IS VERTICAL INTEGRATION A SUBSTITUTE FOR DERIVATIVE HEDGING IN MITIGATING RISK?

by

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A dissertation submitted to the Faculty of the University of Delaware in partial fulfillment of the requirements for the degree of Doctor of Philosophy in Economics

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ABSTRACT

This study makes a significant contribution to the existing literature by examining vertical integration and derivative hedging policies together. Although the present studies theoretically prove the substitutability of vertical integration and derivative hedging, the interaction of these two risk management strategies has not been empirically tested.

I assert that vertical integration is used as a substitute for derivative hedging by many managers to achieve the desired level of volatility. This hypothesis is validated by various univariate and multivariate tests. The results of the univariate tests show that the decrease in firms' derivative use following a vertical integration is highly significant. I also find a significant difference in derivative use between high and low vertical integration firms. The results of Heckman's selection models also show that vertical integration negatively affects the decision to hedge and that high vertical integration firms use derivatives less compared to low vertical integration firms. These findings empirically support the substitutability theory of vertical integration and derivative hedging.

Additionally, I examine the other determinants of the decision to hedge and the extent of hedging. The results provide consistent evidence for the extant theories of hedging such as financial distress cost, underinvestment cost, economies of scale and

corporate tax theories. The implication of this research is much broader than previous studies that have concentrated on single industries.

Chapter 1

INTRODUCTION

1.1 Importance of Risk Management

Most firms operate in an environment subject to risks such as adverse price movements and increasing costs of inputs. This risk exposure is most likely to increase the company's costs or decrease its profits. The decrease in profits results in a decrease in value in the eyes of investors, and the access to debt markets for these firms becomes more difficult. Maximizing firm or shareholder value is one of the most important goals of managers. It is also one of their greatest challenges. Managers can achieve this goal by hedging, an effective tool for reducing the impact of adverse events on corporations.

The Miller-Modigliani theorem, with perfect capital markets, assumes risk management is irrelevant for firms because shareholders can hedge their own risk and maintain the desired level of volatility by trading the same financial instruments used by firms. However, in the real world, firms face frictions such information asymmetries, taxes, and transaction, distress or bankruptcy costs; thus these frictions prevent the Miller and Modigliani theory from holding in today's economy. Hedging can increase the value of firms by lowering the deadweight costs of these frictions. The value creation effect of hedging has become an essential issue among scholars in recent years (i.e., Allayannis and Weston, 2001; Graham and Rogers, 2002; Carter et al., 2006). They examine whether this financial policy makes any contribution to value creation, but current literature has not yet reached a consensus.

1.2 Motivation of the Research

Derivative hedging has been the traditional choice of many firms to cope with cash flow volatility or input/output price uncertainties. Forwards, futures, swaps and options are the most commonly used financial instruments by many firms. According to a survey conducted by the International Swaps and Derivatives Association on the use of derivatives by Fortune Global 500 companies, 94% of these companies use derivatives to manage their risks (The National Forum, 2012).

In addition to these risk management strategies, vertical integration has been perceived as a powerful hedging mechanism by managers (Garfinkel and Hankins, 2011). Vertical integration is defined as the merger of a firm with its upstream suppliers, its downstream buyers or both. For years, microeconomics has defined vertical integration as a management control tool yet has overlooked its risk management aspect. Bertram (2006) states that integrated electricity firms in New Zealand are more able to manage their risk efficiently compared to the non-integrated firms that were not able to survive.

One of the examples that shows firms choose vertical integration as a hedging mechanism is the recent acquisition of ConocoPhillips's Trainer refinery by Delta Air Lines. Increasing fuel prices are one of the major concerns for Delta Air Lines. In the hope of decreasing fuel expenses by $300 million annually, the company bought its own oil refinery (Bloomberg, 2012). Delta's vertical integration is one of the important motivations for this research. It is worth knowing whether becoming vertically integrated affects the amount of Delta's derivative hedging or that of other companies that follow the same risk management strategy. Delta is not alone in choosing vertical integration as a risk management strategy. Other firms that see vertical integration as a risk management strategy include Apple, the pioneer of the vertical integration model which combines both hardware and software under the same roof, and Coca-Cola, whose acquisition of Coca-Cola Enterprises is another example.

1.3 Objective of the Research

In this study, my main aim is to find out whether vertical integration is a substitute for derivative hedging while managing the firm's risk using a sample of vertically integrated firms. I also critically examine the key determinants of the decision to hedge and the extent of hedging using Heckman's selection model.

There is much theoretical and empirical research on the motivations of derivative hedging activities. These studies use similar determinants of derivative hedging such as firm leverage, growth opportunities, size, investment opportunity, managerial wealth and risk, institutional ownership and so on. However, vertical integration has not been tested as a determinant of derivative hedging. My research mainly focuses on the vertical integration variable that is assumed to be a substitute for derivative hedging. Although there are some theoretical works that show substitutability of vertical integration and derivative hedging, to my knowledge, no empirical work has been done to confirm this theory.

Vertical integration is comparable to derivative hedging. Prior research suggests that vertical integration is a risk management strategy (Garfinkel Hankins, 2011; Fan and Goyal 2006) and managers coordinate risk management strategies (Schrand and Unal, 1998; Hankins, 2009). Smith and Stulz (1985) and Froot et al. (1993) theorize that firms should manage aggregate risk rather than just specific transaction risks. Hankins (2009) interprets this theory as the integration of risk management strategies to reduce the total volatility of the firms. For this reason, vertical integration can be used as a substitute for derivative hedging to smooth the instability of the firm's cash flows as one strategy becomes more advantageous in terms of cost and effectiveness. This research does not examine the cost of each strategy, but tests whether or not firms substitute vertical integration for derivative hedging using both univariate and multivariate settings.

I develop two testable hypotheses that reveal interactions between hedging and vertical integration that are stated in Hypothesis 1 and 2, below. I also test the extant hypotheses on the determinants of corporate hedging activities with my sample. These hypotheses are given in Hypothesis 3 to 9 below.

Hypothesis 1: Vertical integration is a substitute for derivative hedging.

Hypothesis 2: High vertical integration firms use less derivative hedging compared to low vertical integration firms.

Hypothesis 3: There is a positive relationship between leverage and derivative hedging.

Hypothesis 4: There is a positive relationship between growth opportunities and derivative hedging.

Hypothesis 5: There is a negative relationship between the liquidity level of a firm and derivative hedging.

Hypothesis 6: There is a positive relationship between income taxes and derivative hedging.

Hypothesis 7: There is a negative relationship between the proportion of institutional shareholdings and derivative hedging.

Hypothesis 8: There is a positive relationship between firm size and derivative hedging.

Hypothesis 9: There is a negative relationship between hedging substitutes and derivative hedging.

The results of the univariate tests show that there is a significant decrease in firms' derivative use following a vertical integration. Additionally, the difference in derivative use between high and low vertical integration firms is highly significant. The results of Heckman's selection models also show that vertical integration negatively affects the decision to hedge. Moreover, the significant coefficients of high vertical integration dummies in the selectivity model prove that the extent of hedging is negatively affected by being a high vertical integration firm. This result again confirms the hedging aspect of vertical integration. All these findings prove the substitutability of vertical integration and derivative hedging.

The univariate test results related to firm characteristics variables also show that there are significant differences between hedgers and non-hedgers. Firms using financial derivatives are significantly larger in size compared to non-hedgers. Hedger firms have higher debt-to-asset ratios than non-hedgers consistent with financial distress theory. There is no significant difference in the market-to-book ratio between hedgers and non-hedgers. The intensity of capital is significantly higher for hedgers, showing that they have more growth opportunities. Non-hedgers tend to have both more current assets relative to current liabilities and cash to meet short-term obligations. According to t-test results, there is no difference in convertible debt holdings between two groups of firms, but the Wilcoxon test shows that hedgers hold more convertible debt compared to non-hedgers which is inconsistent with the theory. I do not find a significant difference in terms of Tobin's Q between hedgers and non-hedgers.

As regards the tests on the other determinants of the decision to hedge and the extent of hedging, I find consistent evidence for the extant theories of corporate hedging. In general, the results of probit and the selection regression of Heckman's model support all the hypotheses except Hypothesis 5. Financial distress costs, underinvestment costs, and corporate taxes are the major considerations for vertically integrated firms while making hedging decisions.

1.4 Contribution of the Research

Some scholars have found evidence regarding the coordination of risk management strategies (i.e., Babich and Sobel, 2004; Hankins, 2009; Ding et al., 2007; Schrand and Unal, 1998), but none of them have specifically examined whether vertical integration and derivative hedging are coordinated while managing corporate risk. Using a sample of firms from different industries, this study fills a gap in the current literature by answering the following question: Is vertical integration a substitute for derivative hedging in mitigating risk?

This study makes a significant contribution to the existing literature by examining vertical integration and derivative hedging policies together. Although the present studies theoretically prove the substitutability of vertical integration and derivative hedging, the interaction of these two risk management strategies has not been empirically tested. This research is much broader than that of previous studies that have concentrated on single industries.

Aid et al. (2011) is the only study that shows both theoretically and numerically the substitutability of vertical integration and forward hedging in the French electric industry. However, it does not show this empirically. The use of the theoretical approach is more prevalent in their research. The focus on a single industry and on a single type of derivative instrument impedes us from generalizing their conclusion. The closest paper in the spirit of such research is Hankins (2009). Using a sample of bank holding companies, she provides the empirical evidence of substitutability of operational hedging and financial hedging. Different from Hankins

(2009), my research concentrates on vertical integration out of all other types of mergers and acquisitions and tests substitutability of derivative hedging and vertical integration using samples from different industries.

To conclude, this research is unique in terms of revealing the interactions between vertical integration and derivative hedging and is much broader than previous studies that have concentrated on single industries.

1.5 Outline of the Research

This research consists of six chapters. The first chapter explains the importance of risk management, as well as the motivation, objective and contribution of the study. Chapter 2 provides a comprehensive review of the current literature regarding the determinants of hedging and firm value. Chapter 3 specifies the research hypothesis and the methodology. Chapter 4 gives a detailed explanation of the sample selection process and documents the descriptive statistics of my final sample. Chapter 5 presents empirical results of univariate and multivariate tests. The last chapter, Chapter 6, presents the conclusions of the research.

Chapter 2

LITERATURE REVIEW

2.1 Motivation behind Derivative Hedging

The Modigliani and Miller theorem on capital structure is a cornerstone of modern corporate finance. According to the Modigliani and Miller theorem, risk management is irrelevant for firms because the shareholders of the firm can use derivatives to hedge their own risk and maintain their desired level of volatility. This theory is explained in Modigliani (1980) as follows:

> … with well-functioning markets (and neutral taxes) and rational investors, who can 'undo' the corporate financial structure by holding positive or negative amounts of debt, the market value of the firm - debt plus equity - depends only on the income stream generated by its assets. It follows, in particular, that the value of the firm should not be affected by the share of debt in its financial structure or by what will be done with the returns - paid out as dividends or reinvested (profitably). (p. xiii)

The intuition behind the theorem is also explained with a simple analogy by Miller (1991) as follows:

> Think of the firm as a gigantic tub of whole milk. The farmer can sell the milk as it is. Or he can separate out the cream, and sell it at a considerably higher price than the whole milk would bring. The Modigliani-Miller proposition says that if there were no cost of separation (and, of course, no government dairy support program), the

> cream plus the skim milk would bring the same price as the whole milk. (p. 269)

The essence of this argument can be applied to risk management. When a firm hedges using derivative instruments in capital markets, it exchanges high-risk cash flow with a low-risk one. The firm has to give up a correspondingly high return by selling high-risk cash flow to the capital markets, receiving low risk and return in exchange. In a Modigliani-Miller world, the value of the two cash flows are the same and do not change the firm's assets. In this case, hedging becomes irrelevant for firms. However, in the real world, firms face frictions such as information asymmetries, taxes, and transaction, distress or bankruptcy costs; these frictions prevent the Miller and Modigliani theory from holding in today's economy.

Hedging can increase the value of firms by lowering the deadweight costs of these frictions. The value creation effect of hedging has become an essential issue among scholars in recent years (i.e., Allayannis and Weston, 2001; Graham and Rogers, 2002; Carter et al., 2006). They examine whether corporate hedging policy contributes to value creation, but current literature has not yet reached a consensus.

The current studies categorize the frictions under five titles: financial distress costs, underinvestment costs, agency costs, tax benefits and others. In the next section, I present the literature review of these factors that encourage firms to hedge.

2.1.1 Financial Distress Costs

Financial distress occurs when a company does not have enough cash flow to pay off its financial obligations to debt holders. Raising external financing is very costly for firms under financial distress. The difficulty in meeting short-term obligations prevents management from accepting long-term profitable projects. The stress of the probability of bankruptcy and the fear of unemployment make the employees of financially distressed companies less productive. Firms look for incentives to reduce the financial distress because it may be very costly for them. Hedging can prevent costs of financial distress by decreasing cash flow volatility and increasing debt capacity.

Most of the studies use leverage as a proxy for the possibility of incurring financial distress and find a positive association between this variable and firms' hedging activities[1]. However, using different samples, other studies observe no relation between this variable and hedging[2].

2.1.1.1 Articles Related to Financial Distress Costs

Although the literature assumes risk aversion to be the reason underlying corporate demand for insurance, the earliest theoretical paper of Mayers and Smith

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[1] See Dolde (1995), Berkman and Bradbury (1996), Haushalter (2000), Gay and Nam (1998), Graham and Rogers (2002), Crabbe (2002), and Reynolds and Boyle (2005).

[2] See Nance, Smith, and Smithson (1993), Geczy, Minton, and Schrand (1997)

(1982) treats corporate purchase of insurance as a firm's financing decision. They also list other incentives that are consistent with the modern finance theory. For example, lowering expected transaction costs of financial distress is given as another incentive for corporate purchase of insurance in their study. They state firms shift the risk arising from financial distress to the insurance company by insuring themselves.

Smith and Stulz (1985) empirically prove that firm value can be increased by hedging if transaction costs of bankruptcy are a decreasing function of firm value. Their model suggests that firms with higher expected costs of financial distress hedge more compared to others because hedging reduces the probability of bankruptcy by reducing the variance of cash flows. They also state the value of a hedging firm is higher compared to the value of a non-hedging firm since the present value of bankruptcy costs are reduced, and debt capacity is increased via hedging.

Froot, Scharfstein, and Stein (1993) also argue that the probability of bankruptcy can be reduced by hedging. They add if there is a cost associated with financial distress and if carrying debt is advantageous, firms can increase their debt capacity by hedging.

Nance, Smith, and Smithson (1993) provide empirical evidence for the hypotheses explaining corporate hedging policy using survey data on the use of hedging instruments by 169 firms among Fortune 500 and S&P 400 firms. Their results do not support financial distress cost theory since the expected positive sign between hedging and leverage is not observed.

Dolde (1995) uses the debt ratio to measure the expected cost of financial distress and finds a positive association between hedging and this proxy. He concludes hedging increases with the debt ratio.

Mian (1996) is one of the earliest empirical papers to take advantage of changes in financial accounting standards that mandate firms to disclose off-balance-sheet financial instruments in financial statement footnotes. Using 1992 annual reports for a sample of 3,022 firms, he finds inconsistent results with the financial distress cost models. The existing theory states that smaller firms are more likely to hedge when there is a fixed cost component to financial distress, since they have a higher probability of financial distress (Nance, Smith, Smithson, 1993). However, Mian (1996) finds hedger firms are larger compared to non-hedger firms. This result suggests that while hedging, firms take into account economies of scale and information and transaction considerations more than other factors such as the cost of raising capital.

Berkman and Bradbury (1996) test determinants of corporate hedging using a sample of firms listed on the New Zealand Stock Exchange. Although this study uses a sample outside of the USA, their findings are consistent with the existing theory of corporate hedging. They find firms that use derivatives have more leverage compared to nonuser firms.

Using 1994 data from over 4000 non-financial firms, Fenn, Post, and Sharpe (1996) find that firms use interest rate swaps to hedge interest rate risk arising from debt obligations. Additionally, they find significant evidence that firms using swaps issue more short-term debts compared to those that do not since swap users have a lower marginal cost of debt. This result can be explained by the fact that they have a lower marginal cost of debt because they do not bear volatility of debt.

The main aim of Gay and Nam (1998) is to reveal the relationship between underinvestment and the use of derivatives with a sample from both the 1996 Swap Monitor database and the listings of Business 1000. However, they find important results supporting financial distress cost theory. The significant and positive association between hedging and leverage variables indicates firms carrying more leverage use greater amount of derivatives since financial distress costs are higher for those firms.

Horng and Wei (1999) is the first study that examines the real estate investment trusts (REITs) industry's hedging policy. Consistent with the existing hypothesis of financial distress costs, they find that the use of derivatives is high for REITs that are smaller and carry larger amounts of debt. In other words, the cost of financial distress is a major determinant of the level of hedging. Additionally, they find that growth opportunities play an important role in corporate hedging: the higher the market-to-book ratio is, the more derivatives firms use.

Haushalter (2000) concentrates on oil and gas producers to answer questions regarding the determinants and extent of corporate hedging. Using 100 oil and gas producers for 1992 to 1994, he investigates whether the fraction of hedged-against price fluctuations is related to firms' other financing decisions. He concludes that the financial cost is a major determinant of hedging and the extent of hedging increases with financial leverage.

Sinkey and Carter (2000) investigate the factors that encourage banks to hedge as well as the difference in financial characteristics between users and non-users of derivatives. Their findings show that hedgers have riskier capital structures compared to non-hedgers (i.e., more notes and debentures and less equity, larger mismatches between on balance sheet assets and liabilities, greater net loan charge-offs, and lower net interest margins). In addition, a positive relationship is observed between the use of derivatives and the level of interest rate risk.

Graham and Rogers (2002) is the first paper that provides evidence on the importance of hedging in increasing debt capacity and firm value. Using 442 non-financial firms for the year 1994 or 1995, they document that a firm's capital structure is affected by hedging decisions and hedging adds value to firms by increasing debt capacity.

Singh and Upneja (2008) choose a sample of firms from the lodging industry from 2000 to 2004 to investigate determinants of hedging. They find that financial distress costs play an important role in a firm's hedging decision. Additionally, a positive significant relation between floating-rate debt and hedging suggests that firms with a greater amount of floating-rate debt are more likely to use derivatives instruments.

Ertugrul, Sezer, and Sirmans (2008) is another study that examines hedging practices of firms in the equity real estate investment trusts (equity REITs) industry for the period 1999 to 2001. They find financial leverage is significantly positively related to hedging, suggesting that financial distress cost is an important determinant of derivative use in the equity REITs industry. Additionally, they find that smaller firms tend to hedge more. The negative relation between size and extent of hedging supports the financial distress cost theory for hedging.

Purnanandam (2008) develops an empirically testable corporate risk management model in the presence of financial distress costs. Using more than 2,000 non-financial firms, he tests his model that predicts a non-monotonic relation between hedging and leverage and a U-shaped relation between hedging and financial distress costs. He finds that the positive relation between leverage and foreign currency and hedging becomes negative for highly leveraged firms. Additionally, he finds financially distressed firms in highly concentrated industries use more derivatives.

Dionne and Triki (2013) develop a theoretical model in which firms make hedging and leverage decisions simultaneously and test this model empirically using a sample of 36 North American gold mining companies over the periods 1993-1999. They theoretically and empirically show financial distress costs play an important role in firm's hedging decisions. More hedging leads to lower financial distress costs. Contrary to previous findings, their model and results show that hedging does not always increase firms' debt capacity.

Table 2.1 provides a summary of existing studies related to financial distress costs as the determinant of hedging. In the current literature, empirical evidence related to this theory come from different industries such as gold mining, oil and gas producing, lodging, financial and non-financial industries, and REITs. Debt ratio, dividend yield, interest coverage ratio, size, and credit ratings are some of the proxies for financial distress in the current literature. The conclusions vary a little bit with the sample and the proxy used. However, in general, the findings are consistent with the financial distress cost theory that states firms hedge in order to reduce the costs of financial distress especially when debt ratio is used as a proxy.

2.1.2 Underinvestment Costs

According to Myers (1977), the underinvestment problem occurs when the company or the shareholders of the company reject investment in low-risk projects to avoid shifting wealth from themselves to debt holders. Low-risk projects provide a safe cash flow for the debt holders but do not generate excess return for the shareholders. For this reason, shareholders invest in high-risk projects that maximize their wealth at the cost of debt holders and the firm.

The underinvestment problem arises in response to insufficient cash flow. Cash flow of a firm is affected by external risk factors such as changes in interest rates, commodity prices, and foreign exchange rates. Hedging these factors using derivative instruments can be a solution to the underinvestment problem since it reduces the volatility of cash flows, and improves debt holders' conditions without reducing incentives for the shareholders resulting a higher firm value. The ratio of market value to book value and research and development expenses are the two commonly used proxies for investment growth opportunities to test this theory. The current literature presents mixed evidence for the underinvestment theory.

Table 2.1 Summary of Previous Studies Related to Financial Distress Costs

This table provides a summary of existing studies related to financial distress costs as a determinant of hedging. In the proxy column, the "+", "-" and "?" signs in the parentheses predict the relation between corresponding variable and hedging. "+" and "-" mean positive and negative relations are expected, respectively. A "?" indicates there is no prior expectation between hedging and the corresponding variable. A "yes" in the table indicates that the evidence is significant in the predicted direction, "no" indicates it is significant but in the opposite direction and "none" indicates the coefficient is not significant. "neg." and "pos." indicate the direction of the relationship between hedging and the variable when there is no prior expectation.

Research	Sample	Period	Proxy	Conclusions
Mayers and Smith (1982)	None	None	None	They state one of the incentives for corporate purchase of insurance is to lower expected transaction costs of financial distress. Firms shift the risk arising from financial distress to insurance companies by insuring themselves.
Smith and Stulz (1985)	None	None	None	Firm value can be increased by hedging if transaction costs of bankruptcy are a decreasing function of firm value.
Froot, Scharfstein, and Stein (1993)	None	None	None	They argue that the probability of bankruptcy can be reduced by hedging. If there is a cost associated with financial distress and if carrying debt is advantageous, firms can increase their debt capacity by hedging.
Nance, Smith, and Smithson (1993)	169 respondents of Surveyed Firms from Fortune 500 and S&P 400	1986	Convertible debt (?, none); Dividend yield (?, pos.); Interest coverage ratio (-, none); Debt ratio (+, none); Preferred stock (?, none); Short-term liquidity (-, none); Size (-, no)	Their results do not support financial distress cost theory since the expected positive sign between hedging and leverage is not observed.

