residual derivative holdings by changes of the variables that are utilised as proxies of the interdependence of investment opportunities. This table shows summary statistics on the standard deviation of residual derivative holdings. The residual derivative holdings are estimated from the panel regression model with firm and year fixed effects shown in column 3, Table 5.4. Panel A shows the summary statistics for full sample firm observations. Panel B indicates the summary statistics of the standard deviation of residual derivative holdings categorised by the changes of variable Corr. Panel C indicates the summary statistics of the standard deviation of residual derivative holdings categorised by the changes of variable K-L Distance. Panel D indicate the summary statistics of the standard deviation of residual derivative holdings categorised by the changes of variable Fluidity. Panel E indicates the summary statistics of the standard deviation of residual derivative holdings categorised by the changes of variable HHI. Panel F indicates the summary statistics of the standard deviation of residual derivative holdings categorised by the changes of variable HHI4. The prefix "Inc_" indicates that the value of the variables continuously increases during the sample period. The prefix "Dec_" indicates that the value of the variables continuously decreases during the sample period. The prefix "Var_" indicates that the value of the variables fluctuates during the sample period.

| Variables | Obs | Mean | Std. Dev. | Min | Max |
|---|---|---|---|---|---|
| Panel A: Total | | | | | |
| sd_res | 227 | 0.0269 | 0.0271 | 0.0011 | 0.2458 |
| Panel B: By Corr | | | | | |
| Inc_Corr | 3 | 0.0218 | 0.0243 | 0.0051 | 0.0497 |
| Dec_Corr | 5 | 0.0309 | 0.0122 | 0.0137 | 0.0465 |
| Var_Corr | 219 | 0.0269 | 0.0275 | 0.0011 | 0.2458 |
| Panel C: By K-L Distance | | | | | |
| Inc_K-L Distance | 13 | 0.0409 | 0.0631 | 0.0051 | 0.2458 |
| Dec_K-L Distance | 5 | 0.0282 | 0.0136 | 0.0137 | 0.0494 |
| Var_K-L Distance | 209 | 0.0260 | 0.0235 | 0.0011 | 0.1293 |
| Panel D: By Fluidity | | | | | |
| Inc_Fluidity | 0 | n/a | n/a | n/a | n/a |
| Dec_Fluidity | 13 | 0.0434 | 0.0626 | 0.0015 | 0.2458 |
| Var_Fluidity | 214 | 0.0259 | 0.0233 | 0.0011 | 0.1293 |
| Panel E: By HHI | | | | | |
| Inc_HHI | 21 | 0.0263 | 0.0188 | 0.0022 | 0.0651 |
| Dec_HHI | 16 | 0.0176 | 0.0118 | 0.0012 | 0.0437 |
| Var_HHI | 190 | 0.0278 | 0.0287 | 0.0011 | 0.2458 |
| Panel F: By HHI4 | | | | | |
| Inc_HHI4 | 30 | 0.0193 | 0.0104 | 0.0022 | 0.0402 |
| Dec_HHI4 | 19 | 0.0255 | 0.0276 | 0.0012 | 0.1097 |
| Var_HHI4 | 178 | 0.0284 | 0.0288 | 0.0011 | 0.2458 |

**Appendix 5: Estimator Comparison for regressions of Std. Deviation of Residual Derivative Holdings on Proxies of Predation Risk with Time-series Changes of Predation Risk Controlled**

This table presents the results of OLS regressions with the standard deviation of residual derivative holdings as dependent variables. The residuals are estimated from the panel regression model with firm and year fixed effects shown in column 3, table 5.4. In this table, predation risk is represented by variables of MTB, Dm3 and Sd_ocf respectively. All independent variables employed in baseline models are controlled. The proxy variables of financial strength, i.e. Cashholdings and CashDiv are added additionally into the models shown in columns 1, 4 and 7. The proxy variables of managers' personal characteristics, i.e. CEO_age, CEO_tenure, and CEO_gender are added additionally into the models shown in columns 2, 5, and 8. In column 3, 6, and 9, all variables that represent for either financial strength or manger's personal characteristics are jointly controlled. The indicator variables for the change of variables of interest are controlled in all models. Appendix 1 provides detailed information on the construction of variables. Industry dummy is controlled in all models. All models are analysed with robust standard errors.

| Dep. Var: sd of residuals | (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) | (9) |
|---|---|---|---|---|---|---|---|---|---|
| MTB | 0.0043* | 0.0034 | 0.0043* | | | | | | |
| | [0.063] | [0.106] | [0.054] | | | | | | |
| Dm3 | | | | -0.0276*** | -0.0302*** | -0.0276*** | | | |
| | | | | [0.003] | [0.001] | [0.003] | | | |
| Sd_ocf | | | | | | | 0.0221** | 0.0224** | 0.0217** |
| | | | | | | | [0.018] | [0.035] | [0.022] |
| Inc_Vars | -0.0049 | -0.0078** | -0.0062 | -0.0097 | -0.0115 | -0.0095 | 0.0071 | 0.0074 | 0.0068 |
| | [0.201] | [0.046] | [0.120] | [0.217] | [0.149] | [0.234] | [0.239] | [0.239] | [0.243] |
| Dec_Vars | 0.0033 | 0.0062 | 0.0062 | 0.0043 | 0.0063 | 0.0058 | -0.0098** | -0.0116*** | -0.0107*** |
| | [0.855] | [0.670] | [0.750] | [0.718] | [0.589] | [0.615] | [0.019] | [0.005] | [0.010] |
| _cons | -0.0286 | -0.001 | -0.0186 | 0.005 | 0.036 | 0.0179 | -0.0152 | 0.0152 | -0.0017 |
| | [0.190] | [0.968] | [0.504] | [0.827] | [0.198] | [0.541] | [0.484] | [0.569] | [0.952] |
| No. obs. | 227 | 227 | 227 | 212 | 212 | 212 | 227 | 227 | 227 |
| r2 | 0.1768 | 0.1759 | 0.1887 | 0.2077 | 0.2057 | 0.2142 | 0.1802 | 0.1819 | 0.1902 |
| Control for Fundamental Financial Characteristics | Y | Y | Y | Y | Y | Y | Y | Y | Y |
| Addional Controls of Fi.Strength | Y | N | Y | Y | N | Y | Y | N | Y |
| Additional Controls of CEO's Characteristics | N | Y | Y | N | Y | Y | N | Y | Y |
| Industry Dummies | Y | Y | Y | Y | Y | Y | Y | Y | Y |
| Robust Std. Err. | Y | Y | Y | Y | Y | Y | Y | Y | Y |

***, **, * denotes statistical significance at the 1%, 5%, and 10% levels respectively. P-values are reported in parentheses.

**Appendix 6: Estimator Comparison for regressions of Std. Deviation of Residual Derivative Holdings on Proxies of Interdependence of Investment Opportunities with Time-series Changes of Interdependence of Investment Opportunities Controlled**

Estimator comparison for regressions of std. deviation of residuals on measures of the interdependence of investment opportunities with time-series changes controlled. This table presents the results of OLS regressions with the standard deviation of residual derivative holdings as dependent variables. The residuals are estimated from the panel regression model with firm and year fixed effects shown in column 3, table 5.4. In this table, the interdependence of investment opportunities is represented by variables of Corr, K-L Distance and Fluidity respectively. All independent variables employed in baseline models are controlled. The proxy variables of financial strength, i.e. Cashholdings and CashDiv are added additionally into the models shown in columns 1, 4 and 7. The proxy variables of managers' personal characteristics, i.e. CEO_age, CEO_tenure, and CEO_gender are added additionally into the models shown in columns 2, 5, and 8. In column 3, 6, and 9, all variables that represent for either financial strength or manger's personal characteristics are jointly controlled. The indicator variables for the change of variables of interest are controlled in all models. Appendix 1 provides detailed information on the construction of variables. Industry dummy is controlled in all models. All models are analysed with robust standard errors.

| Dep. Var: sd of residuals | (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) | (9) |
|---|---|---|---|---|---|---|---|---|---|
| Corr | 0.0005 | 0.0010 | 0.0008 | | | | | | |
| | [0.881] | [0.769] | [0.807] | | | | | | |
| K-L Distance | | | | -0.0182 | -0.0225 | -0.0194 | | | |
| | | | | [0.321] | [0.207] | [0.279] | | | |
| Fluidity | | | | | | | -0.0010 | -0.0003 | -0.001 |
| | | | | | | | [0.202] | [0.667] | [0.243] |
| Inc.Vars. | -0.0061 | -0.0103 | -0.0055 | 0.0136 | 0.013 | 0.0137 | 0 | 0 | 0 |
| | [0.728] | [0.592] | [0.759] | [0.422] | [0.450] | [0.423] | [.] | [.] | [.] |
| Dec.Vars. | 0.0162 | 0.0126 | 0.0163 | 0.0088 | 0.0107 | 0.0078 | 0.0193 | 0.0198 | 0.0194 |
| | [0.150] | [0.290] | [0.181] | [0.329] | [0.173] | [0.359] | [0.292] | [0.273] | [0.292] |
| _cons | -0.0205 | 0.0222 | 0.0004 | -0.0184 | 0.0162 | -0.0019 | -0.0223 | 0.0148 | -0.0064 |
| | [0.477] | [0.529] | [0.991] | [0.427] | [0.579] | [0.951] | [0.313] | [0.590] | [0.826] |
| No. obs. | 227 | 227 | 227 | 227 | 227 | 227 | 227 | 227 | 227 |
| r2 | 0.1265 | 0.1279 | 0.1354 | 0.1729 | 0.173 | 0.183 | 0.1859 | 0.18 | 0.1952 |
| Control for Fundamental Financial Characteristics | Y | Y | Y | Y | Y | Y | Y | Y | Y |
| Addional Controls of Fi.Strength | Y | N | Y | Y | N | Y | Y | N | Y |
| Additional Controls of CEO's Characteristics | N | Y | Y | N | Y | Y | N | Y | Y |
| Industry Dummies | Y | Y | Y | Y | Y | Y | Y | Y | Y |
| Robust Std. Err. | Y | Y | Y | Y | Y | Y | Y | Y | Y |

***, **, * denotes statistical significance at the 1%, 5%, and 10% levels respectively. P-values are reported in parentheses.

**Appendix 7: Estimator Comparison for regressions of Std. Deviation of Residual Derivative Holdings on HHI/HHI4 with Time-series Changes of Industry Structure Controlled**

Estimator comparison for regressions of std. deviation of residuals on measures of industry structure (HHI & HHI4) with time-series changes controlled. This table presents the results of OLS regressions with the standard deviation of residual derivative holdings as dependent variables. The residuals are estimated from the panel regression model with firm and year fixed effects shown in column 3, table 5.4. In this table, industry structure is represented by variables of HHI and HHI4 respectively. All independent variables employed in baseline models are controlled. The proxy variables of financial strength, i.e. Cashholdings and CashDiv are added additionally into the models shown in columns 1, 4 and 7. The proxy variables of managers' personal characteristics, i.e. CEO_age, CEO_tenure, and CEO_gender are added additionally into the models shown in columns 2, 5, and 8. In column 3, 6, and 9, all variables that represent for either financial strength or manger's personal characteristics are jointly controlled. The indicator variables for the change of variables of interest are controlled in all models. Appendix 1 provides detailed information on the construction of variables. Industry dummy is controlled in all models. All models are analysed with robust standard errors.

| **Dep. Var: sd of residuals** | **(1)** | **(2)** | **(3)** | **(4)** | **(5)** | **(6)** |
|---|---|---|---|---|---|---|
| HHI | 0.1435** | 0.1402** | 0.1411** | | | |
| | [0.013] | [0.017] | [0.015] | | | |
| HHI4 | | | | 0.1378** | 0.1427** | 0.1358** |
| | | | | [0.050] | [0.045] | [0.049] |
| Inc.Vars. | 0.0130** | 0.0124* | 0.0134* | 0.0005 | 0.0001 | 0.0012 |
| | [0.049] | [0.078] | [0.060] | [0.949] | [0.994] | [0.876] |
| Dec.Vars. | -0.0059 | -0.0067 | -0.0062 | 0.0084 | 0.007 | 0.0087 |
| | [0.299] | [0.204] | [0.266] | [0.370] | [0.419] | [0.341] |
| _cons | -0.0123 | 0.0147 | 0.000 | -0.0574* | -0.0323 | -0.0461 |
| | [0.572] | [0.593] | [1.000] | [0.058] | [0.345] | [0.202] |
| No. obs. | 227 | 227 | 227 | 227 | 227 | 227 |
| r2 | 0.1989 | 0.1981 | 0.2084 | 0.1819 | 0.1817 | 0.1902 |
| Control for Fundamental Financial Characteristics | Y | Y | Y | Y | Y | Y |
| Additional Controls of Fi.Strength | Y | N | Y | Y | N | Y |
| Additional Controls of CEO's Characteristics | N | Y | Y | N | Y | Y |
| Industry Dummies | Y | Y | Y | Y | Y | Y |
| Robust Std. Err. | Y | Y | Y | Y | Y | Y |