Table 2.1 Continued

Research	Sample	Period	Proxy	Conclusion
Dolde (1995)	244 respondents from Survey data	1992	Debt ratio (+,no); Sales (-, none); SG&A costs(+,yes)	He finds that hedging increases with the debt ratio.
Mian (1996)	3022 Compustat firms	1991	Size (-, no)	He shows hedger firms are larger compared to non-hedger firms. Firms take into account economies of scale and information and transaction considerations more than other factors such as the cost of raising capital.
Berkman and Bradbury (1996)	116 firms listed New Zeland Stock Exchange	1994	Convertible debt (?, none); Dividend yield (?,pos.); Interest coverage ratio (-, yes); Debt ratio (+, yes); Preferred stock (?, none); Short-term Liquidity (-,yes); Size (-, no)	They find firms that use derivatives have more leverage compared to nonuser firms.
Fenn, Post, and Sharpe (1996)	4000 Compustat nonfinancial corporations	1994	Short-term debt (+, yes)	Firms use interest rate swaps to hedge interest rate risk arising from debt obligations.
Gay and Nam (1998)	325 derivative using nonfinancial firms	1995	Convertible debt (?, none) Interest coverage ratio (-, none) Debt ratio (+,yes) Preferred stock (?, none) Size (-, none)	They find a significant positive relation between hedging and the leverage variable indicating that firms carrying more leverage use greater amounts of derivatives since the financial distress cost is higher for those firms.

Table 2.1 Continued

Research	Sample	Period	Proxy	Conclusion
Ertugrul, Sezer, and Sirmans (2008)	112 REITs	1999 to 2001	Debt ratio (+,yes)	They find financial leverage is significantly positively related to hedging suggesting that financial distress cost is an important determinant of derivative use in equity REITs industry.
Purnanandam (2008)	2256 Compustat&CRSP firms	1996 to 1997	Leverage ratio (+,yes) ; Industry concentration*Leverage ratio (+,yes)	They find that positive relation between leverage and foreign currency and hedging becomes negative for highly leveraged firms. Additionally, they find financially distressed firms in highly concentrated industries use more derivatives.
Dionne and Triki (2013)	48 North American gold mining firms	1991 to 1999	Cash costs (+, yes); Leverage (+,yes)	They theoretically and empirically show financial distress cost plays an important role in firm's hedging decisions. More hedging leads to lower financial distress cost.

2.1.2.1 Articles Related to Underinvestment Costs

Bessembinder (1991) theoretically shows that hedging is a remedy for the underinvestment problem. He states that, by shifting individual future states from default to non-default outcomes, hedging increases the numbers of future states in which shareholders are better off than non-equity claimants. He adds that shareholders who receive a larger portion of incremental benefits from the new projects have more incentives to raise additional capital and less incentive to underinvest.

The framework of Froot, Scharfstein, and Stein (1993) suggests that when the cost of financial distress is high for firms, the underinvestment problem can be solved by hedging. In their paper, they point out three premises. The first one states that firm value is created by positive net present value projects. The second one is that internally generated cash flow is the key to support profitable investment projects. If sufficient cash flow is not generated, firms reduce investments below optimal levels due to costly external financing. The third premise is that unexpected or unfavorable external risk factors such as movements in commodity prices, foreign exchange rates, and interest rates may disrupt internal cash flow that is important in investment decisions. Under this framework, they show that hedging ensures that firms have sufficient internal funds to encourage their shareholders to invest in profitable projects. As a result, hedging can solve the underinvestment problem.

Nance, Smith and Smithson (1993) choose 169 firms out of Fortune 500 and S&P 400 to test hedging theories. They find that firms that have higher research and development (R&D) expenses use more hedging instruments. Additionally, they find that firms with more growth opportunities in their investment set and lower leverage in their capital structure are more likely to be hedgers. These findings are consistent with underinvestment theory since both R&D and growth opportunities are used as proxies to test underinvestment theory.

Dolde (1995) finds that firms with high levels of R&D expenses are more likely to use some form of derivatives instrument.

Contrary to underinvestment theory, Mian (1996) finds a negative relation between a firm's investment opportunities and its hedging amount using 3022 COMPUSTAT firms for the year 1991. He states that mandated reporting requirements can be a reason for this negative relation between market-to-book ratio and hedging. He also finds that firms in regulated utility industries are less likely to hedge, supporting underinvestment theory since the managers of regulated firms have less discretion on investment decisions and are highly monitored by fixed claim holders.

Ross (1996) argues that firms with high growth opportunities are more likely to use derivatives to mitigate the underinvestment problem, but not to increase debt capacity. He states that the increased level of leverage after hedging creates incentives for underinvestment because a relatively higher portion of investment benefit may accrue to bondholders. In his argument, he indicates that firms cannot hedge to increase investment and debt capacity simultaneously when hedging, leverage and investment are jointly considered.

Stulz (1996) discusses that raising additional funds is difficult for financially distressed firms. Even when they have access to external funding, the cost of raising capital through this channel is so costly that management may choose to forgo profitable investment opportunities; as a result firms underinvest. In his argument, he states that hedging may decrease the probability of financial distress and the costs associated with underinvestment thus increase firm value.

Geczy, Minton, and Schnard (1997) investigate the use of foreign currency derivatives for 372 Fortune 500 non-financial firms in 1990. They use three proxies for the growth opportunities available to a firm: the interaction of a firm’s long term debt ratio with research and development expenses scaled by sales, capital expenditures for property, and plant, equipment and market scaled by firm size. They find that firms with greater growth opportunities and lower access to both internal and external financing hedge more with currency derivatives, supporting the underinvestment hypothesis.

Samant (1996) investigates the relationship between the probability and extent of hedging with interest rate swaps as well as some operating and financial ratios. He finds that firms with more growth opportunities, more leverage, lower fixed to total assets ratios and more divergent earning estimates are more likely to hedge with interest rate swaps. According to him, these results reveal that a firm’s hedging practice is motivated by underinvestment, asset substitution, and information asymmetry problems.

Gay and Nam (1998) more closely examines the underinvestment hypothesis as a determinant of corporate hedging policy. Using several different proxies for investment opportunities, they find a positive relation between hedging and these proxies. Firms with enhanced investment opportunities use more derivative hedging when their cash stocks are relatively low. Firms hedge less when there is a positive relation between investment expenditures and internal cash flow, suggesting a potential natural hedge. All of these findings support the idea that firms use derivatives to mitigate potential underinvestment problems.

Most of the studies before Horng and Wei (1999) use samples from non-financial firms that exclude firms in the REITs industry. Their study is the first examining corporate hedging determinants of firms in the REITs industry. They use market-to-book ratio as a proxy for growth opportunities to test the underinvestment hypothesis. They find no relation between growth opportunities and the level of hedging, contradicting with underinvestment theory.

Petersen and Thiagarajan (2000) examines hedging practices of two gold mining firms: American Barrick, which extensively uses derivatives to hedge its gold price risk, and Homestake Mining, which does not use any type of derivatives but uses a combination of financial and operating decisions to manage its risk exposure. Homestake Mining’s investment opportunities are highly correlated with gold prices due to the lower cost of adjusting production. This allows Homestake Mining to naturally adjust volatility of cash flow without using financial derivatives. On the other hand, American Barrick’s growth opportunities mainly depend on acquisitions, exploration and sales. American Barrick's external approach to growth means more reliance on capital market. This approach results in more hedging. So the difference in investment opportunities plays an important role in the firms' choice of risk management strategies.

Allayannis and Ofek (2001) investigate whether firms use foreign currency derivatives for hedging or speculative purposes using a sample of S&P 500 non-financial firms for 1993. The significant negative relation between foreign currency derivatives and hedging suggests firms use this type of derivatives in order to hedge themselves against exchange rate fluctuations but not to speculate in the foreign exchange markets. Additionally, they test the theories related to underinvestment costs using three proxies: research and development expenses scaled by sales, dividend yield, and market-to-book ratio. They find none of these proxies is a determinant of the extent of hedging.

Knopf, Nam, and Thornton (2002) use research and development expenses scaled by total assets and market-to-book ratio as proxies to test underinvestment theory. The positive relations between the amount of hedging and both proxies are expected and consistent with the theory.

Using 442 non-financial firms for the year 1994 or 1995, Graham and Rogers (2002) find a negative relation between research and development expenses and hedging and a positive relation between book-to-market ratio and hedging, contrary to underinvestment theory. However, once they use the approach of Geczy et al. (1996) in which the interaction of debt and market-book-ratio is used as a proxy for investment opportunities, they observe a positive relation between this proxy and hedging that is consistent with the underinvestment hypothesis.

Crabb (2002) tests whether U.S. multinational firms hedge with foreign currency derivatives to mitigate underinvestment using a sample from the S&P COMPUSTAT database for the years 1992-1997. Consistent with underinvestment theory, he finds that multinational firms with the greatest exposure to exchange rate risk through their foreign production or investment hedge more using foreign currency derivatives, and that these firms coordinate investment and hedging decisions as well.

Using a cross-sectional sample of non-financial New Zealand firms in 1999, Reynolds and Boyle (2005) test the relation between a firm's investment and hedging decisions. They cannot find any support for the hypothesis that states firms with better growth opportunities hedge more to smooth their cash flows to limit underinvestment.

Lin and Smith (2007) empirically test whether there is an interaction between hedging, financing and investment decisions for firms with different growth opportunities using simultaneous equations where each decision is treated as endogenous. Their data consists of non-financial firms that are derived from the Swaps Monitor database, covering fiscal years 1992-1996. Using the price-to-earnings ratio as a proxy for growth opportunities, they find that firms with high growth opportunities use derivatives to increase their investment but not the amount of leverage. This result is consistent with the underinvestment problem since higher leverage means that a relatively higher portion of investment benefits accrues to bondholders who, in turn, increase the probability of underinvestment (Ross, 1996).

Additionally, they find that firms with low investment opportunities increase their leverage by hedging.

Singh and Upneja (2008) test underinvestment theory using a sample of firms from the lodging industry from 2000 to 2004. They use market-to-book ratio as a proxy for growth opportunity. Consistent with theory and prior research, they find firms with higher growth opportunities are more likely to use derivatives to hedge. In other words, underinvestment cost is an important determinant of the decision to hedge.

Table 2.2 provides a summary of existing studies related to underinvestment costs. There are different proxies to test the underinvestment cost theory such as book-to-market ratio, R&D expenses, earnings-to-price ratio, market-adjusted cumulative returns, etc. Among them, R&D expenditures and book-to-market ratio are the two most widely used proxies. The conclusions vary a lot with the sample and the proxy used. Empirical results are consistent with the expectation on the relation between R&D and hedging. However, the coefficients of book-to-market ratio are not always in the expected direction.

2.1.3 Managerial Ownership and Risk Aversion

The theories suggest that managerial risk aversion and the form of their compensation may be a possible explanation of hedging activities. Managers may take into account their level of risk to maximize their expected utility while managing

Table 2.2 Summary of Previous Studies Related to Underinvestment Costs

This table provides a summary of existing studies related to underinvestment costs as a determinant of hedging. In the proxy column, the "+" and "-" signs in the parentheses predicts the relation between the corresponding variables and hedging. "+" and "-" mean positive and negative relations are expected, respectively. A "yes" in the table indicates that the evidence is significant in the predicted direction, "no" indicates it is significant but in the opposite direction, and "none" indicates the coefficient is not significant.

Research	**Sample**	**Period**	**Proxy**	**Conclusions**
Bessembinder (1991)	None	None	None	Hedging increases the number of future states in which shareholders are better off than non-equity claimants since hedging is a remedy for the underinvestment problem.
Froot, Scharfstein, and Stein (1993)	None	None	None	They suggest that when the cost of financial distress is high for firms, the underinvestment problem can be solved by hedging.
Nance, Smith, and Smithson (1993)	169 of Surveyed Firms from Fortune 500 and S&P 400	1986	Book-to-market(-,none); R&D(+,yes)	Firms that have higher (R&D) expenses use more hedging instruments. They also find that firms with more growth opportunities in their investment set and lower leverage in their capital structure are more likely to be hedgers.
Dolde (1995)	244 respondents from Survey data	1992	R&D (+,yes)	He finds that firms with high levels of research and development expenses are more likely to use some form of derivatives instrument.
Mian (1996)	3022 Compustat firms	1991	Book-to-market(-,no); Regulated industry(-,yes)	Contrary to underinvestment theory, he finds a negative relation between a firm’s investment opportunities and its hedging amount.

Table 2.2 Continued

Research	Sample	Period	Proxy	Conclusions
Ross (1996)	None	None	None	He argues that firms with high growth opportunities are more likely to use derivatives to mitigate the underinvestment problem, but not to increase debt capacity.
Stulz (1996)	None	None	None	He states that hedging may decrease the probability of financial distress and the costs associated with underinvestment
Geczy, Minton and Schrand (1996)	372 of Fortune 500 non-financial firms	1991	Book-to-market(-,none); Property, plant & equipment(+,yes); R&D(+,yes)	Firms with higher R&D expenditures are more likely to use derivatives, which is consistent with the underinvestment hypothesis.
Samant (1996)				He finds that firms with more growth opportunities, more leverage, lower fixed to total assets ratios and more divergent earning estimates are more likely to hedge with interest
Gay and Nam (1998)	325 derivative using nonfinancial firms	1995	Book-to-market(-,yes); Earnings-to-price(-,yes); Market-adj. cum. returns(+, yes); R&D (+,yes)	Their findings support that firms use derivatives to mitigate potential underinvestment problems
Horng and Wei (1999)	186 REITs	1996	Market-to-book(+,no)	They find no relation between growth opportunities and the level of hedging, contradicting underinvestment theory.
Petersen and Thiagarajan (2000)	Two gold mining firms: American Barrick, Homestake Mining	1976 to 1994	Operating cash flow-desired net investment(+,yes)	They conclude the difference in investment opportunities plays an important role in the firms' choice of risk management strategies.

Table 2.2 Continued

Research	Sample	Period	Proxy	Conclusions
Allayannis and Ofek (2001)	S&P 500 non-financial firms	1993	Book-to-market(-,none); R&D (+,yes)	Only R&D gives consistent results with the underinv
Knopf, Nam and Thornton (2002)	260 non-financial S&P 500 firms	1995	R&D (+, yes); market-to-book(+,yes)	Their results confirm that there is a positive relation between hedging and growth opportunities.
Graham and Rogers (2002)	442 nonfinancial firms	1994 or 1995	R&D(-,no); Book-to-market(-,no); Debt*Market-book-ratio (+,yes)	Only the interaction proxy provide consistent evidence with the underinvestment hypothesis.
Crabb (2002)	32 U.S. multinational firms from S&P COMPUSTAT	1992-1997	Market-to-book*Dummy for exchange rate risk(+,yes)	Consistent with previous research the investment opportunity set significantly affects the firm's hedge ratio.
Reynolds and Boyle (2005)	105 firms listed on the New Zealand Stock Exchange	1999	Tobin's q(+,none); Asset growth-to-cashf flow(+,none)	They cannot find any support for the hypothesis that firm with better growth opportunities hedge more to smooth their cash flows to limit underinvestment.
Lin and Smith (2007)	Non-financial firms in the Swaps Monitor Database	1992 to 1996	price-to-earning ratio(+,yes)	They find that firms with high growth opportunities use derivatives to increase their investment but not leverage.
Singh and Upneja (2008)	47 lodging firms	2000 to 2004	Market-to-boo(+,yes)	Consistent with theory and prior research, they find firms with higher growth opportunities are more likely to use derivatives to hedge.

companies' risk that may, in turn, creates conflicts with shareholders. According to manager utility maximization theory, managers holding greater equity as a fraction of their own wealth or compensated with company shares are more likely to be risk averse. For this reason, they are more motivated to be involved in hedging in order to maximize their own utility. The variance of the firms' expected profits significantly affects managers' utility of wealth. The theory also posits that firms whose managers are compensated with options are less likely to hedge since increasing the risk of the firm will increase the value of options. The predictive power of these theories is also supported by empirical research.

2.1.3.1 Articles Related to Managerial Ownership and Risk Aversion

Stulz (1984) develops a theoretical model in which managers decide the optimal hedging policy using foreign currency forward contracts. In his framework, default-free domestic bonds are the only investment option for the manager, who has to pay some transaction costs if he decides to purchase foreign default-free bonds or enter into foreign currency forward contracts. In such a case a risk-averse manager, who holds a significant portion of his wealth in the company, is more likely to engage in hedging, especially as hedging his own account is more costly than hedging the firm's risk. In other words, Stulz (1984) theoretically shows that managers maximize their own utility rather than firm value.

Smith and Stulz (1985) assert the manager's compensation package plays an important role in a firm's hedging decision. They employ three scenarios to demonstrate how the wealth of the manager affects the optimal hedging policy of a firm. In the first one, the manager's wealth is a concave function of firm value. They state, in this case, that the manager's utility is maximized if the firm is completely hedged. In the second one, the manager has a convex wealth function but a concave utility function. Since his expected income is higher without hedging but at the same time he is risk averse, the optimal hedging policy for this manager is eliminating some risks but not all. So he will partially hedge the firm's risk. In the third scenario, the manager has a convex utility function of firm value which means he is a risk-taker. Bonus or stock options in the compensation makes the managers' utility function convex. In this case, the manager chooses not to engage in hedging at all since volatility in the firm value increases his wealth. They also add that hedging risk through the firm rather than through a personal account provides a comparative advantage for managers since the latter one is costly.

Berkman and Bradbury (1996) provide some evidence of the determinants of hedging using 116 non-financial New Zealand firms in 1994. They use the proportion of shares held by managers to proxy for the diversification of contracting parties. Their result shows that managers who own more shares of the company are involved in more hedging activity. This finding supports that managerial utility maximization plays an important role in the hedging decision.

Using a sample of 48 North American gold mining companies from 1990 to 1993, Tufano (1996) finds support for the managerial risk aversion theory. He documents that the extent of hedging gold price risk tends to be more when managers hold company stocks but less when they hold more options.

Geczy, Minton, Schrand (1997) test managerial contracting cost theory using 372 Fortune 500 non-financial firms. They use the log of the market value of common shares beneficially owned (excluding options) by officers and directors as a group to proxy for managerial wealth, and the log of the market value of the shares obtainable by using outstanding options to proxy for managerial risk aversion. The insignificant coefficients estimates of these proxies reveal that managerial wealth or risk aversion do not affect corporate hedging policy.

Schrand and Unal (1998) examine whether managerial security holdings that convert from mutual to stock affect risk management of firms in the savings and loan industry. They find that firms whose managers are granted options at conversion experience significantly greater return volatility compared to firms whose managers do not receive any options. Additionally, they observe a significant decrease in the total risk of institutions which have greater managerial shareholdings following the conversion.

Gay and Nam (1998) use managerial shareholdings and stock-option holdings as proxies for managerial risk aversion. They fail to find any significant evidence of the notion suggested by current literature that managerial shareholdings positively affect corporate risk management. Contrary to the prediction by previous studies, they observe a positive relation between stock option holdings and hedging. They explain this result by some of the characteristics of stock options that make the expected payoff similar to the expected payoff from common stock.

Haushalter (2000) uses similar proxies as Gezcy, Minton, and Schrand (1997) to measure managerial ownership: he uses the log of market value of the firm's equity owned by officers and directors, and the fractions of the firm's outstanding shares held by directors and officers. He cannot find any support for the notion that the extent of hedging increases with managerial stock ownership.

Perfect, Wiles, and Howton (2000) investigates whether compensation plans of managers have any effect on corporate hedging decisions. Their data consists of 250 executives employed by 59 COMPUSTAT firms. They find that the differences in the risk exposure of firms can be explained by the level of executives' stock options and deferred compensations. Specifically, firms that have contingent compensation plans consisting of options and stock appreciation rights use less hedging.

Carpenter (2000) develops a theoretical framework to investigate the relation between hedging and option compensation plans in which a risk-averse manager is paid with a call option on the assets he manages. She argues that option compensations do not always result in less hedging for the company. Under some conditions, more options may lead compensating managers to be more risk averse, so they adopt an extensive hedging policy. On the other hand, if they hold options that are deep out-of-money, they do not hesitate to take risk, and as a result hedge less.

Roger (2002) investigates whether managerial motives affect firms' hedging policy. Different from previous research in which risk-taking incentives are treated as exogenous variables, he treats them as endogenous variables. Using simultaneous models, he empirically shows that managerial risk-taking incentives play a significant role in corporate risk management. He finds a negative relation between risk-taking incentives measured using options and corporate derivative holdings and even a stronger relation when risk-taking incentives are measured using a combination of stocks and options. His results provide broader evidence than previous studies that are concentrated on a single industry.

Using 260 S&P 500 non-financial firms, Knopf, Nam, and Thornton (2002) find that there is a positive relation between corporate hedging activity and sensitivity of the manager's stock option portfolio. Additionally they report a non-statistically significant result, that hedging activities were negatively related to the sensitivity of the manager's stock option portfolio to stock return volatility.

Rajgopal and Shevlin (2002) investigate whether the incentives of executive stock options affect firm risk using a sample from oil and gas producers. They use variation of cash flows from exploration activity as a proxy for exploration risk, and the sensitivity of the value of the CEO's options to stock return volatility as a proxy for employee stock options risk incentives. They find a positive relationship between employee stock option risk incentives and exploration risk taking. Their findings also suggest that executive stock options create incentives for CEOs to hedge a firm's exploration risk less.

Adkins, Carter, and Simpson (2007) examine whether managerial compensation and ownership affect hedging decisions of U.S. bank holding companies. Their main finding is the importance of managerial incentives on the determinants of both the decision to hedge and the extent of hedging. Consistent with previous research for non-financial firms, they find that managers compensated with options have less incentive to hedge using foreign exchange derivatives while managers compensated with equity holdings extensively engage in hedging activities.