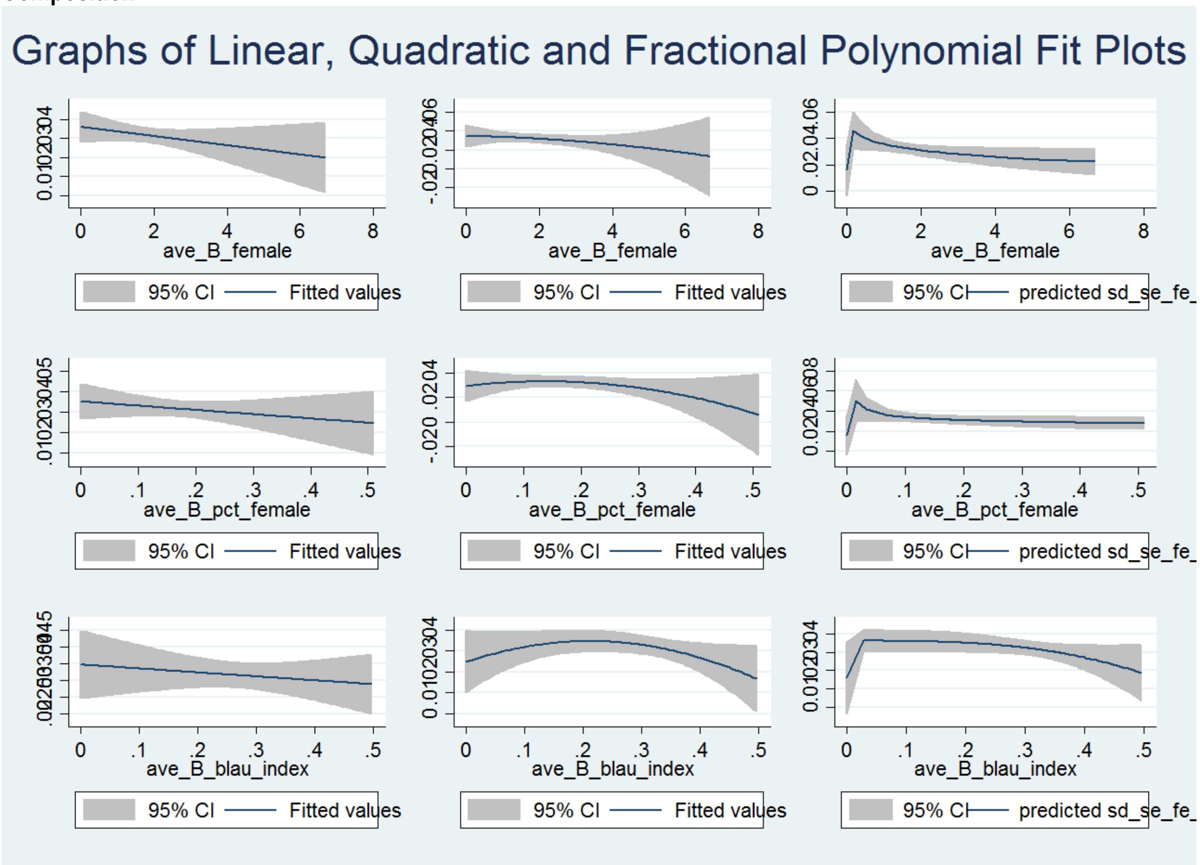
***, **, * denotes statistical significance at the 1%, 5%, and 10% levels respectively. P-values are reported in parentheses.

**Appendix 8: Estimator Comparison for Regressions of Std. Deviation of Derivative Holdings on Proxies of Predation Risk**
This table presents the results of OLS regressions with the standard deviation of derivative holdings as dependent variables. The derivative holdings are the gross notional amounts of derivatives deflated by total assets. In this table, predation risk is represented by variables of MTB, Dm3 and Sd_ocf respectively. All independent variables employed in column 3, Table 5.4 are controlled. The proxy variables of financial strength, i.e. Cashholdings and CashDiv and the proxy variables of managers' personal characteristics, i.e., CEO_age, CEO_tenure, and CEO_gender are added jointly into the models as controls. Appendix 1 provides detailed information on the construction of variables. Industry dummy is controlled in all models. All models are analysed with robust standard errors.

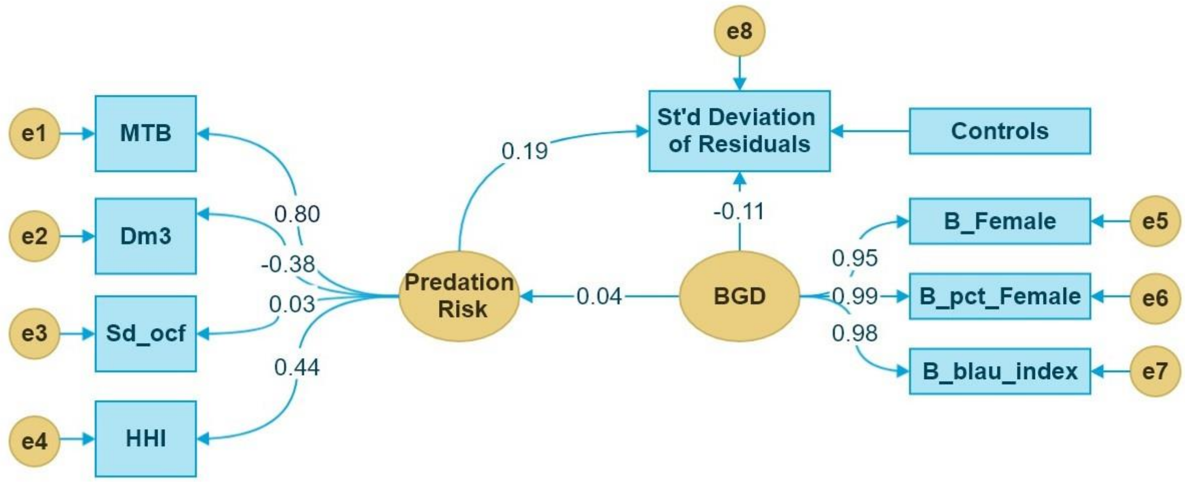
| Dep. Var: sd of de_FX | (1) | (2) | (3) |
|---|---|---|---|
| MTB | 0.0054 | | |
| | [0.112] | | |
| Sd_ocf | | 0.0378*** | |
| | | [0.001] | |
| Dm3 | | | -0.0351*** |
| | | | [0.007] |
| EPCM | -0.0011 | 0.0076 | 0.0227 |
| | [0.962] | [0.739] | [0.355] |
| Fincome | 0.0011 | 0.0011 | 0.0014 |
| | [0.328] | [0.273] | [0.136] |
| Debt | -0.0178 | -0.0180 | -0.0175 |
| | [0.293] | [0.310] | [0.372] |
| Firmsize | 0.0034 | -0.0003 | 0.0029 |
| | [0.121] | [0.896] | [0.177] |
| Institutional | 0.0005 | 0.0005 | 0.0005 |
| | [0.213] | [0.198] | [0.196] |
| TaxlossCF | 0.0015* | 0.0016** | 0.0011 |
| | [0.057] | [0.048] | [0.131] |
| CEOcashcomp | 0.0012 | 0.0028 | 0.0015 |
| | [0.615] | [0.207] | [0.524] |
| CashDiv | -0.1256 | -0.0742 | -0.1297 |
| | [0.433] | [0.655] | [0.458] |
| Cashholding | -0.0290 | 0.0006 | -0.0056 |
| | [0.388] | [0.985] | [0.860] |
| CEO_gender | -0.0005 | 0.0001 | -0.0139 |
| | [0.968] | [0.993] | [0.219] |
| CEO_tenure | -0.0007 | -0.0006 | -0.0004 |
| | [0.228] | [0.313] | [0.490] |
| CEO_age | -0.0003 | -0.0004 | -0.0004 |
| | [0.608] | [0.463] | [0.440] |
| No. obs. | 227 | 227 | 212 |
| r2 | 0.1434 | 0.1421 | 0.1668 |
| Industry Dummies | Y | Y | Y |
| Robust Std. Err. | Y | Y | Y |