Singh and Upneja (2008) provide some evidence on the importance of managerial risk aversion on the decision to hedge using a sample from the lodging industry. They use CEO stock options as a proxy for risk aversion. Their result on this proxy reveals that managers with greater option holdings are more motivated to reduce the volatility of firms' cash flow and earnings with hedging.

Ertugrul, Sezer and Sirmans (2008) is another study that proves the association between managerial compensation and hedging using nontraditional proxies for managerial risk aversion such as estimates of the Black-Scholes sensitivity of CEO's stock option portfolios to stock volatility and the sensitivity of CEO's stock and stock option portfolios to stock prices. The study finds that managers with a higher sensitivity of their wealth to stock price volatility have less motivation to hedge. Additionally, they document that the higher the ratio of CEOs' cash compensation to total compensation, the less they hedge. When the study uses the traditional proxies for risk aversion, it cannot provide significant results supporting managerial risk aversion theories.

Dionne and Trike (2013) examine the hedging activity of 48 North American Gold Mining firms over the period 1991-1999 and find consistent results with managerial risk aversion theory. The value of common shares and options held by directors and officers is used to measure managerial risk aversion. Their results show that managers compensated with shares tend to be more risk averse and, in turn, use more hedging. On the other hand, managers compensated with options have less incentive to hedge the risk.

I summarize the previous studies related to managerial ownership and risk version in Table 2.3. The findings of the current research often confirm the managerial risk aversion hypothesis when option ownership is used as a proxy. The results of the other commonly used proxy, share ownership, are not always in the unexpected direction. Other proxies using different samples result in different conclusions. In conclusion, the validity of managerial risk aversion hypothesis varies a lot with the data and the proxy used.

2.1.4 Corporate Taxes

Theory suggests if a company's tax schedule is convex, hedging provides benefits by reducing the volatility of taxable income. As a result of decreased volatility, the average tax burden of the firms becomes less. A convex tax function means taxes increase more than proportionally with taxable income. In this case, volatile taxable income results in a greater tax burden compared to stable pre-tax income. Hedging creates value to the extent that it decreases the volatility of taxable income. In other words, the more convex the tax schedule is, the greater is the reduction in expected taxes created by hedging.

Table 2.3 Summary of Previous Studies Related to Managerial Ownership and Risk Averison

This table provides a summary of existing studies related to financial distress costs as a determinant of hedging. In the proxy column, the "+", "-" and "?" signs in the parentheses predicts the relation between the corresponding variables and hedging. "+" and "-" mean positive and negative relations are expected, respectively. A"?" indicates there is no prior expectation between hedging and corresponding variables. A "yes" in the table indicates that the evidence is significant in the predicted direction, "no" indicates it is significant but in the opposite direction and "none" indicates the coefficient is not significant. "neg." and "pos." indicate the direction of the relationship between hedging and the variable when there is no prior expectation.

Research	Sample	Period	Proxy	Conclusions
Stulz (1984)	None	None	None	Stulz (1984) theoretically shows that managers maximize their own utility rather than firm value.
Smith and Stulz (1985)	None	None	None	Managers with more stock ownership prefer more risk management while those with more stock options prefer less risk management.
Berkman and Bradbury (1996)	116 firms listed New Zeland Stock Exchange	1994	% Share ownership(+, yes)	Derivative use increases with the proportion of shares held by directors.
Tufano (1996)	48 north american gold mining firms	1990 to 1993	Blockholders(?,neg.); CEO share ownership(+,none); Option ownership(?,neg.); Share ownership(+,yes); Tenure executives(-,yes)	Managers holding more stock options manage less gold price risk, while those holding more stocks manage more gold price risk.

Table 2.3 Continued

Research	Sample	Period	Proxy	Conclusions
Geczy, Minton and Schrand (1997)	372 of Fortune 500 nonfinancial firms	1991	Option ownership(?,none); Share ownership(+,none)	They find little support for the explanations based on managerial self-interest.
Gay and Nam (1998)	325 derivative using nonfinancial firms	1995	Option ownership(?,pos.); Share ownership(+,none)	Contrary to the prediction of previous studies, they observe a positive relation between stock-option holdings and hedging.
Haushalter (2000)	100 public oil and gas producers	1992 to 1994	Blockholders(?,neg.); CEO option ownership(?,pos.); Option ownership(?,neg.); Share ownership(+,no); % Share ownership(+,no)	He cannot find any support for the notion that the extent of hedging increases with managerial stock ownership.
Perfect, Wiles, and Howton (2000)	260 executives employed by 59 random Compustat firms	1980 to 1986	Option owneship(?,pos.); Deferred compensation(?,pos.)	They find that the differences in the risk exposure of firms can be explained by the level of stock options and deferred compensations.
Carpenter (2000)	None	None	None	Under some conditions, compensating managers with more options may lead them to be more risk averse, so they adopt an extensive hedging policy.
Rogers (2002)	524 firms derived from random 10-K filings	1994 to 1995	Sensitivity CEO sigma(-,yes)	He finds a negative relation between risk-taking incentives measured using options and corporate derivative holdings. An even a stronger relation is observed when risk-taking incentives are measured using a combination of stocks and

Table 2.3 Continued

Research	Sample	Period	Proxy	Conclusions
Knopf, Nam and Thornton (2002)	260 non-financial S&P 500 firms	1995	Blockholders(?,none); CEO option ownership(?,pos); CEO share ownership(+,none); Option ownership(?,pos.); Sensitivity CEO price(-,yes);Sensitivity CEO sigma(-	The sensitivity of CEOs' wealth to stock price is positively related to hedging, while the sensitivity of managers' stock option portfolios is negatively related to hedging.
Rajgopal and Shevlin (2002)	117 firm years data for Oil and gas CEOs from 1998 S&P Execucomp database	1992 to 1997	Sensitivity CEO sigma(-,yes)	Executive stock options motivate managers to hedge oil price risk less.
Adkins, Carter and Simpson (2007)	252 large bank holding companies	1996 to 2000	CEO Option ownership(?,neg.); CEO bonus(?,pos.); CEO base salar(?,none)	The main finding is the importance of managerial incentives on the determinants of both the decision to hedge and the extent of hedging.
Singh and Upneja (2008)	47 lodging firms	2000 to 2004	CEO option ownership(?,pos.);	Managerial risk aversion is a significant determinant of the decision to hedge.
Ertugrul, Sezer, and Sirmans (2008)	112 REITs	1999 to 2001	CEO cash compensation(- ,yes);Sensitivity CEO sigma(-,yes); CEO share ownership(+,none); CEO option ownership(?,none)	The managerial risk aversion motive is a significant determinant for corporate hedging in REITs.
Dionne and Triki (2013)	48 North American gold mining firms	1991 to 1999	CEO option ownership(?,neg.); CEO share ownership(+,yes)	Their results show that managers compensated with shares tends to be more risk averse, in turn, use more hedging. On the other hand, managers compensated with options have less incentive to hedge the risk.

The provisions of the corporate tax code make statutory tax schedules convex. Under the current corporate tax rates, the progressivity of the corporate tax structure applies to the range of pre-tax incomes between $0 and $100,000. The convex region is extended by tax preference items, such as tax loss carryforwards, investment tax credits, and foreign tax credits.

2.1.4.1 Articles Related to Tax Benefits

The theoretical study of Mayers and Smith (1982) shows how hedging helps to reduce a corporation's expected tax liability. According to this study, provisions in the tax codes which change the effective marginal tax brackets motivate firms to hedge.

Smith and Stulz (1985) point out that the structure of a tax cost is an important determinant of hedging. They show that if hedging is not too costly, firms with convex tax schedules benefit from hedging because it increases the expected post-tax value of firms by smoothing out pre-tax values.

Nance, Smith and Smithson (1993) provide empirical evidence for the tax hypothesis using a dummy variable that indicates whether income is in the convex tax region of tax code, using tax loss carryforwards and investment tax credits as proxies. They find that firms with more investment tax credits are more likely to hedge. Additionally, they report firms that have more of their income in the progressive region of the tax schedule are more motivated to hedge.

Berkman and Bradbury (1996) test tax theories using a sample of firms from New Zealand and find supportive results. They use the tax-loss carryforwards dummy as a proxy for tax convexity and conclude that firms with tax-loss carryforwards are more likely to involve in hedging activities.

Tufano (1996) also uses tax loss carryforwards as a proxy for the tax incentives. He concludes that the degree of convexity in a firm's tax schedule does not affect the extent of corporate risk management of gold mining firms.

Mian (1996) uses the same proxies in Nance, Smith, and Smithson (1993) but draws different conclusions. Contrary to the theory, he documents that the lower the incidence of progressivity and tax loss carryforwards that firms have, the less likely they are to hedge. However, when he uses the incidence of foreign tax credits as a proxy, he finds consistent results with the theory, which suggests that hedgers have a higher incidence of foreign tax credits compared to non-hedgers.

Geczy, Minton, and Schrand (1997) also use net operating loss carryforwards as a proxy for tax incentives. Their study fails to provide evidence for the hedging benefits of tax preference items. In other words, it does not find any significant relation between foreign exchange rate hedging and tax loss carryforwards using a sample of industrial firms from Fortune's 1991 list.

Fok, Carroll, and Chiou (1997) test the tax hypothesis with the data on the corporate use of off-balance sheet activities of S&P 500 firms from 1990-1992 using the Swaps Monitor Publication. They measure the convexity of a firm's statutory function with tax loss carryforwards and investment credits. However, they do not find any support for the relationship between tax convexity and hedging.

Haushalter (2000) tests the relation between hedging and taxes for oil and gas producers using the marginal tax rate as a proxy. He documents significant but contradictory results related to the tax hypothesis. His finding suggests that firms with lower marginal tax rates hedge more compared to those with higher marginal tax rates.

Graham and Rogers (2002) test whether tax incentives affect the extent of hedging using 442 non-financial firms for the year 1994 or 1995. They use tax loss carryforwards and tax savings as proxies for the convexity of the tax function. However, they fail to support the hypothesis that tax incentives are determinants of a firm's hedging policy.

Dionne and Triki (2013) examine whether the hedging activity of 48 North American gold mining firms is affected by tax incentives. They fail to provide any significant evidence for the tax arguments using tax savings as proxy.

The previous studies related to corporate tax as a motive for hedging are summarized in Table 2.4. Tax credit, tax-loss carryforward, and tax saving are some of the proxies the current research uses. Among them, tax-loss carryforward is the most widely preferred one to test the corporate tax theory. The results of existing studies provide weak empirical support for the tax hypothesis. Arez and Bartram (2009) explain this weakness with the fact that tax incentives are hardly identified in statistical tests since other incentives dominate hedging incentives.

Table 2.4 Summary of Previous Studies Related to Corporate Taxes

This table provides a summary of existing studies related to financial distress costs as a determinant of hedging. In the proxy column, the "+", "-" and "?" signs in the parentheses predicts the relation between the corresponding variables and hedging. "+" and "-" mean positive and negative relations are expected, respectively. A "yes" in the table indicates that the evidence is significant and in the predicted direction, "no" indicates it is significant in the opposite direction and "none" indicates the coefficient is not significant.

Research	Sample	Period	Proxy	Conclusions
Mayers and Smiths (1982)	None	None	None	They assert that provisions in the tax codes which change the effective marginal tax brackets motivate firms to hedge.
Smith and Stulz (1985)	None	None	None	They show that if hedging is not too costly, firms with convex tax schedules benefit from hedging because it increases the expected post-tax value of firms by smoothing out pre-tax values.
Nance, Smith, and Smithson (1993)	169 of Surveyed Firms from Fortune 500 and S&P 400	1986	Prog. Corp. tax structure (+,none); Tax credits(+,yes); Tax-loss carry-forwards(+,none)	They find that firms with more investment tax credits are more likely to hedge. They report firms that have more of their income in the progressive region of the tax schedule are more motivated to hedge.
Berkman and Bradbury (1996)	116 firms listed New Zeland Stock Exchange	1994	Tax-loss carry-forwards dummy(+,yes)	They conclude firms with tax-loss carry-forwards are more likely to involve in hedging activities.
Tufano (1996)	48 north american gold mining firms	1990 to 1993	Tax-loss carry-forwards (+,none)	He concludes the degree of convexity in firm’s tax schedule does not affect the extent of corporate risk management of gold mining firms.

Table 2.4 Continued

Research	Sample	Period	Proxy	Conclusions
Mian (1996)	3022 Compustat firms	1991	Prog. Corp. tax structure (+,none); Tax credits(+,yes); Tax-loss carry-forwards dummy(+,none)	His result is consistent result the theory suggesting that hedgers have a higher incidence of foreign tax credits compared to non-hedgers.
Geczy, Minton and Schrand (1997)	372 of Fortune 500 nonfinancial firms	1991	Tax-loss carry forwards(+,none)	They fail to provide evidence for the hedging benefits of tax preference items.
Fok, Carroll, and Chiou (1997)	331 non-financial firms	1990 to 1992	Tax credits(+,none); Tax-loss carry forwards(+,none)	They do not find any support for the relationship between tax convexity and hedging.
Haushalter (2000)	100 public oil and gas producers	1992 to 1994	Prog. Corp. tax structure(+,yes); Marginal tax rate(-,no)	His finding suggests that firms with lower marginal tax rates hedge more compared to those with higher marginal tax rates.
Graham and Rogers (2002)	442 nonfinancial firms	1994 or 1995	Tax-loss carry forwards(+,no); Tax savings(+,none)	They failed to support the hypothesis that tax incentives are determinant of firms' hedging policies
Dionne and Triki (2012)	48 North American gold mining firms	1991 to 1999	Tax savings(+,no)	They fail to provide any significant evidence for the tax arguments using tax saving as proxy.

2.1.5 Hedging Substitutes

The current literature lists different hedging substitutes. In my research, the literature review for these substitutes is explained in the following sections.

2.1.5.1 Operational Hedging

In addition to derivative hedging, operational strategies have been perceived as risk management techniques against uncertainties by many scholars. Lewellen (1971) states that mergers and acquisitions (M&A) can help to reduce cash flow volatility if the combining firms' cash flows are not perfectly correlated. His paper sheds light on current literature by first recognizing risk management benefits of M&A among other operational decisions.

Hurchzermeier and Cohen (1996) show that long-term hedging for the exchange rate exposure can be achieved by operational hedging. Stulz (1990) states that costless acquisitions reduce cash flow volatility that in turn benefits shareholders. Gupta and Gerchak (2002) mention operational flexibility of mergers. Many other scholars also recognize mergers as a hedging mechanism (Amihud and Lev, 1981; Hirshleifer, 1988; Penas and Unal, 2004; Hankins, 2009).

Hankins (2009) is the closest study to my research. Using a sample of bank holding companies, Hankins concludes operational hedging can be a substitute for financial hedging by showing the decrease in financial hedging after acquisitions. She also shows that firms do not only manage the particular transaction risk, but also that they manage the total volatility arising from all transactions. Vertical integration is a specific type of M&A decision where two related industries merge. For this reason, the results of her paper are not promising in regard to whether or not vertical integration can be substituted for derivative hedging. In addition, the findings of her study are only valid for the sample of bank holding companies.

2.1.5.2 Vertical Integration

Klein et al. (1978) and Williamson (1979) are the pioneers who suggest vertical integration as a risk management tool, especially when there is high asset specificity. Carlton (1979) is also one of the advocates of this view. He states that vertical integration is a hedging mechanism for firms that face uncertainty about the availability of inputs. Klein and Murphy (1997) and Baker et al. (1997) expect that firms are more likely to engage in vertical integration when there is high uncertainty in the market.

In the industrial organization literature, vertical integration is seen as a cure to contracting problems. These kinds of problems usually increase in periods when uncertainty is high. Williamson (1971) states that evolving technology prevents perfect contracts. This results in contractual incompleteness; vertical integration is an effective solution for this problem. Carlton (1979) states that vertical integration is a risk management tool for firms facing potentially uncertain availability of inputs. Kedia, Ravid, and Pons' (2008) paper investigates whether vertical integration provides any benefit when there is price uncertainty. The recent study of Garfinkel and

Harkins (2011) also empirically shows vertical integration as an operational hedging mechanism, and that the tendency of firms towards vertical integration is increasing with higher asset specificity. This paper is unique since it broadly concludes that vertical integration is a risk management tool.

In his theoretical paper, Hirshleifer (1988) asserts the substitutability of vertical integration and financial hedging. Specifically, he states that when the demand is inelastic, firms may use future trading as a substitute for vertical integration while managing their risk. Aid et al. (2011) questions whether vertical integration and forward hedging are substituted by French electric firms. They developed an equilibrium model that compares the impact of forward hedging to the impact of hedging via vertical integration on prices, risk premia and retail market shares within French electricity markets. The numerical application of the models used in their paper confirms the substitutability of vertical integration and forward hedging. In addition, they add that the two mechanisms are not perfect substitutes. Their paper is the closest to the idea of my research.

In summary, some theoretical studies exist in regard to the risk management aspects of vertical integration and derivative hedging. However, beyond them, the current literature lacks empirical evidence on the interaction between vertical integration and derivative hedging.

2.1.5.3 Other Hedging Substitutes

Corporate hedging is affected by other financing policies. The risk can be managed by alternative activities that substitute for off-balance sheet hedging instruments. Structuring liabilities and assets on the balance sheet in such a way that both shareholders and bondholders are better off is one way to reduce financial risk. According to Nance, Smith, and Smithson (1993), issuing convertible debt or preferred stock instead of straight debt may be a solution to agency problems and, for this reason, reduces the need for hedging. Convertible debt reduces conflicts of interest between bondholders and shareholders whereas the probability of financial distress is reduced by preferred stocks. Additionally, investing in more liquid or less risky assets or imposing dividend restrictions may be alternative ways of managing risk.

Previous studies use several different proxies to test hedging alternatives. For example, Berkman and Bradbury (1996) and Nance, Smith, and Smithson (1993) use a firm's liquidity, dividend, convertible debt, and preferred-stock ratio to control for hedging substitutes. Mian (1996), Geczy, Minton, and Schrand (1995), and Tufano (1996) use a measure of a firm's liquidity and Wysocki (1996) uses a firm's dividend ratio.

2.2 Effects of Financial Hedging On Firm Value

Although the analysis of effects of financial hedging on firm value will be considered as a future work, I present the literature review on this issue since it is closely related to hedging.

The Miller-Modigliani theorem, with perfect capital markets, assumes risk management is irrelevant for firms because shareholders can hedge their own risk and maintain the desired level of volatility by trading the same financial instruments used by firms. However, in the real world, firms face frictions such as information asymmetries, taxes, and transaction, distress or bankruptcy costs; thus these frictions prevent Miller and Modigliani theory from holding in today's economy. Hedging can increase the value of firms by lowering the deadweight costs of these frictions. The value creation effect of hedging has become an essential issue among scholars in recent years, such as in Allayannis and Weston (2001); Graham and Rogers (2002); Carter et al. (2006). They examine whether this financial policy has any contribution to value creation, but current literature has not yet reached a consensus.

The theoretical models in the studies of Smith and Stulz (1985), Bessembinder (1991) and Froot, Scharfstein and, Stein (1993) prove that hedging increases the value of a firm by reducing the probability of financial distress, expected taxes, and the variance of cash flows and agency conflicts.

Allayannis and Weston (2001) is the first study that provides evidence on the relation between hedging and firm value for a sample of 720 large non-financial firms. The study shows that firms using foreign currency derivatives gain approximately a

5% hedging premium compared to nonusers. This result is supported by Graham and Rogers (2002). They argue that hedging increases debt capacity and interest tax deductions, and that hedging firms enjoy 1.1 % higher value than non-hedgers do.

Lookman (2004) examines the amount of the hedging premium with a sample of oil and gas exploration and production (E&P) firms. He separates firms into two groups: firms that hedge their primary risk and firms that hedge their secondary risk. The results of his study show that hedging leads to a lower value for undiversified firms hedging their primary risk and a higher value for diversified firms with an E&P segment that hedge their secondary risk.

Adam and Fernando (2006) show that the firms which are engaged in gold hedging have benefited from significant cash flow gains over the period 1990 to 2000. They state these cash flow gains result in an increased shareholder value.

Jin and Jorin (2006) investigate the effect of hedging on firm value for a sample of 119 U.S. oil and gas producers and find results that contradict previous studies. They conclude that risk management is irrelevant, at least for oil and gas producing firms, since they fail to observe any significant difference in firm values between hedgers and non-hedgers.

Carter, Rogers, and Simkins (2006) provide evidence for the notion that hedging enhances a firm’s value using a sample from the U.S. airline industry. They show if firms in this industry hedge their jet fuel costs, their hedging premium may be as large as 10%, which is greater than 5% reported by Allayannis and Weston (2001). They also observe a positive relation between hedging and value increases in capital investment, suggesting that reduction of underinvestment costs is the main reason for this premium.

Mackay and Moeller (2007) theoretically and empirically show that corporate hedging can enhance firm value when the revenues and costs are nonlinearly related to risk factors for a sample of 34 oil refiners. Specifically, they posit that firm value is increased up to 3% if the revenues that are concave in product prices are hedged, and the convex costs are left exposed to uncertainty.

Bartram, Brown, and Fehle (2009) provide international evidence on the value-enhancing effect of hedging. Using a sample of 7,319 firms in 50 countries, including the United States, they find that hedging results in a higher firm value only for certain risks, such as interest rate risk.

Fauver and Naranjo (2010) use a large sample of 1746 firms headquartered in the US over the period 1991 to 2000 and find that corporate risk management has a negative 8.4% impact on firm value. They also state that this negative impact is especially observed for firms with greater agency and monitoring problems.

Khediri and Folus (2010) investigate the effect of hedging on firm value for French non-financial firms. Their univariate results show that hedging firms have lower values than non-hedging firms. However, they fail to observe any significant result that hedging increases firm value in the multivariate analysis.

Table 2.6 provides a summary of the previous studies related to hedging’s effect on firm value. The current literature provides mixed evidence on hedging’s effect on firm value. Some of the scholars (i.e., Allayannis and Weston, 2001; Graham and Rogers, 2002; Carter, Rogers and Simkins, 2006; Mackay and Moeller, 2007) are advocates of the theory that hedging enhances firm value, the findings of others (i.e., Fauver and Naranjo, 2010) oppose it. There are also some scholars who do not find any relationship between hedging and firm value (i.e., Jin and Jorin, 2006; Khediri and Folus, 2010). Based on the literature reviewed in this chapter, I develop some testable hypotheses and set up my expectations which are explained in detail in the next chapter.

Table 2.5 Summary of Previous Studies Related to Hedging Effect on Firm Value

This table provides a summary of existing studies related to hedging's effect on firm value.

Research	Sample	Period	Conclusions
Smith and Stulz (1985)	None	None	They prove that hedging increase the value of a firm by reducing the probability of financial distress, expected taxes, the variance of cash flows and agency conflicts.
Bessembinder (1991)	None	None	Hedging can increase the value of the firm by reducing financial distress costs and mitigating underinvestment.
Froot, Scharfstein, and Stein (1993)	None	None	Hedging can increase the value of the firm by reducing financial distress costs and mitigating underinvestment.
Allayannis and Weston (2001)	720 large US non-financial firms	1990 to 1995	They show firms using foreign currency derivatives gain approximately 5% hedging premium compared to nonusers.
Graham and Rogers (2002)	442 nonfinancial firms	1994 or 1995	They argue that hedging increases debt capacity and interest tax deductions, and hedging firms enjoy a 1.1 % higher value than non-hedgers do.
Lookman (2004)	125 exploration and production firms	1992 to 1994 and 1999 to 2000	He shows that hedging leads to a lower value for undiversified firms hedging their primary risk and a higher value for diversified firms with an E&P segment that hedges their secondary risk.

Table 2.5 Continued

Research	Sample	Period	Conclusions
Adam and Fernando (2006)	92 North American gold mining firms	1989 to 1999	They show that the firms engaged in gold hedging have benefited from significant cash flow gains resulting in increased shareholder value.
Jin and Jorin (2006)	119 US oil and gas producers	1998 to 2001	They conclude that risk management is irrelevant at least for oil and gas producing firms since they fail to observe any significant difference in firm values between hedgers and non-hedgers.
Carter, Rogers, and Simkins (2006)	28 US airlines	1994 to 2000	They show if firms in this industry hedge their jet fuel costs, their hedging premium may be as large as 10% .
Mackay and Moeller (2007)	34 oil refiners	1985 to 2004	They posit that firm value is increased up to 3% if the revenues that are concave in product prices are hedged, and the convex costs are left exposed to uncertainty.
Bartram, Brown, and Fehle (2009)	7309 non-financial firms from 48 countries	1999 to 2000	They find that hedging results in a higher firm value only for certain risks, such as interest rate risk.
Fauver and Naranjo (2010)	1746 US firms	1991 to 2000	They find that corporate risk management has a negative 8.4% impact on firm value.
Khediri and Folus (2010)	320 French non-financial firms	2001	They fail to observe any significant result that hedging increases firm value in the multivariate analysis.

Chapter 3

RESEARCH HYPOTHESES AND METHODOLOGY

3.1 Research Hypotheses

Different companies have different hedging practices. While some companies extensively use financial instruments, others choose not to hedge their risk at all. Many scholars have tried to find motivations for a firm to use derivatives if the assumptions of Miller and Modigliani theorem are relaxed. As mentioned in Chapter 2, these motivations are summarized under five main categories: Financial distress costs, underinvestment costs, managerial ownership and risk aversion, corporate taxes, and hedging substitutes.

In this study, I examine the extant theories regarding the motivations of derivative hedging and try to find the key determinants of the decision to hedge and extent of hedging using a sample of vertically related firms. Existing studies use similar determinants of derivative hedging such as firm leverage, growth opportunities, size, investment opportunity, managerial wealth and risk, institutional ownership and so on. However, vertical integration has not been tested as a determinant of derivative hedging. This study mainly focuses on the vertical integration variable that is assumed to be a substitute for derivative hedging. Although there are some theoretical works that show substitutability of vertical integration and derivative hedging, no empirical work seems to have been done to confirm this theory.

In the following section, I explain the hypotheses tested in this research.

3.1.1 Research Hypotheses on the Determinants of Derivative Hedging

In this study, I develop two testable hypotheses that reveal interaction between hedging and vertical integration. These are stated in Hypothesis 1 and 2. In Hypothesis 3 to 9, I verify the extant hypotheses using my sample.

Hypothesis 1: Vertical integration is a substitute for derivative hedging

Hirshleifer (1988) theoretically shows when the demand is inelastic firms may use futures trading, which is one of the hedging instruments, as a substitute for vertical integration while managing their risk. Garfinkel and Harkins (2011) empirically prove vertical integration provides an operational hedging mechanism because it is associated with a decrease in cash flow volatility. Hankins (2009) also shows that bank holding companies substitute operational hedging via acquisitions for financial hedging. Her paper reveals the interaction of hedging and acquisitions but is limited to bank holding companies. These papers lead me to question the interaction between vertical integration and derivative hedging and test the substitutability of these two hedging mechanisms.

I create three different vertical integration dummies *(VI, VI1, VI2)* as proxies for vertical integration. Vertical integration *(VI)* is the dummy variable that treats observations at the year of vertical integration as non-vertical integration and takes a value of one if the firm is vertically integrated and zero otherwise. Vertical integration alternative 1 *(VI1)* is the dummy variable that treats observations at the year of vertical integration as vertical integration and takes a value of one if the firm is vertically integrated and zero otherwise. Vertical integration alternative 2 *(VI2)* is another dummy variable that assigns a missing value for the observations at the year of vertical integration and takes a value of one if the firm is vertically integrated and zero otherwise.

I create different vertical integration dummies because some firms become vertically integrated at the beginning of the year while others become vertically integrated at the middle or end of the year. If a firm's vertical integration occurs at the end of a year, assigning a vertical integration dummy for the observations in this year may bias the estimates since there is no time for firms to adjust the hedging policy according to vertical integration. I validate this hypothesis by various univariate and multivariate tests. If vertical integration is a substitute for derivative hedging, I expect a significant decrease in derivative use following a vertical integration. I also expect vertical integration dummies to be negatively associated with either decision to hedge or extent of hedging.

Hypothesis 2: High vertical integration firms use less derivative hedging compared to low vertical integration firms

I also create dummy variables that separate high vertical integration firms from low vertical integration firms to see whether high vertical integration firms use less derivative hedging compared to low vertical integration firms. I use four dummy variables to differentiate high and low vertical integration firms using different cutoffs. *HIGHVERTICAL8* is the dummy variable that takes a value of one if the vertical relatedness coefficient of an acquisition exceeds 8%, and zero otherwise. *HIGHVERTICAL9* is the dummy variable that takes a value of one if the vertical relatedness coefficient of an acquisition exceeds 9%, and zero otherwise. *HIGHVERTICAL10* is the dummy variable that takes a value of one if the vertical relatedness coefficient of an acquisition exceeds 10%, and zero otherwise. *HIGHVERTICAL15* is the dummy variable that takes a value of one if the vertical relatedness coefficient of an acquisition exceeds 15%, and zero otherwise. I expect a negative relationship between high vertical integration firms and the extent of derivative use.

I also examine the extant theories regarding the motivations of derivative hedging and try to find the key determinants of hedging using a sample of vertically related firms. These hypotheses are stated in Hypothesis 3 to 9

Hypothesis 3: There is a positive relationship between financial leverage and derivative hedging

Higher financial leverage is associated with less debt capacity and financial flexibility. Highly leveraged and financially distressed firms reduce the cost of debt financing by smoothing earnings via hedging in order to decrease firm risk in the eyes of creditors. So the greater a firm's financial leverage, the more likely it will hedge to lower the probability and expected costs of financial distress. Many studies find that hedging increases with financial leverage (Dolde, 1995; Geczy et. al., 1997;

Haushalter, 2000; Pincus and Rajgopal, 2001; Graham and Rogers, 2002). I also use debt ratio (DA), which is the ratio of the book value of total liabilities to the book value of total assets, as a proxy for financial leverage. The higher a firm's debt ratio is, the greater the probability of financial distress, so the firm is more likely to hedge to prevent the costs of financial distress.

Hypothesis 4: There is a positive relationship between growth opportunities and derivative hedging

Companies that have more growth opportunities available are more likely to hedge cash flows to assure the availability of funds (Pincus and Rajgopal, 2001). A higher market-to-book ratio also indicates lower firm value. I use market-to-book ratio *(MB)* as a proxy for investment/growth opportunities. This ratio is calculated as the market value of equity divided by the book value of equity. It shows if a firm is overvalued *(MB>1)* or undervalued *(MB<1)*. The higher the market-to-book ratio, the more likely a firm will hedge. An additional two variables are used as proxies for the growth opportunities: research and development expenses scaled by assets *(R&D)*, and the ratio of capital expenditures for property, plant, and equipment to firm size *(PPE)*.

Hypothesis 5: There is a negative relationship between a firm's liquidity level and derivative hedging.

If firms maintain greater short-term liquidity, they can reduce the expected financial distress and agency costs associated with long-term debt (Nance et al., 1993). I use two variables as proxies for firms' short-term liquidity: current ratio *(CR)* and dividend payout ratio *(DIV)*. Current ratio is calculated as current assets divided by current liabilities. A lower current ratio means the firm has difficulty meeting short-term debt obligations. The higher a firm's current ratio, the less likely it will hedge. A higher current ratio is also associated with a higher firm value. Dividend payout ratio is calculated as the ratio of dividends per share to common shareholders divided by earnings per share before extraordinary items. The higher a firm's dividend ratio, the higher its need to hedge to reduce the financial distress and agency costs of debt.

Hypothesis 6: There is a positive relationship between income taxes and derivative hedging

If a firm's progressive corporate tax schedule is convex, hedging can increase the expected value of a firm by reducing expected taxes (Mayers and Smith, 1982; Smith and Stulz, 1985). Firms that have a more convex tax schedule will benefit from more reduction in expected taxes. Most empirical studies use a variable based on existing net operating loss (NOL) carryforwards as a proxy for tax function convexity (e.g. Nance et al.,1993; Tufano,1996; Geczy et al., 1997; Graham and Smith,1999; Pincus and Rajgopal, 2001). Graham and Smith (1999) show that profitable firms with NOL carryforwards are more likely to hedge. I use an indicator variable that equals one if the firm is profitable and has NOL tax carryforwards *(TAX)* as a proxy for convexity. I predict a positive relation between this indicator and hedging.

Hypothesis 7: There is a negative relationship between the proportion of institutional shareholdings and derivative hedging

DeMarzo and Duffie (1995) suggest it is hard to differentiate the profits due to managerial ability from profits due to exogenous shocks because markets cannot observe the quality of managers. If the firm has less external monitoring, managers will have more incentives to hedge cash flow volatility to facilitate the market's assessment of their skills (Pincus and Rajgopal, 2001). Geczy et al. (1997) also states that information asymmetry between investors and managers is reduced to more extensive institutional ownership. According to these findings, institutional ownership is expected to affect firms' hedging activities negatively. Conversely, some scholars assert that institutional ownership affects hedging positively because external monitoring likely increases pressure on managers to dampen volatility (Levitt, 1998). I use institutional ownership *(INST)*, calculated as the percentage of a firm's total shares outstanding held by institutions, as a proxy for external monitoring. Although there are different conclusions regarding how institutional ownership affects hedging, I expect a negative relationship between institutional ownership and hedging.

Hypothesis 8: There is a positive relationship between firm size and derivative hedging

Firm size is a proxy for expertise and the use of derivatives varies with the expertise firms have while managing hedging activities. I use the log of market value of equity as a proxy for firm size (SIZE) and predict a positive relation between hedging and firm size. Previous studies find that larger firms are more likely to hedge since they enjoy economies of scale in the process of obtaining expertise and lower average transaction costs needed to hedge effectively (Booth et al., 1984; Nance et al., 1993; Mian, 1996; Geczy et al., 1997; Haushalter, 2000). One of the major impediments toward hedging activities is the management's lack of ability with and knowledge of sophisticated financial instruments (Dolde, 1993). Larger firms can attract employees who are well educated to manage these instruments. As a result, larger firms are more likely to use derivatives than are smaller firms. This positive relation can also be explained by the tremendous start-up costs of hedging. Larger firms can bear this initial cost and thus are more likely to hedge.

Hypothesis 9: There is a negative relation between hedging substitutes and derivative hedging

Nance et al. (1993) argue that issuing convertible debt or preferred stock is another alternative to hedging while controlling the agency and expected financial distress costs associated with long-term financing. In other words, they assert that convertible debt and preferred stock can be possible substitutes for hedging. A firm's use of convertible debt *(CONV)* is calculated as the ratio of book value of total convertible debt to firm size. The firm's use of preferred stock *(PREF)* is calculated as the ratio of book value of total preferred stock to firm size. I expect a negative relation between hedging and both convertible debt and preferred stock.

3.2 Research Methodology

This section discusses research methodology related univariate and multivariate tests.

3.2.1 Univariate Analysis

Field (2005) states that researchers have more confidence in their hypotheses if the observed difference between sample means gets bigger. Univariate tests are one way to investigate the significance of the difference between sample means. I perform different univariate tests to compare differences in derivative hedging amounts between vertically and non-vertically integrated firms as well as between high and low vertical integration firms. I also compare the hedger and non-hedger firms, pre- and post-vertical integration firms, and high and low vertical integration firms. These univariate tests are explained in detail in the following sections.

3.2.1.1 Derivative Use at Different Time Periods

I perform univariate comparisons of the mean and median values of derivative use of vertically integrated firm at different time periods. I have 5 years of derivative hedging data for most of the firms: two years and one year before and after vertical integration (T-2, T-1, T+1, T+2) as well as the year of vertical integration (T). I compare the mean and median of derivative use before vertical integration (T-1) with the derivative use after vertical integration (T, T+1, and T+2). I also perform other univariate tests that compare derivative use at the year of vertical integration (T) with the derivative use of post-vertical integration (T+1, T+2).

Paired sample t-tests are used to compare the means (μ) of derivative use at different time periods since derivative use at different periods is not independent of each other. This test shows whether there is a statistically significant decrease in the mean of derivative use after vertical takeover. The differences in medians (M) of derivatives use at different time periods are tested by sign tests. The sign tests reveal whether medians of derivative use decreased following vertical integration. The null and alternative hypotheses for these two tests are presented below.

Paired T-Test

H_o : μ [difference] = 0

H_a : μ [difference] < 0

Sign Test

H_o : *M* [difference] = 0

H_a : *M* [difference] < 0

The difference equals derivative $_{(T) - (T-1)}$ or derivative $_{(T+1) - (T-1)}$ or derivative $_{(T+2) - (T-1)}$ or derivative $_{(T+1) - (T)}$ or derivative $_{(T+2) - (T)}$. Derivative stands for notional amount of foreign exchange derivatives *(FX)* or interest rate derivatives *(IR)* or commodity derivatives *(COM)* or other type of derivatives *(OTHER)* or total hedging scaled by total assets. I am more interested in total hedging test results but I also perform univariate tests for each type of derivative to point out the source of the decrease in total hedging.

In this study, I use 1%, 5% and 10% levels of significance to test the hypotheses. The test is statistically significant if the value of test statistics lies in the critical region. In this case, I reject the null hypothesis and fail to reject the alternative.

3.2.1.2 Pre- and Post-Vertical Integration Derivative Use

Comparing the mean and median values of pre- and post-vertical integration derivative usage is necessary for a robustness check to prove the decrease in post-vertical integration derivative use. The comparison in this section is different from the previous one. This one treats derivative use at T-2 and T-1 as pre-vertical integration derivative use as a whole whereas derivative use at times T, T+1 and T+2 are treated as post-vertical integration derivative use as a whole. The null and alternative hypotheses for the paired t-test and sign test are presented below.

Paired T-Test

$H_o : \mu$ [derivative $_{\text{(pre-vertical) – (post-vertical)}}$] = 0

$H_a : \mu$ [derivative $_{\text{(pre-vertical) – (post-vertical)}}$] < 0

Sign Test

$H_o : M$ [derivative $_{\text{(pre-vertical) – (post-vertical)}}$] = 0

$H_a : M$[derivative $_{\text{(pre-vertical) – (post-vertical)}}$] < 0

Derivative stands for notional amount of foreign exchange derivatives *(FX)* or interest rate derivatives *(IR)* or commodity derivatives *(COM)* or other type of derivatives *(OTHER)* or total hedging scaled by total assets.

These univariate tests reveal whether the difference in means and medians of post-vertical integration derivative use is statistically significantly lower than pre-vertical integration levels. In this study, I assert that vertical integration is a substitute for derivative hedging; for this reason I expect post-vertical integration derivative use to be lower than pre-vertical integration level.

3.2.1.3 Pre- and Post-Vertical Integration Derivative Use of High and Low Vertical Integration Firms

Using an alternative approach, vertically integrated firms are categorized as high and low vertical integration. Univariate tests compare the mean and median values of pre- and post-vertical integration derivative use of these two types of firms separately. Acquisitions with a vertical integration coefficient less than or equal to 9% are categorized as low vertical integration whereas acquisitions with a vertical integration coefficient greater than 9% are categorized as high vertical integration[3] The null and alternative hypotheses for the paired t-test and sign test are presented below.

Hypotheses for High Vertical Integration Firms:

Paired T-Test

$H_o : \mu$ [derivative(high vertical) $_{\text{(pre-vertical) – (post-vertical)}}$] = 0

$H_a : \mu$ [derivative(high vertical) $_{\text{(pre-vertical) – (post-vertical)}}$] < 0

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[3] Although I try different cutoffs while categorizing the firms, I use the mean of the vertical relatedness coefficient of Complete Hedging Data, which is 9%.

Sign Test

$H_o : M$ [derivative(high vertical) $_{\text{(pre-vertical) – (post-vertical)}}$] = 0

$H_a : M$ [derivative(high vertical) $_{\text{(pre-vertical) – (post-vertical)}}$] < 0

Hypotheses for Low Vertical Integration Firms:

Paired T-Test

$H_o : \mu$ [derivative(low vertical) $_{\text{(pre-vertical) – (post-vertical)}}$] = 0

$H_a : \mu$ [derivative(low vertical) $_{\text{(pre-vertical) – (post-vertical)}}$] < 0

Sign Test

$H_o : M$ [derivative(low vertical) $_{\text{(pre-vertical) – (post-vertical)}}$] = 0

$H_a : M$ [derivative(low vertical)$_{\text{(pre-vertical) – (post-vertical)}}$] < 0

Derivative(high vertical) and derivative(low vertical) stand for the notional amount of total hedging scaled by total assets for high and low vertical integration firms, respectively. I expect the decrease in hedging amount following vertical integration to be statistically significant for high vertical integration firms. For low vertical integration firms, it may or may not be significant; for this reason I have no expectation for this group.

3.2.1.4 Derivative Use of High and Low Vertical Integration Firms

The univariate tests in this section reveal whether the mean and median values of derivative use of high and low vertically integrated firms are different from each other. Firm year observations are categorized into two groups as low and high vertical integration firms. With this approach, pre-vertical integration firm year observations are categorized under low vertical integration.

There are no paired groups; observations are independent of each other. Therefore, a t-test and Wilcoxon rank sum test are performed to reveal the difference in means and medians of derivative use between high and low vertical integration firms. The null and alternative hypotheses for the t-test and Wilcoxon rank sum test are presented below.

T-Test

$H_o : \mu$ [derivative $_{\text{(high-vertical) – (low-vertical)}}$] = 0

$H_a : \mu$ [derivative $_{\text{(high-vertical) – (post-vertical)}}$] $\neq 0$

Wilcoxon Test

$H_o : M$ [derivative $_{\text{(high-vertical) – (low-vertical)}}$] = 0

$H_a : M$[derivative $_{\text{(high-vertical) – (low-vertical)}}$] $\neq 0$

The derivative is for the notional amount of total hedging scaled by total assets. I expect a significant difference in mean and median values of derivative use between high and low vertical integration firms. Specifically, I expect the amount of derivative use of high vertical integration firms to be less compared to low vertical integration firms.

3.2.1.5 Difference in Sample Characteristics

This section explains the univariate tests that compare firms' characteristics of two different groups in the sample. I perform univariate analysis for three different groups[4]: Hedger versus non-hedger firms, pre-vertical integration versus post-vertical integration firms, and low vertical integration versus high vertical integration firms. A t-test is used to compare the means (μ) and a Wilcoxon rank sum test is used to compare the medians *(M).* The null hypotheses of the t-test and Wilcoxon test are presented below.

T-Test	**Wilcoxon Test**
H_{o1}: $\mu_{\text{ASSETS}}(1) - \mu_{\text{ASSETS}}(2) = 0$	H_{o1}: $M_{\text{ASSETS}}(1) – M_{\text{ASSETS}}(2) = 0$
H_{o2}: $\mu_{\text{DA}}(1) - \mu_{\text{DA}}(2) = 0$	H_{o2}: $M_{\text{DA}}(1) – M_{\text{DA}}(2) = 0$
H_{o3}: $\mu_{\text{MB}}(1) - \mu_{\text{MB}}(2) = 0$	H_{o3}: $M_{\text{MB}}(1) – M_{\text{MB}}(2) = 0$
H_{o4}: $\mu_{\text{R\&D}}(1) - \mu_{\text{R\&D}}(2) = 0$	H_{o4}: $M_{\text{R\&D}}(1) – M_{\text{R\&D}}(2) = 0$
H_{o5}: $\mu_{\text{PPE}}(1) - \mu_{\text{PPE}}(2) = 0$	H_{o5}: $M_{\text{PPE}}(1) – M_{\text{PPE}}(2) = 0$
H_{o6}: $\mu_{\text{INST}}(1) - \mu_{\text{INST}}(2) = 0$	H_{o6}: $M_{\text{INST}}(1) – M_{\text{INST}}(2) = 0$
H_{o7}: $\mu_{\text{CR}}(1) - \mu_{\text{CR}}(2) = 0$	H_{o7}: $M_{\text{CR}}(1) – M_{\text{CR}}(2) = 0$
H_{o8}: $\mu_{\text{DIV}}(1) - \mu_{\text{DIV}}(2) = 0$	H_{o8}: $M_{\text{DIV}}(1) – M_{\text{DIV}}(2) = 0$
H_{o9}: $\mu_{\text{TAX}}(1) - \mu_{\text{TAX}}(2) = 0$	H_{o9}: $M_{\text{TAX}}(1) – M_{\text{TAX}}(2) = 0$
H_{o10}: $\mu_{\text{ROA}}(1) - \mu_{\text{ROA}}(2) = 0$	H_{o10}: $M_{\text{ROA}}(1) – M_{\text{ROA}}(2) = 0$
H_{o11}: $\mu_{\text{ROE}}(1) - \mu_{\text{ROE}}(2) = 0$	H_{o11}: $M_{\text{ROE}}(1) – M_{\text{ROE}}(2) = 0$

[4] 1 represents the first group and 2 represents the second group compared. 1 and 2 are used in the null hypotheses of the t-test and Wilcoxon rank sum test to represent different groups.