***, **, * denotes statistical significance at the 1%, 5%, and 10% levels respectively. P-values are reported in parentheses.

**Appendix 9: Graphs for the Relationship between Standard Deviation of Residual Derivative Holdings and Board Gender Composition**



**Appendix 10: Structural Equation Model Building for the Mediation Function of Predation Risk in Explaining the Effects of Board Gender Diversity on Std. Deviation of Residual Derivative Holdings**



**Appendix 11: GMM Estimator Comparison for Regressions of Std. Deviation of Residual Derivative Holdings on Proxies of Board Gender Diversity with Controlled Predation Risk Represented by Variable of Dm3**

This table shows the test results of instrumental variables estimator implemented using the Generalized Method of Moments (GMM). In order to test if the measurement of predation risk can make the results biased, the variable MTB as shown in Table 5.15 is replaced by variable DM3. These models are over-identified by employing two instruments. One is the fraction of male directors who have female connections on outside boards over total directors (B_pct_maledir_outfelink). The other is the fraction of outside female connections that male directors have over total outside directorships (B_maledir_pct_outfelink). The dependent variables are the standard deviation of residual derivative holdings. The residual derivative holdings are estimated from a baseline penal regression model shown in column 3, Table 5.4. The board gender diversity is proxied by three variables, i.e., number of female directors on boards (B_Female), the fraction of female directors on boards (B_pct_Female) and Blau's (1977) index by gender (B_blau_index). All models shown in this table are analysed with industry dummies and robust standard errors. The factors at different levels are controlled. All variables are defined in Appendix 1.

| Dep. Var: Sd of Residuals | (1) | (2) | (3) | (4) | (5) | (6) |
|---|---|---|---|---|---|---|
| B_Female | -0.0127** | -0.0122* | | | | |
| | [0.041] | [0.088] | | | | |
| B_pct_Female | | | -0.1230** | -0.1170* | | |
| | | | [0.041] | [0.087] | | |
| B_blau_index | | | | | -0.0929** | -0.0880* |
| | | | | | [0.046] | [0.091] |
| Dm3 | -0.0205*** | -0.0209*** | -0.0207*** | -0.0211*** | -0.0204*** | -0.0208*** |
| | [0.003] | [0.002] | [0.003] | [0.002] | [0.004] | [0.002] |
| Fincome | 0.0007 | 0.0009 | 0.0008 | 0.0009 | 0.0011 | 0.0012 |
| | [0.473] | [0.396] | [0.450] | [0.370] | [0.245] | [0.211] |
| Debt | -0.0336** | -0.0325* | -0.0333** | -0.0320* | -0.0328* | -0.0311* |
| | [0.045] | [0.051] | [0.048] | [0.055] | [0.057] | [0.065] |
| Firmsize | 0.0032 | 0.0037 | 0.0029 | 0.0035 | 0.0028 | 0.0035 |
| | [0.169] | [0.130] | [0.210] | [0.150] | [0.233] | [0.159] |
| Institutional | 0.0007* | 0.0007* | 0.0007* | 0.0007* | 0.0006* | 0.0007* |
| | [0.056] | [0.050] | [0.064] | [0.057] | [0.069] | [0.060] |
| TaxlossCF | 0.0012 | 0.0011 | 0.0011 | 0.0011 | 0.0011 | 0.001 |
| | [0.100] | [0.104] | [0.110] | [0.114] | [0.128] | [0.127] |
| CEO_cashcomp | -0.0009 | -0.0005 | -0.0009 | -0.0004 | -0.001 | -0.0005 |
| | [0.578] | [0.788] | [0.582] | [0.818] | [0.540] | [0.784] |
| Board_size | -0.0019 | -0.0019 | -0.0040** | -0.0039** | -0.0037** | -0.0036** |
| | [0.306] | [0.328] | [0.018] | [0.024] | [0.030] | [0.039] |
| Board_age | 0.0003 | 0.0006 | 0.0003 | 0.0006 | 0.0003 | 0.0006 |
| | [0.682] | [0.517] | [0.679] | [0.491] | [0.682] | [0.503] |
| Board_tenure | -0.001 | -0.001 | -0.0011 | -0.001 | -0.001 | -0.001 |
| | [0.138] | [0.208] | [0.131] | [0.187] | [0.146] | [0.196] |
| Board_indep | 0.0424 | 0.0427 | 0.0383 | 0.0394 | 0.0361 | 0.0384 |
| | [0.146] | [0.144] | [0.164] | [0.154] | [0.187] | [0.167] |
| Board_outside | 0.001 | 0.001 | 0.0011 | 0.001 | 0.001 | 0.001 |
| | [0.167] | [0.209] | [0.158] | [0.202] | [0.175] | [0.220] |
| CEO_age | | 0.0042 | | 0.0026 | | -0.0016 |
| | | [0.736] | | [0.830] | | [0.884] |
| CEO_tenure | | -0.0001 | | -0.0001 | | -0.0001 |
| | | [0.945] | | [0.939] | | [0.886] |
| CEO_gender | | -0.0005 | | -0.0005 | | -0.0005 |
| | | [0.365] | | [0.322] | | [0.366] |
| CashDiv | | -0.0557 | | -0.0662 | | -0.0741 |
| | | [0.622] | | [0.559] | | [0.520] |
| Cashholdings | | 0.0054 | | 0.0064 | | 0.0074 |
| | | [0.830] | | [0.797] | | [0.769] |
| No. obs. | 218 | 218 | 218 | 218 | 218 | 218 |
| r2 | 0.1673 | 0.1732 | 0.1673 | 0.1737 | 0.1576 | 0.1641 |
| First stage F | 35.0088 | 35.3237 | 36.6718 | 38.1852 | 40.4696 | 38.1331 |
| Hansen's J chi2 | 0.6183 | 0.6092 | 0.5574 | 0.5233 | 0.5789 | 0.4922 |
| Industry Dummies | Y | Y | Y | Y | Y | Y |
| Robust Std. Err. | Y | Y | Y | Y | Y | Y |

***, **, * denotes statistical significance at the 1%, 5%, and 10% levels respectively. P-values are reported in parentheses

**Appendix 12: GMM Estimator Comparison for Regressions of Std. Deviation of Residual Derivative Holdings on Proxies of Board Gender Diversity with Controlled Predation Risk Represented by Variable of Sd_ocf**

This table indicates the test results of instrumental variables estimator implemented using the Generalized Method of Moments (GMM). In order to test if the measurement of predation risk can make the results biased, the variable MTB as shown in Table 15 is replaced by variable Sd_ocf. These models are over-identified by employing two instruments. One is the fractions of male directors who have female connections on outside boards over total directors (B_pct_maledir_outfelink). The other is the fractions of outside female connections that male directors have over total outside directorships (B_maledir_pct_outfelink). The dependent variables are the standard deviation of residual derivative holdings. The residual derivative holdings are estimated from baseline penal regression model shown in column 3, Table 5.4. The board gender diversity is proxied by three variables, i.e. numbers of female directors on boards (B_Female), the fractions of female directors on boards (B_pct_Female) and Blau's (1977) index by gender (B_blau_index). All models shown in this table are analysed with industry dummies and robust standard errors. The factors at different levels are controlled. All variables are defined in Appendix 1.

| Dep. Var: Sd of Residuals | (1) | (2) | (3) | (4) | (5) | (6) |
|---|---|---|---|---|---|---|
| B_Female | -0.0090* | -0.0089* | | | | |
| | [0.085] | [0.092] | | | | |
| B_pct_Female | | | -0.0902* | -0.0891* | | |
| | | | [0.083] | [0.090] | | |
| B_blau_index | | | | | -0.0706* | -0.0700* |
| | | | | | [0.086] | [0.093] |
| Sd_ocf | 0.0198* | 0.0208* | 0.0202* | 0.0212* | 0.0209* | 0.0215** |
| | [0.080] | [0.053] | [0.075] | [0.050] | [0.066] | [0.048] |
| Fincome | 0.0009 | 0.001 | 0.0009 | 0.0009 | 0.0011 | 0.0011 |
| | [0.302] | [0.288] | [0.324] | [0.307] | [0.218] | [0.222] |
| Debt | -0.0384** | -0.0355** | -0.0382** | -0.0352** | -0.0374** | -0.0344** |
| | [0.013] | [0.022] | [0.013] | [0.022] | [0.015] | [0.025] |
| Firmsize | 0.0001 | 0.0005 | -0.0001 | 0.0005 | -0.0001 | 0.0005 |
| | [0.999] | [0.851] | [0.965] | [0.867] | [0.960] | [0.850] |
| Institutional | 0.0007* | 0.0007* | 0.0007* | 0.0007* | 0.0007* | 0.0007* |
| | [0.056] | [0.055] | [0.060] | [0.058] | [0.061] | [0.059] |
| TaxlossCF | 0.0013* | 0.0012* | 0.0013* | 0.0012* | 0.0013* | 0.0012* |
| | [0.069] | [0.065] | [0.070] | [0.067] | [0.074] | [0.072] |
| CEO_cashcomp | -0.0001 | 0.0007 | 0.0001 | 0.0007 | -0.0002 | 0.0006 |
| | [0.971] | [0.733] | [0.981] | [0.713] | [0.935] | [0.780] |
| Board_size | -0.0023 | -0.0021 | -0.0038** | -0.0037** | -0.0036** | -0.0035** |
| | [0.192] | [0.260] | [0.025] | [0.037] | [0.034] | [0.049] |
| Board_age | 0.0001 | 0.0002 | 0.0001 | 0.0003 | 0.0001 | 0.0003 |
| | [0.897] | [0.755] | [0.881] | [0.731] | [0.870] | [0.742] |
| Board_tenure | -0.0011 | -0.0009 | -0.0011 | -0.001 | -0.0011 | -0.001 |
| | [0.114] | [0.242] | [0.103] | [0.211] | [0.107] | [0.211] |
| Board_indep | 0.0354 | 0.0376 | 0.0338 | 0.0363 | 0.0341 | 0.0373 |
| | [0.170] | [0.149] | [0.177] | [0.153] | [0.179] | [0.153] |
| Board_outside | 0.0011 | 0.0011 | 0.0011 | 0.0011 | 0.0011 | 0.0011 |
| | [0.142] | [0.160] | [0.140] | [0.158] | [0.155] | [0.173] |
| CEO_age | | 0.0089 | | 0.0085 | | 0.0061 |
| | | [0.444] | | [0.464] | | [0.584] |
| CEO_tenure | | -0.0001 | | -0.0001 | | -0.0001 |
| | | [0.839] | | [0.837] | | [0.787] |
| CEO_gender | | -0.0004 | | -0.0004 | | -0.0004 |
| | | [0.358] | | [0.343] | | [0.393] |
| CashDiv | | -0.0789 | | -0.0853 | | -0.0881 |
| | | [0.502] | | [0.472] | | [0.465] |
| Cashholdings | | 0.0159 | | 0.0162 | | 0.0163 |
| | | [0.525] | | [0.513] | | [0.518] |
| No. obs. | 225 | 225 | 225 | 225 | 225 | 225 |
| r2 | 0.1487 | 0.156 | 0.1494 | 0.157 | 0.1441 | 0.1503 |
| First stage F | 40.0332 | 38.8964 | 45.8723 | 45.7721 | 53.0044 | 50.1828 |
| Hansen's J chi2 | 1.5981 | 1.6452 | 1.4906 | 1.5080 | 1.4266 | 1.3851 |
| Industry Dummies | Y | Y | Y | Y | Y | Y |
| Robust Std. Err. | Y | Y | Y | Y | Y | Y |

***, **, * denotes statistical significance at the 1%, 5%, and 10% levels respectively. P-values are reported in parentheses.