H_{o12}: $\mu_{\text{CONV}}\,(1) - \mu_{\text{CONV}}\,(2) = 0$ H_{o12}: $M_{\text{CONV}}\,(1) – M_{\text{CONV}}\,(2) = 0$

H_{o13}: $\mu_{\text{PREF}}\,(1) - \mu_{\text{PREF}}\,(2) = 0$ H_{o13}: $M_{\text{PREF}}\,(1) – M_{\text{PREF}}\,(2) = 0$

H_{o14}: $\mu_{\text{SIZE}}\,(1) - \mu_{\text{SIZE}}\,(2) = 0$ H_{o14}: $M_{\text{SIZE}}\,(1) – M_{\text{SIZE}}\,(2) = 0$

H_{o15}: $\mu_{\text{TOBIN}}\,(1) - \mu_{\text{TOBIN}}\,(2) = 0$ H_{o15}: $M_{\text{TOBIN}}\,(1) – M_{\text{TOBIN}}\,(2) = 0$

ASSETS is book value of total assets. *LEV* is long-term debt scaled by market value of equity. *DA* is debt-to-asset ratio, calculated as book value of total liabilities divided by book value of total assets. MB is market-to-book ratio calculated as market value of equity divided by book value of equity. *R&D* is research and development expenses scaled by total assets. *PPE* is the intensity of capital investment calculated as capital expenditures for property, plant, and equipment to firm size. *INST* is the percentage of a firm's total outstanding shares held by institutions. *CR* is the current ratio calculated as current assets divided by liabilities. *DIV* is the dividend payout ratio, calculated as dividends per share to common shareholders divided by earnings per share before extraordinary items. *ROA* is return on assets calculated as operating incomes scaled by total assets. *ROE* is return on equity calculated as operating income scaled by market value of equity. *CONV* is book value of total convertible debt scaled by firm size. *PREF* is book value of total preferred stock scaled by firm size. *SIZE* is the log of total assets. *TOBIN* is calculated as book value of total assets plus market value of common equity minus book value of common equity divided by book value of total assets. The detailed definitions and the calculations of the variables used in this study can be found in Appendix A.

The null hypothesis (H_o) for the t-test is where, for each independent variable, the difference between the means (μ) of two groups is zero, whereas the null hypothesis for the Wilcoxon test states, for each independent variable, the difference between the medians (*M*) of two groups is zero.

3.2.2 Multivariate Analysis

Univariate tests are one way to verify the difference between different groups, but the outcomes of these tests need to be verified by multivariate tests since univariate tests do not allow for interaction of independent variables. I perform different multivariate regressions to test my hypotheses stated in Section 3.1.1 and 3.1.2. Using Heckman's selectivity corrected model, I examine the effect of vertical integration and other extant variables on the decision to hedge and the extent of hedging. The next two sections give detailed information about the models to be performed in this research.

3.2.2.1 Determinants of Decision to Hedge and Extent of Hedging

I conduct multivariate regressions to examine the validity of my hypotheses stated in Section 3.1.1. These regressions reveal the determinants of the decision to hedge and the extent of hedging. Haushalter (2000) and Barton (2001) state the determinants of the decision to hedge are different from the determinants of the extent of hedging, assuming that a firm hedges. If the model is not controlled for selectivity, the estimates will be biased (Heckman, 1979). I use Heckman's selection model in which participation in the decision to hedge is employed in the first stage; given that firms decide to hedge, the second stage assesses decisions about the extent of hedging.

First Stage of Heckman's Selection Model: Decision to Hedge

$$\text{Prob}(\text{HEDGER}_{it} = 1 | X_{it}, Y_{it}) = \mathbf{\Phi}\,(\alpha + X_{it}\beta + Y_{it}\,\gamma + u_{it}) \tag{1}$$

$$X_{it} = \{\text{VERTICAL}_{it}, \text{DA}_{it}, \text{MB}_{it}, \text{RD}_{it}, \text{PPE}_{it}, \text{INST}_{it}, \text{CR}_{it}, \text{DIV}_{it}, \text{TAX}_{it}, \text{CONV}_{it}, \text{PREF}_{it}, \text{SIZE}_{it}, \text{YEAR}_{it}\} \tag{2}$$

$$Y_{it} = \{\text{SIZE}_{it}, \text{INDUSTRY}_{it}\} \tag{3}$$

In the probit model presented in equation (1), the dependent variable (*HEDGER*) is the dummy variable which takes the value of 1 if a firm hedges, and 0 otherwise; **Φ** is the cumulative distribution function of the standard normal distribution; α is the constant term; β are the coefficients that measure the direct effect of a unit change in the correspondence independent variables on the log-odds, u_{it} is the error term, X_{it} is a vector of control variables including different vertical integration dummy ($VERTICAL_{it}$)[5], debt-to-asset ratio (DA_{it}), market-to-book ratio (MB_{it}), research and development expenses (RD_{it}), capital expenditures (PPE_{it}), institutional ownership ($INST_{it}$), current ratio (CR_{it}), dividend payout ratio (DIV_{it}), tax convexity

[5] *VERTICAL* may equal *VI*, *VI1*, *VI2*, *HIGHVERTICAL8*, *HIGHVERTICAL9*, *HIGHVERTICAL10*, or *HIGHVERTICAL15* depending on the model specification used. For a detailed explanation of these vertical integration dummy variables see Section 3.1.1

dummy (TAX_{it}), convertible debt ($CONV_{it}$), preferred stock ($PREF_{it}$), industry dummies ($INDUSTRY_{it}$) and year dummies ($YEAR_{it}$)[6].

Y_{it} is a vector of exogenous variables that affect whether firms hedge but are less likely to affect hedge ratio in the second stage. Including additional variables in Y_{it} which are not in X_{it} provides a better identification of the selectivity-corrected hedging equation parameters with less severe collinearity. I used firm size ($SIZE_{it}$) which is calculated as the log of a firm's total assets and industry dummies ($INDUSTRY_{it}$) as instrumental variables. Firm size is seen as a proxy for hedging expertise. One of the major impediments toward hedging activities is the management's lack of ability with and knowledge of sophisticated financial instruments (Dolde, 1993). Larger firms have more expertise in hedging and attract employees who are well educated to manage these instruments. Additionally, the existence of large fixed start-up costs of hedging may discourage small firms from engaging in hedging (Allayannis and Weston, 2001). Therefore, firm size is a good industrial variable that affects a firm's decision to hedge but less likely to affect the amount of hedging since the amount of derivative use is based on cost accounting and has nothing to do with having expertise in hedging program. Haushalter (2000) and Geczy, Minton, and Schrand (1997) find size have a positive effect on the decision to hedge. Industry dummies are proxies for the industry specific shocks and risks. Some

[6] The theoretical reasons for including these variables in the multivariate regressions have been discussed in Section 3.1.1.

industries are much riskier than others and Nian (2004) find that firms are more likely to hedge if more of their competitors hedge. Therefore, industry in which a firm operates is more likely to affect decision to hedge but less likely to have an impact on the extent of hedging because hedging is a matter of cost analysis. Thus, the firm specific risks are more of a concern while determining the amount of hedging rather than the industry specific risks. It does not make sense to think that the management of a firm increases or decreases the level of hedging because other firms in the industry do so.

The probit regression model can be expressed in detail as equation (4)

$$\begin{aligned} HEDGER_{it} = {} & \alpha + \beta_1 VERTICAL_{it} + \beta_2 DA_{it} + \beta_3 MB_{it} + \beta_4 RD_{it} + \beta_5 PPE_{it} \\ & + \beta_6 INST_{it} + \beta_7 CR_{it} + \beta_8 DIV_{it} + \beta_9 TAX_{it} + \beta_{10} TAX_{it} \\ & + \beta_{11} CONV_{it} + \beta_{12} PREF_{it} + {}_{13} YEAR_{it} + \gamma_1 SIZE_{it} \\ & + \gamma_2 INDUSTRY_{it} + u_{it} \end{aligned} \tag{4}$$

VERTICAL, *DA*, *CR*, *DIV*, *CONV* and *PREF* are likely to be choice variables for a firm but the current literature related to the hedging[7] treats them as exogenous. Following the literature, I also consider that they are determined exogenously in the probit regression model in equation (4). Brown and Toft (2002) suggest a justification for this situation. They state that the investment and capital structure choice decisions are rather strategic long-run decisions that are both expensive and time consuming to

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[7] See Garfinkel and Hankins (2011), Berkman and Bradbury (1996), Gay and Nam (1998), Ertugrul et al. (2008), Mian (1996), Geczy et al. (1995) and Tufano (1996).

adjust with flexible short-run policies such as a firm's hedging policy that consists of decisions based on a firm's near-term forecasts of price, demand, market conditions, etc. They also add that treating these variables as exogenous allows researchers to concentrate on the decision to hedge in the short run without attempting to find an optimal policy for a firm by adjusting its level of investment, capital structure and the product mix in the long run.

Second Stage of Heckman's Selection Model: Extent of Hedging

In the second stage, I need to correct for self-selection by incorporating a transformation of the predicted individual probabilities estimated in the first stage as an additional variable. This is called the inverse Mills' ratio (λ_i) and is calculated as in equation (5)

$$\lambda_{it}=\phi(\alpha + X_{it}\beta+ Y_{it}\gamma + u_{it}) / \boldsymbol{\Phi}(\alpha + X_{it}\beta + Y_{it}\gamma + u_{it}) \qquad (5)$$

where $\boldsymbol{\Phi}$ denotes the cumulative distribution function of the standard normal distribution and ϕ is the standard normal density function. The extent of hedging equation can be specified as (6)

$$TOTALHEDGE_{it} = \mu + X_{it}\,\delta + \varepsilon_i \qquad (6)$$

where $TOTALHEDGE_{it}$ is the total notional amount of hedging at year t for firm i scaled by the total assets of that year; μ is the constant term and X_{it} is a vector of explanatory variables previously defined; δ are the coefficients and ε_{it} is the error term. *TOTALHEDGE* is only observed if a firm engages in hedging activity, so the conditional expectation of the extent of hedging, given the firm hedges, is:

$$E[TOTALHEDGE_{it}|X_{it}, Y_{it}\ HEDGER_{it} = 1] = \mu + X_{it}\beta + E[u_{it}|X_{it}, Y_{it}\ HEDGER_{it} = 1] + \varepsilon_{it} \quad (7)$$

Under the assumption that the error terms are jointly normal, I have the equation below:

$$E[TOTALHEDGE_{it}|X_{it}, Y_{it}\ HEDGER_{it} = 1] = \mu + X_{it}\beta + \rho_{\varepsilon u}\sigma_u\lambda_i(X_{it}\delta, Y_{it}\gamma) + \varepsilon_{it} \quad (8)$$

In equation (8), $\rho_{\varepsilon u}$ is the correlation between unobserved determinants of propensity to hedge (u) and unobserved determinants of extent of hedging (ε); σ_u is the standard deviation of u, and λ_i is the inverse Mills ratio evaluated at ($X_{it}\delta$, $Y_{it}\gamma$).

The second-stage Heckman self-selection corrected regression model can be expressed in detail as (9)

$$\begin{aligned} TOTALHEDGE_{it} = \mu &+ \delta_1 VERTICAL_{it} + \delta_2 DA_{it} + \delta_3 MB_{it} + \delta_4 RD_{it} + \delta_5 PPE_{it} + \delta_6 INST_{it} \\ &+ \delta_7 CR_{it} + \delta_8 DIV_{it} + \delta_9 TAX_{it} + \delta_{10} CONV_{it} + \delta_{11} PREF_{it} \\ &+ \beta_{12} YEAR_{it} + \rho_{\varepsilon u}\sigma_u\lambda_{it}(X_{it}\delta, Y_{it}\gamma) + \varepsilon_{it} \quad (9) \end{aligned}$$

In summary, this chapter explains the hypotheses tested in this research and gives a detailed explanation of the methodology. In the next chapter, Chapter 4, the sample selection process is explained and descriptive statistics are presented.

Chapter 4

SAMPLE SELECTION AND DESCRIPTIVE STATISTICS

4.1 Sample Selection

The initial sample contains merger and acquisitions (M&As) reported in Thomson Financial's Securities Data Company (SDC) Platinum Mergers and Acquisitions database that meet my selection criteria[8] from 1998 to 2013. For these M&As, I calculate a vertical integration relatedness coefficient to identify vertical takeovers by using Input-Output (IO) data from the Bureau of Economic Analysis (BEA). Acquisitions are categorized as vertical integration if the vertical relatedness coefficient exceeds 1%. In addition, five years of hedging data is collected for vertically integrated firms from the 10-K report of each company using the Electronic Data Gathering, Analysis and Retrieval (EDGAR) system. The 5-year span represents the two years before and after vertical integration plus the year of vertical integration. Finally, firm characteristics variables are obtained from the COMPUSTAT database and then merged with the existing data.

[8] Selection criteria is explained in detail in Section 4.2.

I construct two final samples to perform my analysis. The first one, which I call Complete Hedging Data, includes 143 vertically related firms with five years of complete hedging information. It has 643 firm-year observations. The other dataset, called Partial Hedging Data, consists of 55 vertically related firms with missing hedging information. This dataset has 144 firm-year observations[9]. Univariate and multivariate analyses are performed with either Complete Hedging Data or both. The construction of initial M&A data, identification of vertical integrated acquisitions within M&As and the collection process of derivative hedging data are explained in detail in the following sections.

4.1.1 Merger and Acquisition Data

I collect all M&As from SDC Platinum Mergers and Acquisitions database from 1998 through2013. 1998 was the first year in which the U.S. Securities and Exchange Commission began requiring companies to disclose derivatives accounting and provide quantitative and qualitative disclosures about their market risks. I restrict my sample acquisitions to those that satisfy the following conditions:

(1) The target and acquirer should be a public company.

(2) The target and acquirer should be incorporated in US.

(3) The deal is classified by SDC as successful or unconditional, and the acquirer owns less than 50% of the target prior to the announcement and obtains 100% of the target shares.

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[9] This dataset includes all firms in Complete Hedging Data.

(4) The deal should not be classified as a spin-off, repurchase, recapitalization, divestiture, leveraged buyout, or self-tender offer.

(5) The form of the deal should not be classified as acquisition of remaining interest, acquisitions of assets or buyback.

(6) The acquirer or target should not be a financial firm[10].

After applying above selection criteria, I can assign a vertical relatedness coefficient to 1,604 contests. I also exclude the M&As where the acquirer and target have same NAICS codes, since vertical integration should take place among different industries. These restrictions reduce the number of observations to 903.

The next section is related to vertical integration data. In Section 3.1.2., the calculation of vertical relatedness coefficient is explained and in Section 3.1.2.1, detailed information regarding the identification of vertically integrated acquisitions is given.

4.1.2 Vertical Integration Data

Vertical integrations have been identified in many ways. COMPUSTAT segment disclosures report customers comprising 10 % of firm's sales. Hertzel et al. (2008) and Fee and Thomas (2004) use this information to identify downstream firms. Amihud and Lev (1981) and Johnson and Houston (2000) subjectively classify acquisitions. Fan (2000) uses the input self-sufficiency ratio (ISR) which is defined as

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[10] Firms in the finance industry use derivatives for speculative purposes rather than hedging purposes. Therefore, firms that have four-digit SIC codes between 6,000 and 6,999 are removed from M&A data

the firm's in-house input capacity divided by the required input capacity. Relying on Standard Industrial Classification (SIC) codes is a popular method used by many scholars. According to Fan and Goyal (2006), this is a problematic approach since the degree of relatedness is not revealed, and some classification errors may occur. This method classifies two businesses as unrelated if they do not share the same two-, three- or four-digit code (Garfinkel and Hankins, 2011). For example, the two vertically integrated industries, oil-refining and chemical industries, are classified as unrelated with this approach.

Fan and Goyal (2006) identify vertical integration by measuring intra-firm relationships. In this approach, they calculate the vertical integration relatedness coefficient by using IO data from the BEA. Other scholars use the same technique (Ahern and Harford, 2014; Garfinkel and Hankins, 2011; Fan and Lang, 2000; Lawson, 1997). This vertical integration relatedness coefficient is defined as the opportunity for vertical integration between industries *i* and *j* (Garfinkel and Hankins, 2011). A higher vertical integration coefficient means greater use of input *i* in the production of output *j*. In this research, Fan and Goyal (2006)'s methodology is adopted to identify vertical takeovers.

4.1.2.1 Vertical Relatedness Coefficient Calculation

Every five years, the Bureau of Economic Analysis (BEA) publishes Input-Output (IO) data. The BEA publishes IO data for different industries. I utilize 1997 and 2002 benchmark IO tables which are within my sample period to calculate the vertical relatedness coefficient between different IO industries [11].

The following explains the calculation of the vertical relatedness coefficient:

(1) The amount of output required from industry *i* to produce one dollar's worth of industry *j*'s output is calculated (v_{ij}).

(2) The amount of output required from industry *j* to produce one dollar's worth of industry *i's* output (v_{ji}) is also calculated.

(3) In the spirit of Fang and Goyal (2006), the vertical relatedness coefficient (V_{ij}) is calculated as the maximum of $\{v_{ij}, v_{ji}\}$.

Table 4.1 illustrates the calculation of vertical relatedness coefficients in detail using pipeline transportation (industry i) and oil & gas extraction industries (industry j) as an example. The numbers come from the 2002 Benchmark IO table. In 2002, about \$1.101 billion (Q_j) in output of the oil and gas extraction industry was used by the pipeline transportation industry. The total output of the pipeline transportation industry for the corresponding year was about \$22.315 billion (a_{ij}). Using these numbers, the amount of output required from the oil and gas industry to produce one dollar's worth of pipeline transportation industry was \$0.0494 (v_{ij}=1101.9/22315.8).

[11] The 2007 benchmark IO accounts were released a year after I started my research. At that time I had already completed my data selection and variable construction process. Therefore, I only use 1998 and 2002 IO accounts to identify vertical takeovers. When I compare1998 and 2002 VR coefficients, I see that the difference between these two is not very significant for a large number of observations. For 375 firms (32%) out of initial 1056 vertically related firms, the difference is greater than 0.15. For 75 (7 %) of firms, it is above 0.20. However, for future work it is suggested performing the analyses with a data that integrates 2007 VR coefficients.

Table 4.1 Industry-Level Vertical Relatedness Coefficient Calculation: An Illustration from Oil &Gas Extraction and Pipeline Transportation Industries

This table is an illustrative example of the vertical relatedness coefficient calculation between oil &gas extraction and pipeline transportation industries using the 2002 Benchmark Input-Output table published by the Bureau of Economic Analysis. IO code is the input-output code reported in the Use Table. All other variables are defined in the table

Industry i = Oil and gas extraction [IO code:211000] Industry j = Pipeline transpotation [IO code: 48600]	
Industry i's output used by industry j (a_{ij})	1,101.9
Total output of industry j (Q_j)	22,315.8
Value of i's output used to produce $ 1 of j's output ($v_{ij}=a_{ij}/Q_j$)	0.0494
Industry j's output used by industry i (a_{ji})	330.8
Total output in industry i (Q_i)	89,156.6
Value of j's output used to produce $ 1 of i's output ($v_{ji}=a_{ji}/Q_i$)	0.0037
Vertical relatedness between i and j industries ($V_{ij}=max\{v_{ij}, v_{ji}\}$)	0.0494

In the same year, the oil and gas extraction industry consumed $330.8 million in output of the pipeline transportation industry. The total output of the oil and gas extraction industry was about $89.156 billion. The amount of output required from the pipeline transportation industry to produce one dollar's worth of oil and gas extraction industry was calculated as $0.0037 ($v_{ji}$=330.8/89156.6). The vertical relatedness between the two industries is 0.0494 ($V_{ij}=max\{v_{ij},v_{ji}\}$). This number indicates the maximum amount of input transfers between two industries on a per-dollar basis.

I also calculate the vertical relatedness coefficient at the 4-digit IO level to see whether there is an improvement over the 6-digit IO level while calculating the vertical relatedness coefficient and identifying vertical takeovers. In Table 4.2, I report the means, standard errors, and percentile distribution of the vertical relatedness coefficients at 4-digit and 6-digit levels across all pairs of the IO industries using the 1997 and 2002 Benchmark IO provided by BEA[12].The distributions of the coefficients are similar in the 2 years within 6- and 4-digit levels. The number of observations (or IO pairs) decreases markedly when we calculate the vertical relatedness coefficient using 4-digit IO level.

The means of vertical relatedness coefficients at the 6-digit level in 1997 and 2002 are 0.0082 and 0.0113, respectively whereas the means at the 4-digit level in 1997 and 2002 are 0.0149 and 0.0101, respectively. It seems the mean of the vertical relatedness coefficient at the 4-digit level is somewhat greater than at the 6-digit level but not significantly so. The distribution of the coefficient is highly skewed. The percentile distribution reveals that at the 6-digit level, economically significant vertical relatedness is found among 15 % of industry pairs whereas the significance level of vertical relatedness increases to 20% at the 4-digit level in both. In 1997 and 2002, the maximum value from one industry to another for the production of 1 dollar’s worth of output is 97 cents, and 99 cents at the 6 digit IO level. For the 4-digit IO level, it is 90 cents in 1997 and 74 cents in 2002.