**Appendix 13: Summary of Changes and Frequency of Changes in Board Gender Composition during the Sample Period**

This table reports the frequency of changes in board gender diversity that is proxied by three variables, i.e. numbers of female directors (Fe_dir), fractions of female directors on boards (Fe_dir%) and Blau's (1977) index by gender (Bindex). Four types of changes in board gender diversity are identified. They are continuously incased (Fe_dir_X0), continuously decreased (Fe_dir_0Y), fluctuated (Fe_dir_XY), and unchanged (Fe_dir_00). The headings with "inc_" and "dec_" mean increased and decreased female participation on bards. The numbers as suffixes indicate the times of increase or decrease of female participation on boards during the sample period.

| Variable | Obs | Mean | Std. Dev. | Min | Max | inc_1 | inc_2 | inc_3 | inc_4 | inc_5 | dec_1 | dec_2 | dec_3 | dec_4 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Panel A: | | | | | | | | | | | | | | |
| Fe_dir increased | 127 | 1.1969 | 0.4549 | 1 | 3 | 105 | 19 | 3 | | | | | | |
| Fe_dir_X0 | 78 | 1.1795 | 0.4185 | 1 | 3 | 65 | 12 | 1 | | | | | | |
| Fe_dir_XY | 49 | 1.2245 | 0.5109 | 1 | 3 | 40 | 7 | 2 | | | | | | |
| Fe_dir decreased | 85 | 1.0824 | 0.2765 | 1 | 2 | | | | | | 78 | 7 | | |
| Fe_dir_0Y | 36 | 1.1111 | 0.3187 | 1 | 2 | | | | | | 32 | 4 | | |
| Fe_dir_XY | 49 | 1.0612 | 0.2422 | 1 | 2 | | | | | | 46 | 3 | | |
| Fe_dir_00 | 64 | 0.0000 | 0.0000 | 0 | 0 | | | | | | | | | |
| Panel B: | | | | | | | | | | | | | | |
| Fe_dir% increased | 185 | 1.7784 | 0.8658 | 1 | 5 | 80 | 78 | 17 | 8 | 2 | | | | |
| Fe_dir%_X0 | 42 | 1.9762 | 1.1580 | 1 | 5 | 19 | 12 | 6 | 3 | 2 | | | | |
| Fe_dir%_XY | 143 | 1.7203 | 0.7544 | 1 | 4 | 61 | 66 | 11 | 5 | 0 | | | | |
| Fe_dir% decreased | 175 | 1.5657 | 0.7152 | 1 | 4 | | | | | | 96 | 62 | 14 | 3 |
| Fe_dir%_0Y | 32 | 1.4063 | 0.5599 | 1 | 3 | | | | | | 20 | 11 | 1 | 0 |
| Fe_dir%_XY | 143 | 1.6014 | 0.7425 | 1 | 4 | | | | | | 76 | 51 | 13 | 3 |
| Fe_dir%_00 | 10 | 0.0000 | 0.0000 | 0 | 0 | | | | | | | | | |
| Panel C: | | | | | | | | | | | | | | |
| Bindex increased | 185 | 1.7730 | 0.8675 | 1 | 5 | 81 | 77 | 17 | 8 | 2 | | | | |
| Bindex_X0 | 41 | 1.9756 | 1.1723 | 1 | 5 | 19 | 11 | 6 | 3 | 2 | | | | |
| Bindex_XY | 144 | 1.7153 | 0.7541 | 1 | 4 | 62 | 66 | 11 | 5 | 0 | | | | |
| Bindex decreased | 176 | 1.5625 | 0.7144 | 1 | 4 | | | | | | 97 | 62 | 14 | 3 |
| Bindex_0Y | 32 | 1.4063 | 0.5599 | 1 | 3 | | | | | | 20 | 11 | 1 | 0 |
| Bindex_XY | 144 | 1.5972 | 0.7416 | 1 | 4 | | | | | | 77 | 51 | 13 | 3 |
| Bindex_00 | 10 | 0.0000 | 0.0000 | 0 | 0 | | | | | | | | | |

**Appendix 14: Summary Statistics of Standard Deviation of Residual Derivative Holdings by Changes of Board Gender Composition**

This table indicates the summary of the standard deviation of residual derivative holdings by changes of board gender composition. Panel A reports for the total sample. Panel B reports the summary of statistics of the standard deviation of residual derivative holdings based on the different types of changes in numbers of female directors on boards. Panel C and D reports based on the different types of changes in fractions of female directors on boards and Blau's (1977) index by gender.

| Variable | Obs | Mean | Std. Dev. | Min | Max |
|---|---|---|---|---|---|
| Panel A: Total | 227 | 0.0331 | 0.0380 | 0.0009 | 0.4150 |
| Panel B: By B_female | | | | | |
| fe_dir_X0 | 78 | 0.0311 | 0.0283 | 0.0056 | 0.1594 |
| fe_dir_0Y | 36 | 0.0292 | 0.0180 | 0.0039 | 0.0722 |
| fe_dir_XY | 49 | 0.0472 | 0.0633 | 0.0035 | 0.4150 |
| fe_dir_00 | 64 | 0.0270 | 0.0275 | 0.0009 | 0.1339 |
| Panel C: By B_pct_female | | | | | |
| fe_dir%_X0 | 42 | 0.0291 | 0.0233 | 0.0078 | 0.1474 |
| fe_dir%_0Y | 32 | 0.0333 | 0.0272 | 0.0009 | 0.1339 |
| fe_dir%_XY | 143 | 0.0353 | 0.0440 | 0.0035 | 0.4150 |
| fe_dir%_00 | 10 | 0.0182 | 0.0168 | 0.0037 | 0.0581 |
| Panel D: By B_blau_index | | | | | |
| Bindex_X0 | 41 | 0.0295 | 0.0234 | 0.0078 | 0.1474 |
| Bindex_0Y | 32 | 0.0333 | 0.0272 | 0.0009 | 0.1339 |
| Bindex_XY | 144 | 0.0351 | 0.0439 | 0.0035 | 0.4150 |
| Bindex_00 | 10 | 0.0182 | 0.0168 | 0.0037 | 0.0581 |

**Appendix 15: Effects of Quadratic Function of Board Gender Composition on Standard Deviation of Residuals with Changes of Female Board Directors Controlled.** This table indicates the test results of OLS regressions on quadratic functions of board gender diversity that is proxied by three variables (i.e. B_pct_female, B_female, and B_blau_index). The categorical variables representing the changes in board gender composition are added to the models. Fdir_X0 indicates that female directors are continuously increased while Fdir_0Y indicates that female directors are continuously decreased. Fdir_00 represents unchanged board gender composition. Fdir_XY representing fluctuated board gender composition is set as a base group. The dependent variables are the standard deviation of residual derivative holdings. The residual derivative holdings are estimated from baseline penal regression model shown in column 3, Table 5.4. All models shown in this table are analysed with industry dummies and robust standard errors. The factors at different levels are controlled as shown in Table 5.14. All variables are defined in Appendix 1.

| Dep. Var: Sd of Residuals | (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) | (9) |
|---|---|---|---|---|---|---|---|---|---|
| B_female^2 | -0.0014** | -0.0014* | -0.0014* | | | | | | |
| | [0.034] | [0.065] | [0.073] | | | | | | |
| B_pct_female^2 | | | | -0.1652** | -0.1874** | -0.2080** | | | |
| | | | | [0.014] | [0.016] | [0.013] | | | |
| B_Blau_index^2 | | | | | | | -0.1163** | -0.1302** | -0.1373** |
| | | | | | | | [0.044] | [0.044] | [0.047] |
| Fdir_X0 | -0.0161* | -0.0161* | -0.0156* | -0.0063 | -0.0049 | -0.0042 | -0.007 | -0.0055 | -0.0046 |
| | [0.066] | [0.065] | [0.081] | [0.209] | [0.334] | [0.434] | [0.182] | [0.294] | [0.400] |
| Fdir_0Y | -0.0172** | -0.0172** | -0.0166** | -0.0024 | -0.0048 | -0.0036 | -0.0024 | -0.0047 | -0.0035 |
| | [0.039] | [0.039] | [0.048] | [0.652] | [0.392] | [0.513] | [0.648] | [0.396] | [0.521] |
| Fdir_00 | -0.0206** | -0.0206** | -0.0200** | -0.0154** | -0.0140* | -0.0131 | -0.0175** | -0.0160* | -0.0152* |
| | [0.023] | [0.030] | [0.043] | [0.031] | [0.091] | [0.110] | [0.027] | [0.070] | [0.084] |
| MTB | 0.0047** | 0.0042* | 0.0043* | 0.0041* | 0.0032 | 0.0033 | 0.0040* | 0.0031 | 0.0032 |
| | [0.047] | [0.095] | [0.097] | [0.064] | [0.184] | [0.195] | [0.070] | [0.198] | [0.206] |
| Fincome | 0.0004 | 0.0005 | 0.0005 | 0.0006 | 0.0007 | 0.0007 | 0.0008 | 0.001 | 0.001 |
| | [0.578] | [0.520] | [0.574] | [0.490] | [0.412] | [0.446] | [0.262] | [0.232] | [0.286] |
| Debt | -0.0166 | -0.0279* | -0.0280* | -0.0155 | -0.0278* | -0.0273* | -0.0148 | -0.0269* | -0.0265* |
| | [0.244] | [0.075] | [0.080] | [0.248] | [0.062] | [0.069] | [0.264] | [0.069] | [0.078] |
| Firmsize | 0.0003 | 0.0004 | 0.0007 | 0.0005 | 0.0014 | 0.0017 | 0.0009 | 0.0018 | 0.0021 |
| | [0.880] | [0.874] | [0.772] | [0.813] | [0.555] | [0.484] | [0.654] | [0.446] | [0.388] |
| Institutional | 0.0004 | 0.0005 | 0.0005 | 0.0004 | 0.0005 | 0.0005 | 0.0004 | 0.0005 | 0.0005 |
| | [0.294] | [0.191] | [0.191] | [0.247] | [0.147] | [0.153] | [0.241] | [0.142] | [0.145] |
| TaxlossCF | 0.0012* | 0.0011* | 0.0012* | 0.001 | 0.0011 | 0.0011 | 0.001 | 0.001 | 0.001 |
| | [0.085] | [0.090] | [0.091] | [0.139] | [0.117] | [0.122] | [0.169] | [0.144] | [0.148] |
| CEO_cashcomp | 0.0012 | 0.0002 | 0.0003 | 0.0014 | 0.0003 | 0.0004 | 0.0011 | 0.0001 | 0.0001 |
| | [0.446] | [0.915] | [0.878] | [0.405] | [0.875] | [0.794] | [0.482] | [0.997] | [0.958] |
| No. obs. | 227 | 227 | 227 | 227 | 227 | 227 | 227 | 227 | 227 |
| r2 | 0.1628 | 0.1856 | 0.1883 | 0.135 | 0.1638 | 0.1692 | 0.1373 | 0.1658 | 0.1698 |
| Controls for Board characters | N | Y | Y | N | Y | Y | N | Y | Y |
| Controls for CEO's characters | N | N | Y | N | N | Y | N | N | Y |
| Controls for financial strength | N | N | Y | N | N | Y | N | N | Y |
| Industry Dummies | Y | Y | Y | Y | Y | Y | Y | Y | Y |
| Robust Std. Err. | Y | Y | Y | Y | Y | Y | Y | Y | Y |

***, **, * denotes statistical significance at the 1%, 5%, and 10% levels respectively. P-values are reported in parentheses.

**Appendix 16: Subsample Analysis by Number of Female Directors**

Subsample Analysis by Number of Female Directors. This table indicates the test results of subsample analysis. The sample firms are grouped based upon the numbers of female directors on boards. Variables of B_pct_female and B_blau_index are utilised to represent the board gender diversity. The dependent variables are the standard deviation of residual derivative holdings. The residual derivative holdings are estimated from baseline penal regression model shown in column 3, Table 5.4. All models shown in this table are analysed with industry dummies and robust standard errors. The factors at different levels are controlled as shown in Table 5.14. All variables are defined in Appendix 1.