In previous research[13] acquisitions are categorized as vertical integration if the vertical relatedness coefficient exceeds 1%[14]. I also use the same cutoff for identifying

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[12] The number of observations used to compute the statistics varies with the coefficients and time. This is due to changes in the classification system, IO level used in calculations and missing observations in the IO tables over time.

[13] See Fan and Goyal, 2006; Ahern and Harford, 2014; and Garfinkel and Hankins, 2011).

Table 4.2 Summary Statistics of Vertical Relatedness Coefficients for IO Industry Pairs

This table reports the means, standard errors, and percentile distribution of 1997 and 2002 vertical relatedness coefficients calculated using 1997 and 2002 Benchmark IO tables provided by the Bureau of Economic Analysis at 6- and 4-digit levels. 1997 and 2002 represents the year of IO Table.

	6-Digit IO Level		4-Digit IO Level	
	1997	**2002**	**1997**	**2002**
Number of observations	*76,789*	*57,091*	*12,204*	*11,497*
Mean	*0.0082*	*0.0113*	*0.0149*	*0.0101*
Standard error	*0.0377*	*0.0465*	*0.0515*	*0.0285*
Percentile:				
0	0.0000	0.0000	0.0000	0.0000
10	0.0000	0.0000	0.0001	0.0001
20	0.0000	0.0001	0.0005	0.0004
30	0.0002	0.0003	0.0011	0.0011
40	0.0004	0.0007	0.0016	0.0018
50	0.0008	0.0013	0.0024	0.0028
60	0.0014	0.0022	0.0038	0.0042
70	0.0024	0.0038	0.0062	0.0066
80	0.0046	0.0070	0.0107	0.0112
85	0.0155	0.0101	0.0155	0.0151
90	0.0110	0.0170	0.0264	0.0228
95	0.0297	0.0441	0.0600	0.0432
100	0.9720	0.9904	0.9070	0.7463

vertically related IO pairs. Fan and Goyal (2006) discuss the economic significance of 1% and 5% cutoffs. They state that although cutoffs seem to be small at first, a considerable portion of an industry’s value of shipments consists of labor expenses and value-added. The National Bureau of Economic Research’s manufacturing

[14] Hereafter, this category is called cutoffs. If vertical integration identification is based on 1%, then I call it a 1% cutoff. If vertically integrated acquisitions are identified based on 5%, then I call it a 5% cutoff and so on.

productivity database indicates that, on average, about 50% of an industry's value of shipments is material cost (Fan and Goyal, 2006). Thus, the interindustry vertical relatedness coefficients currently based on an industry's value of shipments would be twice in magnitude if based on material costs. To explain it differently, a vertically related merger at the 5% cutoff means that the output of the industry of a firm generally accounts for 10% of the input of a merging firm (Fan and Goyal, 2006). Shenoy (2012) also states the economic significance of these cutoffs and the explanation of this study is consistent with Fan and Goyal (2006).

Table 4.3 presents the number and the percentages of vertically integrated 6- and 4-digit IO pairs at different cutoffs. Panel A reports the number and percentages based on the 1997 IO Table whereas the numbers and percentages of Panel B are based on the 2002 IO Table. 1997 and 2002 IO tables report 76,789 and 57,091 IO pairs at the 6-digit level, respectively. The 1997 IO Table shows that at the 1% cutoff 11 percent of the 6-digit IO pairs have signs of vertical integration. This number drops to 3 percent and 2 percent at the 5% and 10% cutoffs, respectively. In 2002, the number of vertically integrated IO pairs is almost same as in 1997. However, the lower total number of IO pairs inflates the percentages a little. In 2002, the total number of 4-digit IO pairs is 11,497 whereas it is 12,203 in 1997. The 4-digit percentages of vertically integrated IOs are slightly higher compared to the 6-digit ones in both 1997 and 2002 IO tables.

Table 4.3 Frequency of Vertically Integrated IO Pairs at Different Cutoffs

This table presents the number and the percentages of vertically related 6- and 4-digit IO pairs at different cutoffs. 1% cutoff, 5% and 10% cutoffs are the different measures used while identifying vertically integrated IO pairs. If the vertical integration coefficient for an IO pair is greater than 1 percent, then it is vertically integrated at the 1% cutoff. If vertical integration coefficient for an IO pair is greater than 5 percent, then it is vertically integrated at the 5% cutoff. If vertical integration coefficient for an IO pair is greater than 10 percent, then it is vertically integrated at the 10% cutoff. Panel A numbers and percentages are based on the 1997 IO Table whereas Panel B numbers and percentages are based on the 2002 IO Table. 4-digit IO and 6-digit IO stand for the number of vertically related IO pairs identified using 4- and 6-digit IOs, respectively. 4-digit percent and 6-digit percent are the percentages of vertically related 4- and 6-digit IO pairs, respectively.

Cutoffs	4-Digit IO	6-Digit IO	4- Digit Percent.	6-Digit Percent.
		Panel A: 1997 IO Table		
1% cutoff	1,939	8,214	16%	11%
5% cutoff	709	2,523	6%	3%
10% cutoff	381	1,357	3%	2%
Total	12,203	76,789	100%	100%
		Panel B: 2002 IO Table		
1% cutoff	2,516	8,627	22%	15%
5% cutoff	460	2,527	4%	4%
10% cutoff	148	1,362	1%	2%
Total	11,497	57,091	100%	100%

Figures 4.1 and 4.2 present cumulative distribution plots for 1997 and 2002 vertical relatedness coefficients between pairs of merging firms. These distribution plots are almost identical with the plot in Fan and Goyal (2006). The distribution plot for 1997 shows that approximately 60% of the mergers have vertical relatedness coefficients less than 1%. At the 5% cutoff, about 40% of the mergers are classified as vertically related. The distribution of 2002 vertical relatedness coefficients is almost same as the distribution in 1997. These figures reveal that mergers are not clustered around 1% and 5% cutoffs. This means the classification of vertical mergers is not sensitive to the choice of cutoffs (Fan and Goyal, 2006).

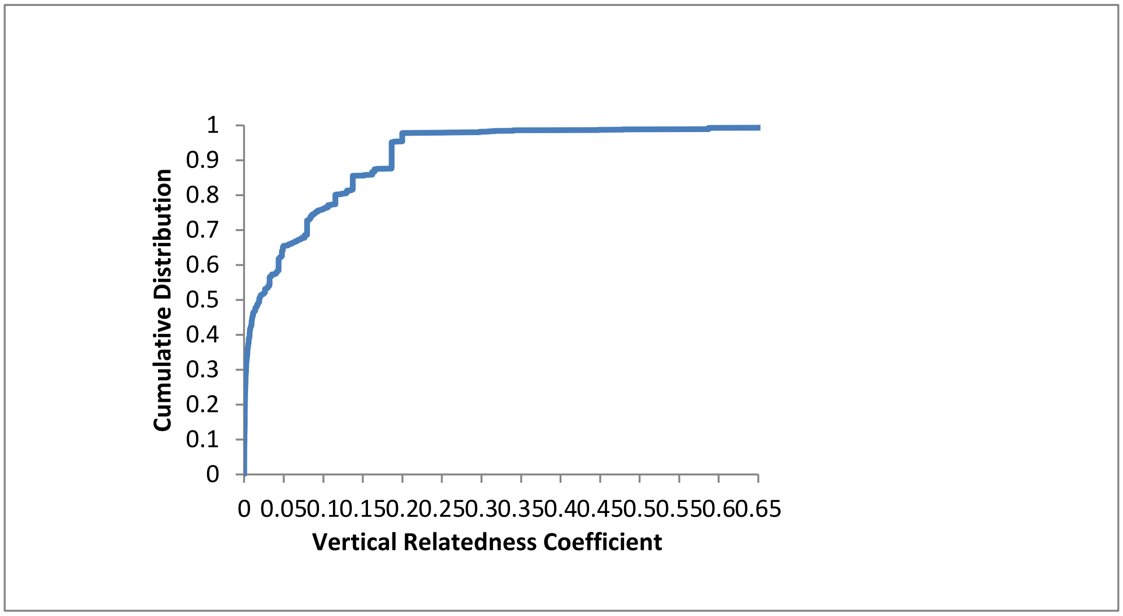

Figure 4.1 Cumulative Distribution Plot of 1997 Vertical Relatedness Coefficients

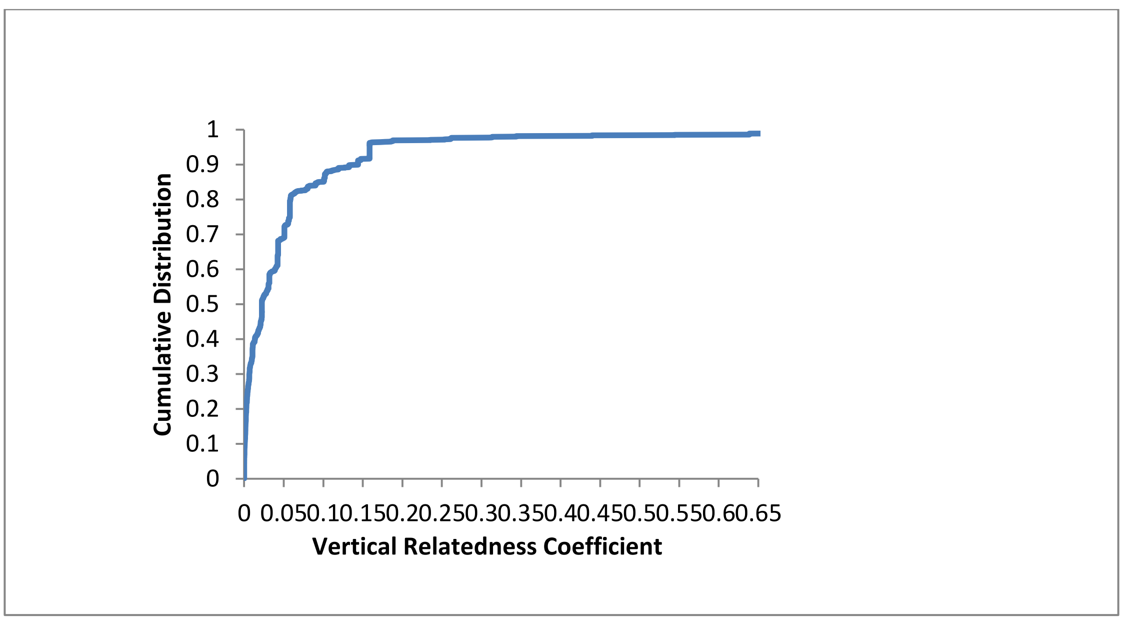

Figure 4.2 Cumulative Distribution Plot of 2002 Vertical Relatedness Coefficients

4.1.2.2 Identification of Vertically Integrated M&As

The vertical relatedness coefficient to identify vertical takeovers is calculated using 1997 and 2002 benchmark IO accounts. These accounts rely on North American Industry Classification System (NAICS) codes. For each observation, I record the primary NAICS codes of the acquirer and target. Using NAICS-IO concordance table from the BEA, all NAICS in the SDC are mapped to a 1997 and 2002 IO industry. I make sure for each NAICS code there is a corresponding 6-digit IO industry. Since NAICS codes do not stay the same over the years, and the SDC Platinum dataset uses 2012 definition of NAICS codes, I cannot map all NAICS codes to an IO industry at first. For those that do not have any matching IO industries, I check whether there is a re-definition over time. If there is, then I find the corresponding 1997 and 2002 NAICS codes by using the NAICS concordance table across the years. For each deal, I map the NAICS recorded in the SDC to the appropriate 1997 and 2002 IO industry. As a result, for each acquirer-target pair, I have a corresponding IO industry. After assigning IOs, vertical relatedness coefficients are merged into SDC data by IO pair to determine vertical takeovers.

Table 4.4 presents the summary statistics of vertical relatedness coefficients of M&A data at different vertical integration cutoffs. It is worth noting that the M&A sample contains 903 firms after all selection criteria are applied. Two vertical relatedness coefficients are assigned to each deal: one is based on the 6-digit IOs, and the other is based on the 4-digit IOs. Panel A presents summary statistics for the vertical relatedness coefficient calculated using 6-digit IOs whereas Panel B statistics are based on 4-digit IOs.

At the 1% cutoff, 256 M&As out of 903 are categorized as vertically integrated at the 6-digit IO level and almost same number of vertical takeovers are identified if we use the vertical relatedness coefficient at the 4-digit IO level. I analyze summary statistics of vertical relatedness coefficient at the 6-digit IO level. At 5%, 10% and 15% cutoffs, the numbers of vertical takeovers reduce to 129, 85 and 58, respectively. The mean of the vertical relatedness coefficient increases with the cutoffs. The

Table 4.4 Summary Statistics of Vertical Relatedness Coefficient of M&A Data

This reports the summary statistics of vertical relatedness coefficient of final M&A data after all selection criterias are applied at different cutoffs. The sample contains 903 firms that are extracted from SDC Platinum Merger and Acquisitions database. The 1% cutoff, 5% and 10% cutoffs are the different measures used for identification of vertically integrated IO pairs. If vertical integration coefficient for an IO pair is greater than 1 percent, then it is vertically integrated at 1% cuttoff. If vertical integration coefficient for an IO pair is greater than 5 percent, then it is vertically integrated at 5% cuttoff. If vertical integration coefficient for an IO pair is greater than 10 percent, then it is vertically integrated at 10% cuttoff. Panel A statistics are based on 1997 Benchmark IO Table whereas Panel B statistics are based on 2002 benchmark IO Table. 4-digit IO and 6-digit IO level stand for the number of vertically related IO pairs identified using 4- and 6-digit IOs, respectively

Variable	N	Mean	Std Dev	Minimum	Maximum
Panel A: 6-digit IO Level					
1% cutoff	256	0.1001	0.1269	0.0100	0.7101
5% cutoff	129	0.1693	0.1492	0.0517	0.7101
10% cutoff	85	0.2180	0.1636	0.1006	0.7101
15% cutoff	58	0.2680	0.1772	0.1518	0.7101
Panel B: 4-digit IO Level					
1% cutoff	255	0.1367	0.1254	0.0122	0.6422
5% cutoff	172	0.1871	0.1241	0.0510	0.6422
10% cutoff	138	0.2144	0.1239	0.1036	0.6422
15% cutoff	115	0.2338	0.1272	0.1585	0.6422

maximum vertical relatedness coefficient is 71%. Panel B shows that the means of vertical relatedness coefficients at the 4-digit IO level is greater than the means based on the 6-digit IO level at 1% and 5% cutoffs.

These statistics show that I am able to identify relatively more acquisitions that are vertically integrated if I use 1% cutoff. 4-digit IO level does not improve the identification of vertical takeovers significantly at this cutoff and the variation of the numbers at 4-digit IO level is low from cutoff to cutoff. Therefore, I adopt the 1% cutoff at the 6-digit IO level to identify vertical takeovers and collect derivative hedging data for 256 vertical takeovers[15].The next section explains the hedging data collection process in detail and presents some statistics of corporate derivative use.

4.1.3 Derivative Hedging Data

Using the EDGAR system, I collect the data on hedging practices from the 10-K report of each company for 256 vertical takeovers. Where it is possible I collect five years of hedging data for these vertical takeovers. Five-year data consists of the effective year of the vertical merger, as well as two years before and after the effective year of vertical integration. In 1998, the U.S. Securities and Exchange Commission adopted the Financial Reporting Release No.48 (SEC 1997) (FFR No. 48) which requires companies to disclose derivatives accounting and provide quantitative and qualitative disclosures about their market risks in their 10-K report item 7a. Since FRR

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[15] I perform my analysis with the 4-digit IO level but the results are almost same with the 6-digit IO level.

No. 48 does not require firms to disclose the notional amount of derivatives used and does not impose any standard format of disclosure about the use of derivatives, the hedging data is hand collected.

The notional amounts of derivatives are usually reported in Item 7a or Item 8 of 10-K reports. I first read these paragraphs to determine the notional amount of derivatives used by the company. If the information needed was not found, I searched for the following keywords within the 10-K: notional, hedge, derivative, swap, futures, forward, option, cap, collar and interest rate. For each acquirer firm, I record the notional amount of derivative instruments for hedging purposes under the related type of derivatives. Financial derivatives are categorized under four main categories: foreign exchange derivatives, interest rate derivatives, commodity derivatives, and others.

Additionally for each main category, I construct different sub-categories and record hedging data under these sub-categories. Foreign exchange derivatives have three sub-categories: foreign exchange forward or futures, foreign exchange swaps, and foreign exchange options. Interest rate derivatives have four sub-categories: interest rate swaps, interest rate caps or floor, interest rate option and interest rate forward. Finally, commodity derivatives have three sub-categories: commodity forward or futures, commodity options, and commodity swaps. If a derivative type does not fall under any of these main categories, then I record them under others. At the end of this process, I aggregate the notional amount of all derivative instruments under each main category to calculate the total amount of derivatives used by firms.

Finally for each firm, I obtain firm characteristics variables from the COMPUSTAT database.

Table 4.5 explains final sample selection process after hedging data is completed. I deleted 45 firms out of 256 vertically related firms because I was unable to collect or calculate derivative use for those firms. I also excluded 6 firms because

Table 4.5 Final Sample Selection Process

This table shows how the final sample of vertically related firms is constructed from initial M&A data from 1998 to 2013. Two final samples are constructed to perform analyses. Complete Hedging Data includes 143 vertically related firms with 5 years of complete hedging information. This dataset contains 603 firm-year observations after the variables are winsorized at 1% and 99% values. Partial Hedging Data consists of 55 vertically related firms that have significant amounts of missing hedging information over the 5-year period. This dataset has 144 firm-year observations after the variables are winsorized at 1% and 99% values. For a robustness check, some analyses are performed using both datasets.

Initial M&A firms which have non-missing VR coefficient greater than 0.01	**256**
Less: Firms with missing notional amount of derivative information during 5-year period	(45)
Less: Firms with missing asset information during 5-year period	(6)
Less: Firms with outlier hedging ratios	(7)
Total number of firms with at least one year of hedging information	**198**
Less: Firms with missing notional amount of derivative information in some years **(Partial Hedging Data)**	(55)
Total number of firms that have hedging information during 5-year period (Complete *Hedging Data*)	**143**

they lack data years of missing assets which is needed to calculate the hedge ratio[16]. Finally, additional 7 firms were deleted due to having hedge ratios greater than 1. I end up with 198 firms that have at least one year of derivative use data. 143 of these firms have 5 years of complete hedging information. This dataset is named Complete

[16] Note that hedge ratio is calculated as the notional amount of derivative divided by total assets.

Hedging Data and is the main dataset used in this study. The other 55 firms have missing hedging ratios; I call this dataset Partial Hedging Data. After variables in both of datasets are winsorized at 1% and 99% values[17], Complete Hedging Data and Partial Hedging Data have 603 and 144 firm-year observations, respectively. Some of the analyses are performed with Complete Hedging Data and some are performed with both datasets. In Appendix B gives detailed information about vertical takeovers used in this research.

4.2 Sample Descriptive Statistics

This section consists of two subsections: Section 4.2.1 and Section 4.2.2. Section 4.2.1 explains the descriptive statistics related to derivative use whereas Section 4.2.2 gives detailed information about the descriptive statistics related firm characteristics data.

4.2.1 Descriptive Statistics Related to Derivative Use

In Table 4.6, the industry sector distribution by year of 198 vertically integrated firms in both Complete Hedging Data and Partial Hedging Data is presented along with the mean of vertical relatedness coefficient (VR) in each industry. My sample is very

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[17] The distribution of the statistics can be seriously affected by outliers. In order to reduce the influence of possibly spurious extreme value in my sample, all variables are winsorized at 1% and 99% values. The studies that use winsorized sample includes Choi et al. (2013), Hankins (2009), Garfinkel and Hankins (2011), Singh and Upneja (2008), and Purnanandam (2008).

diverse; the firms in my sample operate in 28 distinct industry sectors. The number of vertical takeovers is the highest in 1999. Figure 4.3 and 4.4 better present the distribution of vertical integration by year and industry, respectively. The number of vertical takeovers is the highest in the drugs sector, followed by the telecommunications sector. More than half of vertical acquisitions took place in drugs, telecommunications, business services, and computer and office equipment sectors. The mean of vertical relatedness coefficient differs a lot from industry to industry. The degree of vertical integration in oil and gas & petroleum refining and transportation equipment is the highest at 0.39 whereas leather and leather products, food and kindred products and advertising services sectors are the lowest at less than 0.03.

In Table 4.7, summary statistics of derivative use by industry are presented. Derivative use is defined as the total notional amount of derivatives scaled by total assets. The mean of derivative use varies from 0 to 0.236. The food and kindred products industry has the highest mean whereas the advertising services industry has the lowest. Figure 4.5 better visualizes the mean of derivative use by industry sector. It is worth noting that the mean within an industry sector is highly affected by the number of observations. Therefore, any inference from these statistics may not be accurate. For example, the drugs industry has a maximum of 0.54 which is higher than other industry sectors but the number of observations is high which lowers the mean . On the other hand, the food and kindred products industry has only 5 firm-year observations but has the highest mean.

Table 4.6 Distribution of Vertical Takeovers by Industry Sector and Year

This table presents the distribution of vertical takeovers in Complete Hedging Data and Partial Hedging Data during 1998 to 2013 by industry. The Industry Sector column defines the industry sectors of the acquirer firms; total represents the total number of vertical takeovers in the corresponding industry; Percent shows the percentage contribution of vertical takeovers within an industry to the whole sample. The last column presents the mean of vertical relatedness coefficient (VR) in each industry sector at the 6-digit IO level. VR is calculated using 1997, 2002 Input-Output tables published by the Bureau of Economic Analysis.

	Industry Sector	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	Total	Percent	Mean VR
1	Advertising Services	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	2	1%	0.013
2	Business Services	1	4	3	1	0	0	3	0	0	1	0	1	0	0	0	0	14	7%	0.030
3	Chemicals and Allied Products	1	2	0	0	0	0	1	1	0	0	0	0	0	0	1	0	6	3%	0.125
4	Communications Equipment	0	0	0	0	1	0	1	0	0	2	0	0	0	0	0	0	4	2%	0.083
5	Computer and Office Equipment	0	2	0	0	0	0	0	1	1	2	2	0	2	1	1	0	12	6%	0.115
6	Construction Firms	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	1	1%	0.078
7	Drugs	1	7	4	3	2	3	2	5	5	1	4	3	4	1	1	1	47	24%	0.058
8	Electric, Gas, and Water Distribution	0	2	3	1	0	0	0	0	0	0	0	0	1	0	2	0	9	5%	0.140
9	Electronic and Electrical Equipment	0	3	3	1	0	0	0	0	0	1	0	0	0	1	0	0	9	5%	0.077
10	Food and Kindred Products	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1%	0.021
11	Leather and Leather Products	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	1	1%	0.027
12	Machinery	1	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	3	2%	0.032
13	Measuring, Medical, Photo Equip.; Clocks	0	1	1	0	0	0	1	0	0	1	1	0	2	0	1	1	9	5%	0.033
14	Mining	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	1	1%	0.039

Table 4.6 Continued

	Industry Sector	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	Total	Percent	Mean VR
15	Miscellaneous Manufacturing	1	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	2	1%	0.077
16	Motion Picture Produc. and Distribution	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1%	0.104
17	Oil and Gas; Petroleum Refining	1	1	0	0	0	1	0	1	0	0	0	0	2	1	0	0	7	4%	0.398
18	Paper and Allied Products	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	2	1%	0.101
19	Prepackaged Software	0	0	2	0	0	0	0	0	1	1	0	0	1	0	0	0	5	3%	0.063
20	Printing, Publishing, and Allied Services	0	0	0	0	0	0	1	0	0	1	0	1	0	0	0	0	3	2%	0.067
21	Radio and Television Broadcasting Stations	1	2	1	0	0	0	0	0	0	0	0	1	0	0	0	0	5	3%	0.181
22	Sanitary Services	2	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	2%	0.130
23	Stone, Clay, Glass, and Concr. Prdcts	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1%	0.013
24	Telecommunications	2	8	4	0	2	0	0	4	4	0	0	1	1	1	0	0	27	14%	0.133
25	Textile and Apparel Products	1	0	0	1	1	0	0	0	0	0	0	0	0	0	0	1	4	2%	0.030
26	Transportation Equipment	1	0	1	0	0	0	0	1	0	0	0	0	0	0	0	0	3	2%	0.394
27	Wholesale Trade-Durable Goods	2	0	3	0	0	0	0	0	0	1	0	0	0	0	1	0	7	4%	0.047
28	Wholesale Trade-Nondurable Goods	2	0	1	1	0	1	1	0	0	2	0	0	0	0	0	1	9	5%	0.051
	TOTAL	17	34	28	10	9	6	10	14	11	14	7	8	13	5	7	5	198	100%	0.098

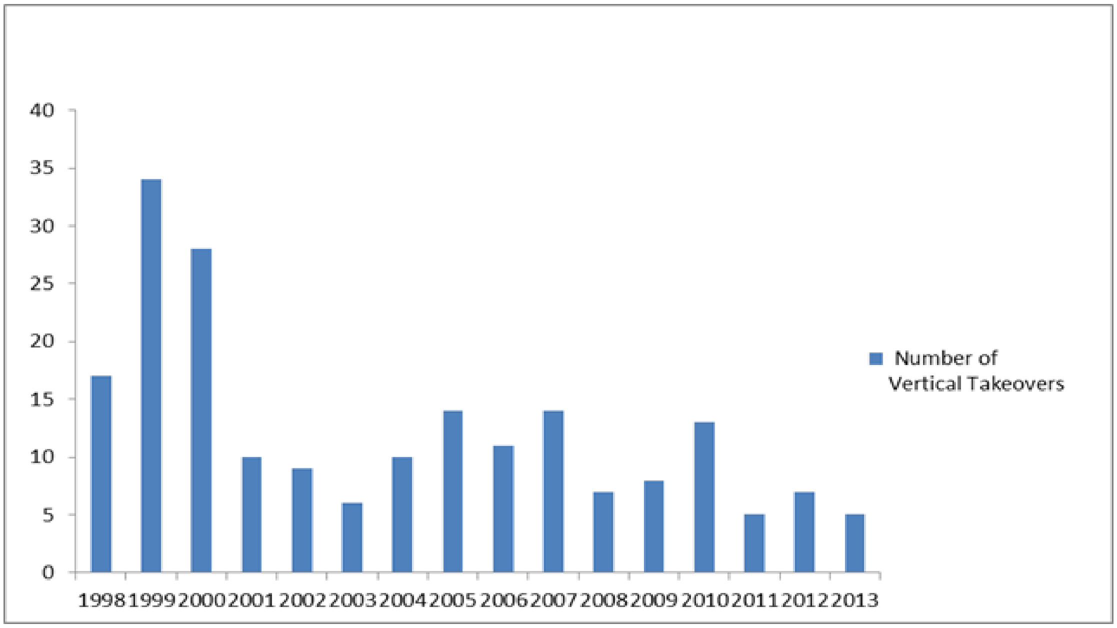

Figure 4.3 Distribution of Vertical Integration by Year

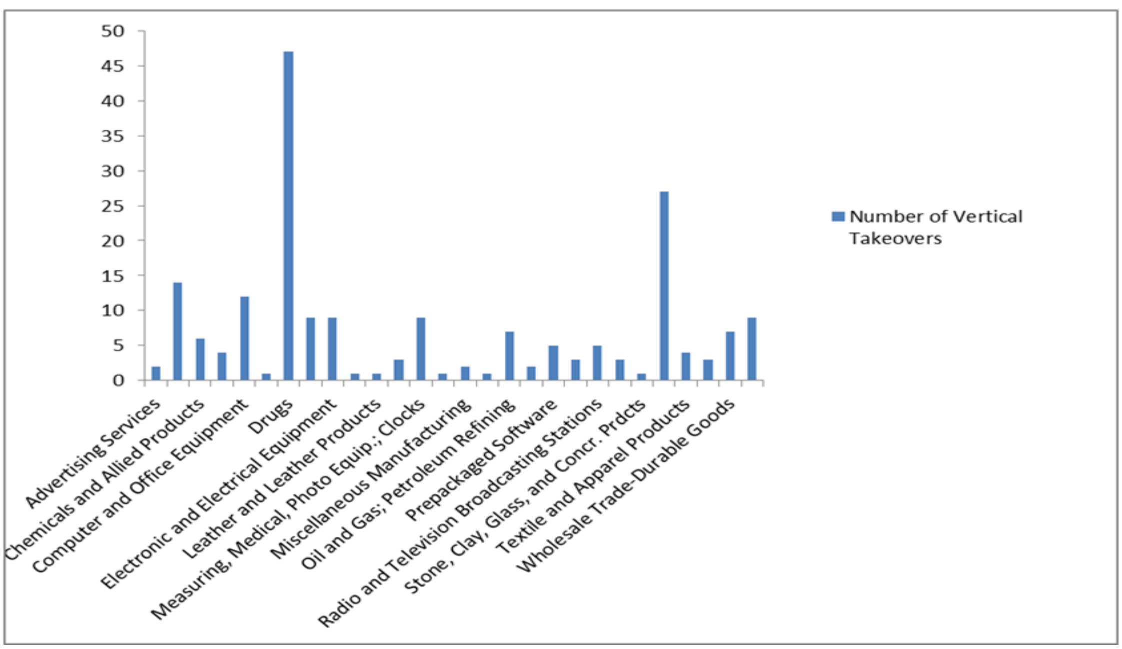

Figure 4.4 Distribution of Vertical Integration by Industry Sector

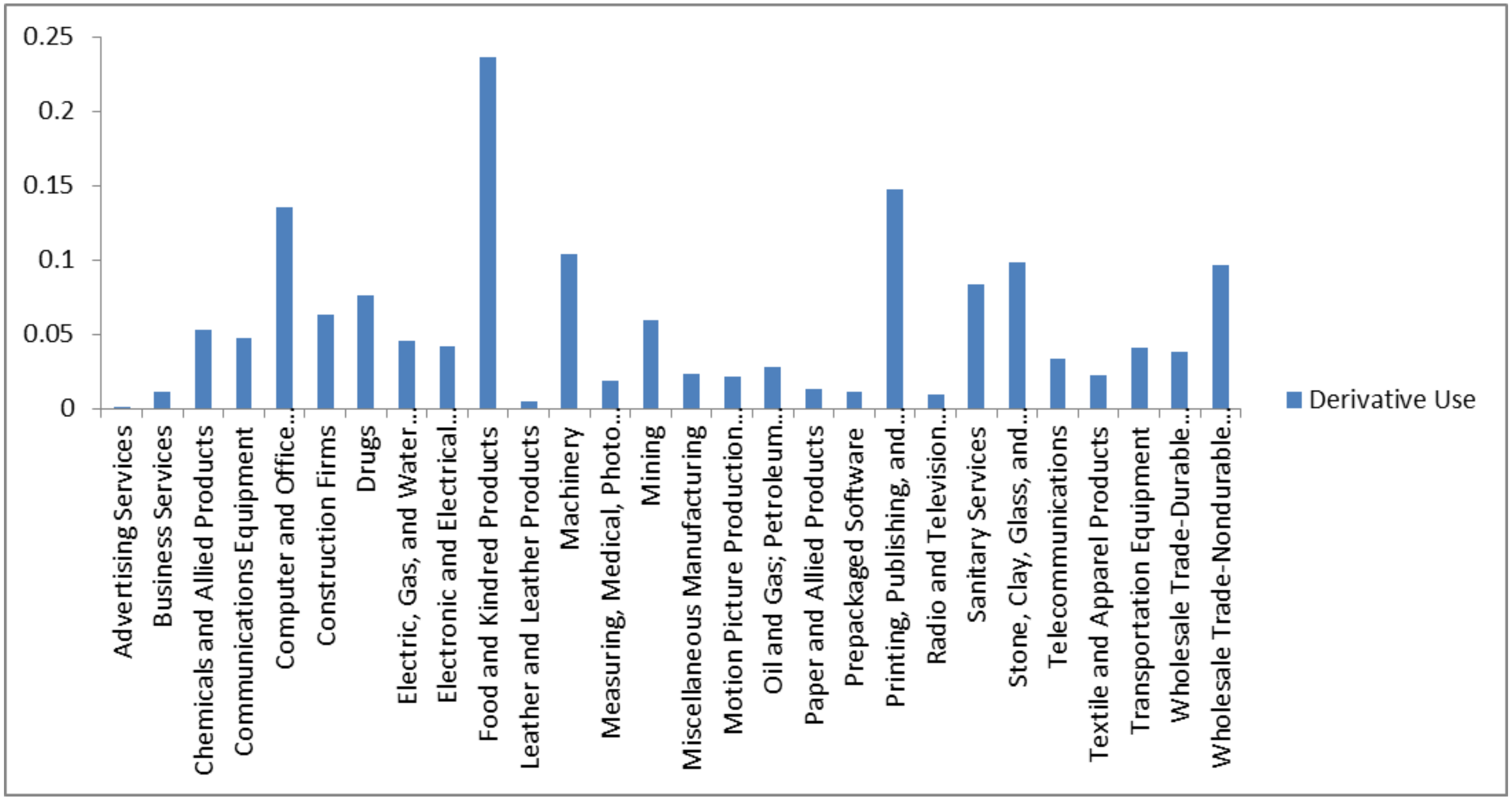

Figure 4.5 Derivative Use by Industry

Table 4.8 shows the frequency of participation in hedging activity by firms in both Complete Hedging Data and Partial Hedging Data over a 5-year period. Time T is the year of vertical integration, T-2, T-1, T+1, T+2 stand for 2 years and 1 year before and after vertical integration.

Panel A numbers and percentages are based on Complete Hedging Data. As stated earlier, derivative use information is available for all firms in this data over a 5-year period so this frequency table is best for examining the hedging decisions of firms over time. The increase in the number and the percentages of non-hedgers as well as the decrease in the number and the percentages of hedgers show that vertical integration may affect a firm's participation decision in hedging activity.

I also present frequencies excluding firms that never hedge in Panel B. The number of non-hedgers decreased by 26 in each time period which means 26 firms in my sample never hedged over the sample period. Additionally, the frequency of hedgers and non-hedgers in Partial Hedging Data is given in Panel C. Any interpretation regarding the decision to hedge using these frequencies will be biased since this data has missing hedging information. The number of observations decreases over time. This is a sign that, for many firms, hedging information is not available at time T+2.

Table 4.7 Summary Statistics of Derivative Use by Industry Sector

This table shows summary statistics of derivative use by industry sector of firms in both Complete and Partial Hedging Data. Derivative use is measured as the total notional amount of derivatives scaled by total assets. N is the number of firm-years, Mean is the mean of derivative use, Median is the median of derivative use, Min is the minimum of the derivative use and Max is the maximum of derivative use.

Industry Sector	N	Mean	Median	Std Dev	Min	Max
Advertising Services	10	0.000	0.000	0.000	0.000	0.000
Business Services	70	0.012	0.000	0.034	0.000	0.141
Chemicals and Allied Products	30	0.053	0.044	0.051	0.000	0.154
Communications Equipment	20	0.047	0.033	0.051	0.000	0.124
Computer and Office Equipment	60	0.135	0.148	0.110	0.000	0.416
Construction Firms	5	0.063	0.069	0.051	0.000	0.133
Drugs	235	0.076	0.007	0.116	0.000	0.540
Electric, Gas, and Water Distribution	45	0.045	0.031	0.054	0.000	0.207
Electronic and Electrical Equipment	45	0.042	0.000	0.063	0.000	0.181
Food and Kindred Products	5	0.236	0.236	0.046	0.204	0.269
Leather and Leather Products	5	0.004	0.004	0.005	0.000	0.011
Machinery	15	0.104	0.067	0.118	0.000	0.345
Measuring, Medical, Photo Equipment; Clocks	45	0.018	0.000	0.035	0.000	0.136
Mining	5	0.059	0.038	0.038	0.036	0.104
Miscellaneous Manufacturing	10	0.023	0.016	0.026	0.000	0.062
Motion Picture Production and Distribution	5	0.022	0.022	0.006	0.017	0.026
Oil and Gas; Petroleum Refining	35	0.028	0.002	0.052	0.000	0.202
Paper and Allied Products	10	0.013	0.009	0.016	0.001	0.043
Prepackaged Software	25	0.011	0.000	0.018	0.000	0.052
Printing, Publishing, and Allied Services	15	0.147	0.114	0.136	0.000	0.383
Radio and Television Broadcasting Stations	25	0.010	0.000	0.016	0.000	0.045
Sanitary Services	15	0.083	0.051	0.102	0.019	0.403
Stone, Clay, Glass, and Concrete Products	5	0.098	0.114	0.050	0.014	0.143
Telecommunications	135	0.034	0.010	0.084	0.000	0.510
Textile and Apparel Products	20	0.022	0.000	0.049	0.000	0.186
Transportation Equipment	15	0.041	0.009	0.061	0.000	0.198
Wholesale Trade-Durable Goods	35	0.038	0.000	0.074	0.000	0.266
Wholesale Trade-Nondurable Goods	45	0.097	0.084	0.109	0.000	0.463

Table 4.8 Frequency of Participation in Hedging Activity over a 5-Year Period

This table presents the number and percentage of hedgers and non-hedgers over a 5-year period. The number in the parentheses is the percentage of hedgers and non-hedgers at the corresponding time period. The sample is split into five time periods. T-2 stands for the time 2 years before vertical integration, T-1 stands for the time 1 year before vertical integration, T stands for the time of vertical integration, T+1 stands for the time 1 year after vertical integration and T+2 stands for the time two years after vertical integration. Panel A, B, and C numbers and percentages are based on Complete Hedging Data, Complete Hedging Data Excluding Firms Never Hedged and Partial Hedging Data, respectively.

Hedging Status	T-2	T-1	T	T+1	T+2	TOTAL
Panel A: Frequency of Complete Hedging Data						
Non-Hedger	50	56	56	61	69	292
	(35%)	(39%)	(39%)	(43%)	(48%)	(41%)
Hedger	93	87	87	82	74	423
	(65%)	(61%)	(61%)	(57%)	(52%)	(59%)
TOTAL	143	143	143	143	143	715
Panel B: Frequency of Complete Hedging Data Excluding Firms Never Hedged						
Non-Hedger	14	20	20	25	33	112
	(13%)	(19%)	(19%)	(23%)	(31%)	(21%)
Hedger	93	87	87	82	74	423
	(87%)	(81%)	(81%)	(77%)	(69%)	(79%)
TOTAL	107	107	107	107	107	535
Panel C: Frequency of Partial Hedging Data						
Non-Hedger	17	22	19	15	12	85
	(45%)	(48%)	(42%)	(45%)	(55%)	(46%)
Hedger	21	24	26	18	10	99
	(55%)	(52%)	(58%)	(55%)	(45%)	(54%)
TOTAL	38	46	45	33	22	184

Table 4.9 summarizes the level of derivative use of 143 vertically related firms in Complete Hedging Data under four main derivative categories over5-year period. Panel A shows foreign exchange derivative statistics, Panel B shows interest rate derivative statistics, Panel C shows commodity derivative statistics and Panel D shows

other type of derivative statistics. Foreign exchange derivatives consist of foreign exchange forwards/futures, swaps and options. Interest rate derivatives consist of interest rate swaps, caps/floors, options and forwards. Commodity derivatives consist of commodity forwards/futures, options and swaps. Other derivatives are the ones that do not fall under these categories.

Firms in my sample heavily rely on foreign exchange derivatives and interest rate derivatives to hedge their risk. This is not a surprising result and is consistent with previous studies. The mean of derivative use decreases from 0.0675 (T-1) to 0.0572 (T) following vertical integration. The mean decreases further to 0.0523 (T+1) and 0.0484 (T+2) in the next two years of post-vertical integration. The stable decrease in derivative use following vertical integration suggests that vertical integration plays an important role in risk management and may be a substitute for derivative hedging. Additionally, these findings show that it takes time for firms to adjust their hedging policy after vertical integration.

Table 4.9 Summary Statistics of Derivative Use over a 5-Year Period

This table summarizes the level of derivative use of 143 vertically related firms in Complete Hedging Data under four main derivatives categories over a 5-year period. Derivative use is defined as the notional amount of derivatives scaled by total assets of the corresponding year. Panel A, B, C, and D statistics are related to foreign exchange (FX), interest rate (IR), commodity (Com) and other (Other) derivatives, respectively. If a derivative type cannot be recognized under any of the main categories, then it is recorded under Other. Each main category consists of different sub-categories. The sample is split into five time periods: T-2 stands for the time 2 years before vertical integration, T-1 stands for the time 1 year before vertical integration, T stands for the time of vertical integration, T+1 stands for the time 1 year after vertical integration and T+2 stands for the time two years after vertical integration.

		Pre-Vertical Integration						Vertical Integration			Post-Vertical Integration					
		T-2			T-1			T			T+1			T+2		
Variable	**N**	**Mean**	**Median**	**Std Dev**	**Mean**	**Median**	**Std Dev**	**Mean**	**Median**	**Std Dev**	**Mean**	**Median**	**Std Dev**	**Mean**	**Median**	**Std Dev**
Panel A: Foreign Exchange Derivatives																
FX Forward/Futures	143	0.0200	0.0000	0.0482	0.0237	0.0000	0.0511	0.0274	0.0000	0.0587	0.0262	0.0000	0.0583	0.0271	0.0000	0.0602
FX Swap	143	0.0020	0.0000	0.0142	0.0030	0.0000	0.0188	0.0021	0.0000	0.0153	0.0007	0.0000	0.0045	0.0011	0.0000	0.0067
FX Option	143	0.0035	0.0000	0.0236	0.0041	0.0000	0.0233	0.0008	0.0000	0.0046	0.0027	0.0000	0.0234	0.0007	0.0000	0.0046
Total FX	143	0.0255	0.0000	0.0587	0.0307	0.0000	0.0631	0.0303	0.0000	0.0644	0.0296	0.0000	0.0694	0.0289	0.0000	0.0627
Panel B: Interest Rate Derivatives																
IR Swaps	143	0.0257	0.0000	0.0504	0.0303	0.0000	0.0840	0.0194	0.0000	0.0479	0.0194	0.0000	0.0471	0.0167	0.0000	0.0410
IR Caps/Floors	143	0.0008	0.0000	0.0056	0.0009	0.0000	0.0063	0.0006	0.0000	0.0059	0.0002	0.0000	0.0019	0.0000	0.0000	0.0000
IR Options	143	0.0001	0.0000	0.0010	0.0006	0.0000	0.0060	0.0003	0.0000	0.0028	0.0003	0.0000	0.0031	0.0024	0.0000	0.0153
IR Forwards	143	0.0012	0.0000	0.0073	0.0016	0.0000	0.0109	0.0017	0.0000	0.0121	0.0019	0.0000	0.0124	0.0002	0.0000	0.0022
Total IR	143	0.0277	0.0000	0.0521	0.0334	0.0000	0.0881	0.0220	0.0000	0.0524	0.0218	0.0000	0.0494	0.0193	0.0000	0.0438
Panel C: Commodity Derivatives																
Com Forward/Futures	143	0.0005	0.0000	0.0061	0.0010	0.0000	0.0115	0.0006	0.0000	0.0062	0.0000	0.0000	0.0003	0.0000	0.0000	0.0004
Com Options	143	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Com Swaps	143	0.0000	0.0000	0.0003	0.0001	0.0000	0.0011	0.0001	0.0000	0.0007	0.0001	0.0000	0.0013	0.0001	0.0000	0.0006
Total Com	143	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Panel D: Other Type of Derivatives																
OTHER	143	0.0042	0.0000	0.0236	0.0023	0.0000	0.0118	0.0043	0.0000	0.0274	0.0008	0.0000	0.0047	0.0001	0.0000	0.0009
DERIVATIVE USE	143	**0.0580**	**0.0138**	**0.0844**	**0.0675**	**0.0097**	**0.1100**	**0.0572**	**0.0097**	**0.0886**	**0.0523**	**0.0078**	**0.0886**	**0.0484**	**0.0001**	**0.0831**

In Table 4.10, derivative use of firms in Complete Hedging Data is presented using an alternative approach. This approach requires acquisitions in my sample to be categorized as low and high vertical integration. If the acquisitions have a vertical relatedness coefficient less than or equal to %, then they are categorized as low vertical integration. Acquisitions with a vertical relatedness coefficient greater than 9% are categorized as high vertical integration. I use the 9% cutoff because the mean of the vertical relatedness coefficient of the sample is around 0.09.