| **Dep. Var: Sd of Residuals** | **(1) fedir=1** | **(2) fedir<=1** | **(3) fedir=2** | **(4) fedir=3** | **(5) fedir=1** | **(6) fedir<=1** | **(7) fedir=2** | **(8) fedir=3** |
|---|---|---|---|---|---|---|---|---|
| B_pct_female | -0.3555 | 0.0546 | 0.135 | -0.1212*** | | | | |
| | [0.358] | [0.769] | [0.394] | [0.008] | | | | |
| B_blau_index | | | | | -0.2015 | 0.0372 | 0.0945 | -0.1660** |
| | | | | | [0.371] | [0.724] | [0.453] | [0.012] |
| MTB | 0.0033 | -0.0007 | 0.0055 | 0.0034 | 0.0032 | -0.0008 | 0.0054 | 0.0041 |
| | [0.725] | [0.923] | [0.297] | [0.342] | [0.728] | [0.914] | [0.300] | [0.293] |
| Fincome | 0.0012 | 0.0001 | 0.0004 | 0.0002 | 0.0012 | 0.0001 | 0.0005 | 0.0013 |
| | [0.546] | [0.993] | [0.812] | [0.965] | [0.544] | [0.993] | [0.769] | [0.729] |
| Debt | 0.0093 | -0.0326 | -0.0298 | -0.0286 | 0.0096 | -0.0334 | -0.0299 | -0.0285 |
| | [0.878] | [0.449] | [0.209] | [0.257] | [0.875] | [0.436] | [0.212] | [0.267] |
| Firmsize | 0.0193** | 0.0143** | -0.0011 | -0.0057* | 0.0193** | 0.0143** | -0.001 | -0.0055 |
| | [0.023] | [0.038] | [0.762] | [0.098] | [0.024] | [0.039] | [0.792] | [0.101] |
| Institutional | 0.0015 | 0.0013 | 0.0013** | -0.0002 | 0.0015 | 0.0013 | 0.0013** | -0.0002 |
| | [0.220] | [0.192] | [0.015] | [0.510] | [0.222] | [0.196] | [0.013] | [0.504] |
| TaxlossCF | 0.006 | 0.0049 | 0.0006 | 0.0001 | 0.0059 | 0.0048 | 0.0005 | 0.0001 |
| | [0.122] | [0.126] | [0.525] | [0.979] | [0.123] | [0.124] | [0.564] | [0.990] |
| CEO_cashcomp | -0.0032 | -0.0053 | 0.0065 | 0.0018 | -0.0033 | -0.0052 | 0.0066 | 0.0015 |
| | [0.725] | [0.460] | [0.175] | [0.378] | [0.721] | [0.468] | [0.172] | [0.452] |
| No. obs. | 68 | 76 | 90 | 61 | 68 | 76 | 90 | 61 |
| r2 | 0.3744 | 0.3109 | 0.3983 | 0.3158 | 0.3725 | 0.3114 | 0.3965 | 0.3188 |
| Controls for Board characters | Y | Y | Y | Y | Y | Y | Y | Y |
| Controls for CEO's characters | Y | Y | Y | Y | Y | Y | Y | Y |
| Controls for financial strength | Y | Y | Y | Y | Y | Y | Y | Y |
| Industry Dummies | Y | Y | Y | Y | Y | Y | Y | Y |
| Robust Std. Err. | Y | Y | Y | Y | Y | Y | Y | Y |

***, **, * denotes statistical significance at the 1%, 5%, and 10% levels respectively. P-values are reported in parentheses.

**Appendix 17: Subsample Analysis by Fractions of Female Directors on Boards**

This table indicates the test results of subsample analysis. The sample firms are grouped based upon the fractions of female directors on boards according to Kanter's (1977a, b) method. Sample firms are only categorised by two due to limited observations in the uniform and balanced groups. Firms with the uniform board are reported combined with firms with skewed boards while firms with the balanced board are reported combined with firms with tilted boards. Board gender diversity is proxied by three variables, i.e., numbers of female directors on boards (B_female), fractions of female directors on boards (B_pct_female) and Blau's (1977) index by gender (B_blau_index). The dependent variables are the standard deviation of residual derivative holdings. The residual derivative holdings are estimated from baseline penal regression model shown in column 3, Table 5.4. All models shown in this table are analysed with industry dummies and robust standard errors. The factors at different levels are controlled as shown in Table 5.14. All variables are defined in Appendix 1.

| **Dep. Var: Sd of Residuals** | **(1) %fe_dir<=skewed** | **(2) %fe_dir>=tilted** | **(3) %fe_dir<=skewed** | **(4) %fe_dir>=tilted** | **(5) %fe_dir<=skewed** | **(6) %fe_dir>=tilted** |
|---|---|---|---|---|---|---|
| B_female | -0.0029 | -0.0099** | | | | |
| | [0.782] | [0.010] | | | | |
| B_pct_female | | | -0.0287 | -0.1171*** | | |
| | | | [0.782] | [0.007] | | |
| B_blau_index | | | | | -0.0125 | -0.1324** |
| | | | | | [0.849] | [0.027] |
| MTB | 0.0079 | 0.0003 | 0.0079 | 0.0003 | 0.0079 | 0.0003 |
| | [0.110] | [0.919] | [0.111] | [0.929] | [0.112] | [0.929] |
| Fincome | 0.0008 | 0.0013 | 0.0008 | 0.0016 | 0.0009 | 0.0017 |
| | [0.474] | [0.395] | [0.475] | [0.317] | [0.447] | [0.318] |
| Debt | -0.0309 | -0.0487** | -0.031 | -0.0485** | -0.0308 | -0.0483** |
| | [0.167] | [0.019] | [0.169] | [0.020] | [0.162] | [0.021] |
| Firmsize | 0.0071* | -0.0047 | 0.0071* | -0.005 | 0.0070* | -0.0045 |
| | [0.055] | [0.131] | [0.056] | [0.118] | [0.055] | [0.155] |
| Institutional | 0.0008 | 0.0002 | 0.0008 | 0.0002 | 0.0008 | 0.0003 |
| | [0.177] | [0.514] | [0.176] | [0.572] | [0.173] | [0.484] |
| TaxlossCF | 0.0020* | 0.0003 | 0.0020* | 0.0003 | 0.0020* | 0.0003 |
| | [0.097] | [0.729] | [0.096] | [0.763] | [0.099] | [0.771] |
| CEO_cashcomp | -0.0005 | 0.0028 | -0.0005 | 0.0027 | -0.0004 | 0.0025 |
| | [0.878] | [0.124] | [0.874] | [0.126] | [0.893] | [0.183] |
| No. obs. | 146 | 81 | 146 | 81 | 146 | 81 |
| r2 | 0.2021 | 0.3551 | 0.2021 | 0.3497 | 0.2017 | 0.3435 |
| Controls for Board characters | Y | Y | Y | Y | Y | Y |
| Controls for CEO's characters | Y | Y | Y | Y | Y | Y |
| Controls for financial strength | Y | Y | Y | Y | Y | Y |
| Industry Dummies | Y | Y | Y | Y | Y | Y |
| Robust Std. Err. | Y | Y | Y | Y | Y | Y |

***, **, * denotes statistical significance at the 1%, 5%, and 10% levels respectively. P-values are reported in parentheses.