Panel A and B in Table 4.10 present summary statistics of derivative use of firms with low and high vertical integration respectively, over a 5-year period. The decrease in post-acquisition derivative use (*TOTAL*) of high vertical integration firms seems greater compared to the decrease of low vertical integration firms. Derivative use of low vertical integration firms is 0.060 at time T and decreases to 0.055 at time T+2, whereas derivative use of high vertical integration firms is 0.052 at time T and decreases to 0.038 at time T+2. This result can be interpreted to mean that high vertical integration is a better hedging mechanism. For this reason, high vertical integration firms tend to use fewer derivatives compared to low vertical integration firms.

Table 4.10 Summary Statistics of Derivative Use over a 5-Year Period—Alternative Approach with Complete Hedging Data

This table summarizes the level of derivative use of firms with low and high vertical integration in Complete Hedging Data under four main derivatives categories over a 5-year period. Acquisitions with a vertical integration coefficient less than or equal to 9% are categorized as low vertical integration whereas acquisitions with a vertical integration coefficient greater than 9% are categorized as high vertical integration. Derivative use is defined as the notional amount of derivatives scaled by total assets of the corresponding year. Panel A, B, C, and D statistics are related to foreign exchange (FX), interest rate (IR), commodity (Com) and other (Other) derivatives, respectively. If a derivative type cannot be recognized under any of the main categories, then it is recorded under Other. Each main category consists of different sub-categories. The sample is split into five time periods: T-2 stands for the time 2 years before vertical integration, T-1 stands for the time 1 year before vertical integration, T stands for the time of vertical integration, T+1 stands for the time 1 year after vertical integration and T+2 stands for the time two years after vertical integration.

		Pre-Vertical Integration						Vertical Integration			Post-Vertical Integration					
		T-2			T-1			T			T+1			T+2		
Variable	N	Mean	Median	Std Dev	Mean	Median	Std Dev	Mean	Median	Std Dev	Mean	Median	Std Dev	Mean	Median	Std Dev
Panel A: Low Vertical Integration																
FX	90	0.025	0.000	0.056	0.030	0.000	0.061	0.031	0.000	0.068	0.032	0.000	0.076	0.032	0.000	0.068
IR	90	0.027	0.000	0.053	0.029	0.000	0.069	0.024	0.000	0.055	0.026	0.000	0.058	0.023	0.000	0.052
COM	90	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
OTHER	90	0.005	0.000	0.028	0.002	0.000	0.010	0.005	0.000	0.032	0.001	0.000	0.005	0.000	0.000	0.000
TOTAL	90	**0.057**	**0.008**	**0.085**	**0.061**	**0.005**	**0.096**	**0.060**	**0.004**	**0.093**	**0.058**	**0.002**	**0.098**	**0.055**	**0.000**	**0.091**
Panel B: High Vertical Integration																
FX	53	0.027	0.000	0.064	0.032	0.000	0.066	0.028	0.000	0.059	0.026	0.000	0.057	0.024	0.000	0.053
IR	53	0.029	0.008	0.051	0.041	0.000	0.114	0.018	0.000	0.049	0.015	0.000	0.029	0.014	0.000	0.025
COM	53	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
OTHER	53	0.002	0.000	0.014	0.003	0.000	0.014	0.004	0.000	0.016	0.001	0.000	0.005	0.000	0.000	0.001
TOTAL	53	**0.059**	**0.025**	**0.085**	**0.079**	**0.019**	**0.131**	**0.052**	**0.012**	**0.081**	**0.043**	**0.010**	**0.070**	**0.038**	**0.006**	**0.068**

Table 4.11 shows the summary statistics of high and low vertical integration firms using both complete and partial hedging data. Despite missing observations for some of the years, the same conclusion is made. High vertical integration firms decrease the amount of derivative hedging following vertical acquisition. These are just summary statistics but they provide important evidence on the importance of vertical integration in corporate risk management decisions.

4.2.2 Descriptive Statistics Related to Firm Characteristics

Table 4.12 reports descriptive statistics for firms in both Complete and Partial Hedging Data groups. I also report descriptive statistics of Complete and Partial Hedging Data separately in Tables 4.13 and 4.14, respectively. After winsorizing all variables at 1% and 99% values, the total number of observations is 747.

About 62% of firms in the sample use derivative hedging over a 5-year period. As mentioned earlier, hedging data has no missing hedging information whereas partial hedging data has many missing observations regarding hedging activity. 21 firms in partial hedging data have a missing *HEDGER* variable. A dummy takes a value of one if a firm holds a nonzero derivative position at the end of the year and zero otherwise. 10 of the firms report whether they hedge or not but do not report the amount of hedging they use so the *TOTALHEDGE* variable is missing for those firms. On average, firms in my sample hold a notional amount of 6 percent of book value of total assets in derivatives. The maximum notional amount is 54 percent which means

Table 4.11 Summary Statistics of Derivative Use over a 5-Year Period with Complete Hedging Data and Partial Hedging Data

This table summarizes the level of derivative use of firms with low and high vertical integration in Complete Hedging Data and Partial Hedging Data under four main derivatives categories over a 5-year period. Acquisitions with a vertical integration coefficient less than or equal to 9% are categorized as low vertical integration whereas acquisitions with a vertical integration coefficient greater than 9% are categorized as high vertical integration. Derivative use is defined as the notional amount of derivatives scaled by total assets of the corresponding year. Panel A, B, C, and D statistics are related to foreign exchange (FX), interest rate (IR), commodity (Com) and other (Other) derivatives, respectively. If a derivative type cannot be recognized under any of the main categories, then it is recorded under Other. Each main category consists of different sub-categories. The sample is split into five time periods: T-2 stands for the time 2 years before vertical integration, T-1 stands for the time 1 year before vertical integration, T stands for the time of vertical integration, T+1 stands for the time 1 year after vertical integration and T+2 stands for the time two years after vertical integration.

	Pre-Vertical Integration								**Vertical Integration**				**Post-Vertical Integration**							
	T-2				**T-1**				**T**				**T+1**				**T+2**			
Variable	**N**	**Mean**	**Median**	**Std Dev**	**N**	**Mean**	**Median**	**Std Dev**	**N**	**Mean**	**Median**	**Std Dev**	**N**	**Mean**	**Median**	**Std Dev**	**N**	**Mean**	**Median**	**Std Dev**
									Panel A: Low Vertical Integration											
FX	107	0.027	0.000	0.060	112	0.032	0.000	0.067	110	0.027	0.000	0.063	104	0.029	0.000	0.072	99	0.029	0.000	0.065
IR	107	0.262	0.000	3.109	112	0.018	0.000	0.039	110	0.024	0.000	0.058	104	0.026	0.000	0.064	99	0.026	0.000	0.070
COM	107	0.000	0.000	0.000	112	0.000	0.000	0.000	110	0.000	0.000	0.000	104	0.000	0.000	0.000	99	0.000	0.000	0.000
OTHER	107	0.004	0.000	0.022	112	0.002	0.000	0.012	110	0.004	0.000	0.029	104	0.001	0.000	0.004	99	0.000	0.000	0.000
TOTAL	107	0.061	0.014	0.091	112	0.053	0.000	0.086	110	0.055	0.002	0.091	104	0.056	0.000	0.098	99	0.055	0.000	0.099
									Panel B: High Vertical Integration											
FX	70	0.032	0.000	0.069	74	0.069	0.000	0.317	72	0.358	0.000	2.762	68	0.030	0.000	0.062	61	0.021	0.000	0.050
IR	70	0.034	0.001	0.074	74	0.040	0.000	0.106	72	0.019	0.000	0.045	68	0.018	0.000	0.032	61	0.019	0.000	0.055
COM	70	0.000	0.000	0.000	74	0.000	0.000	0.000	72	0.000	0.000	0.000	68	0.000	0.000	0.000	61	0.000	0.000	0.000
OTHER	70	0.003	0.000	0.013	74	0.002	0.000	0.012	72	0.003	0.000	0.014	68	0.001	0.000	0.004	61	0.000	0.000	0.001
TOTAL	70	0.069	0.028	0.101	74	0.078	0.019	0.124	71	0.056	0.022	0.083	68	0.048	0.010	0.075	61	0.040	0.004	0.079

Table 4.12 Descriptive Statistics of Firms in Complete Hedging Data and Partial Hedging Data

This table shows descriptive statistics of 198 vertically integrated firms in Complete Hedging Data and Partial Hedging Data. The sample includes 747 firm-year observations for the period 1998-2013. VR is the vertical relatedness coefficient based on the 6-digit IO level. VI is a vertical integration dummy variable that takes a value of one if the observation is at time T+1 and T+2, and zero otherwise. VI1 is a vertical integration dummy variable that takes a value of one if the observation is at time T, T+1 and T+2, and zero otherwise. VI 2is a vertical integration dummy variable that takes a value of one if the observation is at time T+1 and T+2, missing if it is at time T, and zero if it is at time T-1 and T-2. T-2 stands for the time 2 years before vertical integration, T-1 stands for the time 1 year before vertical integration, T stands for the time of vertical integration, T+1 stands for 1 year after vertical integration and T+2 stands for two years after vertical integration..HIGHVERTICAL8 is a dummy variable that takes a value of one if the vertical relatedness coefficient of acquisition exceeds 8%, and zero otherwise.HIGHVERTICAL9 is a dummy variable that takes a value of one if the vertical relatedness coefficient of acquisition exceeds 9%, and zero otherwise. HIGHVERTICAL10 is a dummy variable that takes a value of one if the vertical relatedness coefficient of acquisition exceeds 10%, and zero otherwise. HIGHVERTICAL15 is a dummy variable that takes a value of one if the vertical relatedness coefficient of acquisition exceeds 15%, and zero otherwise. Note that vertical dummies take a value of zero if the firm year observation is before vertical integration. TOTALHEDGE is the total notional amount of derivatives scaled by total assets. HEDGER is a dummy variable that takes a value of one if a firm holds a nonzero derivative position at the end of year, and zero otherwise. ASSETS is the book value of total assets. DA is debt-to-asset ratio, calculated as book value of total liabilities divided by book value of total assets. MB is market-to-book ratio calculated as market value of equity divided by book value of equity. R&D is research and development expenses scaled by total assets. PPE is the intensity of capital investment calculated as capital expenditures for property, plant, and equipment to firm size. INST is the percentage of a firm's total shares outstanding held by institutions. CR is the current ratio calculated as current assets divided by liabilities. DIV is the dividend payout ratio, calculated as dividends per share to common shareholders divided by earnings per share before extraordinary items. ROA is return on assets calculated as operating incomes scaled by total assets. ROE is return on equity calculated as operating income scaled by market value of equity. CONV is book value of total convertible debt scaled by firm size. PREF is book value of total preferred stock scaled by firm size. SIZE is the log of total assets. TOBIN is calculated as book value of total assets plus market value of common equity minus book value of common equity divided by book value of total assets. LTOBIN is the log of TOBIN.

Variable	N	Mean	Median	Std Dev	Min	Max
HEDGER	726	0.620	1.000	0.486	0.000	1.000
TOTALHEDGE	716	0.059	0.010	0.091	0.000	0.540
VI	747	0.367	0.000	0.482	0.000	1.000
VI1	747	0.570	1.000	0.495	0.000	1.000
VI2	595	0.461	0.000	0.499	0.000	1.000
VR	747	0.101	0.058	0.126	0.013	0.710
HIGHVERTICAL8	747	0.246	0.000	0.431	0.000	1.000
HIGHVERTICAL9	747	0.233	0.000	0.423	0.000	1.000
HIGHVERTICAL10	747	0.189	0.000	0.392	0.000	1.000
HIGHVERTICAL15	747	0.124	0.000	0.330	0.000	1.000

Table 4.12 Continued

Variable	N	Mean	Median	Std Dev	Min	Max
ASSETS *($mill)*	747	25427	4445	47689	8	333795
DA	747	0.242	0.213	0.183	0.000	1.262
MB	747	3.390	2.591	3.787	-18.642	39.825
R&D	747	0.057	0.019	0.104	0.000	0.783
PPE	747	0.510	0.208	0.765	0.006	9.191
INST	747	0.465	0.599	0.354	0.000	1.174
CR	747	2.506	1.770	2.113	0.238	13.741
DIV	747	0.139	0.000	0.385	-3.125	2.353
TAX	747	0.307	0.000	0.461	0.000	1.000
ROA	747	0.098	0.121	0.148	-0.773	0.361
ROE	747	0.106	0.104	0.146	-0.766	0.666
CONV	747	0.046	0.000	0.107	0.000	0.561
PREF	747	0.003	0.000	0.026	0.000	0.358
SIZE	747	8.359	8.400	2.275	2.097	12.718
TOBIN	747	2.096	1.660	1.452	0.611	11.539

Table 4.13 Descriptive Statistics of Firms in Complete Hedging Data

This table shows descriptive statistics of 143 vertically integrated firms in Complete Hedging Data. The sample includes 603 firm-year observations for the period 1998-2013. VR is the vertical relatedness coefficient based on the 6-digit IO level. VI is a vertical integration dummy variable that takes a value of one if the observation is at time T+1 and T+2, and zero otherwise. VI1 is a vertical integration dummy variable that takes a value of one if the observation is at time T, T+1 and T+2, and zero otherwise. VI 2is a vertical integration dummy variable that takes a value of one if the observation is at time T+1 and T+2, missing if it is at time T, and zero if it is at time T-1 and T-2. T-2 stands for the time 2 years before vertical integration, T-1 stands for the time 1 year before vertical integration, T stands for the time of vertical integration, T+1 stands for 1 year after vertical integration and T+2 stands for two years after vertical integration..HIGHVERTICAL8 is a dummy variable that takes a value of one if the vertical relatedness coefficient of acquisition exceeds 8%, and zero otherwise.HIGHVERTICAL9 is a dummy variable that takes a value of one if the vertical relatedness coefficient of acquisition exceeds 9%, and zero otherwise. HIGHVERTICAL10 is a dummy variable that takes a value of one if the vertical relatedness coefficient of acquisition exceeds 10%, and zero otherwise. HIGHVERTICAL15 is a dummy variable that takes a value of one if the vertical relatedness coefficient of acquisition exceeds 15%, and zero otherwise. Note that vertical dummies take a value of zero if the firm year observation is before vertical integration. TOTALHEDGE is the total notional amount of derivatives scaled by total assets. HEDGER is a dummy variable that takes a value of one if a firm holds a nonzero derivative position at the end of year, and zero otherwise. ASSETS is the book value of total assets. DA is debt-to-asset ratio, calculated as book value of total liabilities divided by book value of total assets. MB is market-to-book ratio calculated as market value of equity divided by book value of equity. R&D is research and development expenses scaled by total assets. PPE is the intensity of capital investment calculated as capital expenditures for property, plant, and equipment to firm size. INST is the percentage of firm's total shares outstanding held by institutions. CR is the current ratio calculated as current assets divided by liabilities. DIV is the dividend payout ratio, calculated as dividends per share to common shareholders divided by earnings per share before extraordinary items. ROA is return on assets calculated as operating incomes scaled by total assets. ROE is return on equity calculated as operating income scaled by market value of equity. CONV is book value of total convertible debt scaled by firm size. PREF is book value of total preferred stock scaled by firm size. SIZE is the log of total assets. TOBIN is calculated as book value of total assets plus market value of common equity minus book value of common equity divided by book value of total assets. LTOBIN is the log of TOBIN

Variable	N	Mean	Median	Std Dev	Min	Max
HEGDER	603	0.624	1.000	0.485	0.000	1.000
TOTALHEDGE	603	0.058	0.010	0.092	0.000	0.540
VI	603	0.390	0.000	0.488	0.000	1.000
VI1	603	0.589	1.000	0.492	0.000	1.000
VI2	483	0.487	0.000	0.500	0.000	1.000
VR	603	0.092	0.057	0.107	0.013	0.710
HIGHVERTICAL5	603	0.303	0.000	0.460	0.000	1.000
HIGHVERTICAL8	603	0.237	0.000	0.426	0.000	1.000
HIGHVERTICAL9	603	0.221	0.000	0.415	0.000	1.000
HIGHVERTICAL10	603	0.179	0.000	0.384	0.000	1.000
HIGHVERTICAL15	603	0.121	0.000	0.326	0.000	1.000

Table 4.13 Continued

Variable	N	Mean	Median	Std Dev	Min	Max
ASSETS *($mill)*	603	22584	4399	38559	10	242223
DA	603	0.241	0.213	0.174	0.000	1.192
MB	603	3.566	2.711	4.026	-18.642	39.825
R&D	603	0.058	0.020	0.103	0.000	0.783
PPE	603	0.470	0.204	0.715	0.006	9.191
INST	603	0.460	0.610	0.356	0.000	1.174
CR	603	2.406	1.789	1.849	0.334	11.841
DIV	603	0.128	0.000	0.383	-3.125	2.353
TAX	603	0.308	0.000	0.462	0.000	1.000
ROA	603	0.102	0.124	0.143	-0.773	0.361
ROE	603	0.103	0.097	0.135	-0.699	0.630
CONV	603	0.051	0.000	0.112	0.000	0.561
PREF	603	0.002	0.000	0.017	0.000	0.321
SIZE	603	8.386	8.389	2.207	2.302	12.398
TOBIN	603	2.189	1.756	1.551	0.611	11.539

Table 4.14 Descriptive Statistics of Firms in Partial Hedging Data

This table shows descriptive statistics of 55 vertically integrated firms in Partial Hedging Data. The sample includes 144 firm-year observations for the period 1998-2013. VR is the vertical relatedness coefficient based on the 6-digit IO level. VI is a the vertical integration dummy variable that takes a value of one if the observation is at time T+1 and T+2, and zero otherwise. VI1 is a vertical integration dummy variable that takes a value of one if the observation is at time T, T+1 and T+2, and zero otherwise. VI 2is a vertical integration dummy variable that takes a value of one if the observation is at time T+1 and T+2, missing if it is at time T, and zero if it is at time T-1 and T-2. T-2 stands for the time 2 years before vertical integration, T-1 stands for the time 1 year before vertical integration, T stands for the time of vertical integration, T+1 stands for 1 year after vertical integration and T+2 stands for two years after vertical integration..HIGHVERTICAL8 is a dummy variable that takes a value of one if the vertical relatedness coefficient of acquisition exceeds 8%, and zero otherwise.HIGHVERTICAL9 is a dummy variable that takes a value of one if the vertical relatedness coefficient of acquisition exceeds 9%, and zero otherwise. HIGHVERTICAL10 is a dummy variable that takes a value of one if the vertical relatedness coefficient of acquisition exceeds 10%, and zero otherwise. HIGHVERTICAL15 is a dummy variable that takes a value of one if the vertical relatedness coefficient of acquisition exceeds 15%, and zero otherwise. Note that vertical dummies take a value of zero if the firm year observation is before vertical integration. TOTALHEDGE is the total notional amount of derivatives scaled by total assets. HEDGER is a dummy variable that takes a value of one if a firm holds a nonzero derivative position at the end of year, and zero otherwise. ASSETS is the book value of total assets. DA is debt-to-asset ratio, calculated as book value of total liabilities divided by book value of total assets. MB is market-to-book ratio calculated as market value of equity divided by book value of equity. R&D is research and development expenses scaled by total assets. PPE is the intensity of capital investment calculated as capital expenditures for property, plant, and equipment to firm size. INST is the percentage of firm's total shares outstanding held by institutions. CR is the current ratio calculated as current assets divided by liabilities. DIV is the dividend payout ratio, calculated as dividends per share to common shareholders divided by earnings per share before extraordinary items. ROA is return on assets calculated as operating incomes scaled by total assets. ROE is return on equity calculated as operating income scaled by market value of equity. CONV is book value of total convertible debt scaled by firm size. PREF is book value of total preferred stock scaled by firm size. SIZE is the log of total assets. TOBIN is calculated as book value of total assets plus market value of common equity minus book value of common equity divided by book value of total assets. LTOBIN is the log of TOBIN.

Variable	N	Mean	Median	Std Dev	Min	Max
HEGDER	123	0.602	1.000	0.492	0.000	1.000
TOTALHEDGE	113	0.062	0.009	0.091	0.000	0.403
VI	144	0.271	0.000	0.446	0.000	1.000
VI1	144	0.493	0.000	0.502	0.000	1.000
VI2	112	0.348	0.000	0.479	0.000	1.000
VR	144	0.135	0.090	0.184	0.013	0.710
HIGHVERTICAL8	144	0.285	0.000	0.453	0.000	1.000
HIGHVERTICAL9	144	0.285	0.000	0.453	0.000	1.000
HIGHVERTICAL10	144	0.229	0.000	0.422	0.000	1.000
HIGHVERTICAL15	144	0.139	0.000	0.347	0.000	1.000

Table 4.14 Continued

Variable	N	Mean	Median	Std Dev	Min	Max
ASSETS *($mill)*	144	37334	4572	73675	8	333795
DA	144	0.245	0.213	0.217	0.000	1.262
MB	144	2.654	2.226	2.429	-7.696	13.014
R&D	144	0.055	0.017	0.109	0.000	0.709
PPE	144	0.676	0.302	0.929	0.007	4.961
INST	144	0.488	0.586	0.342	0.000	1.080
CR	144	2.922	1.672	2.947	0.238	13.741
DIV	144	0.186	0.000	0.389	-2.000	2.212
TAX	144	0.299	0.000	0.459	0.000	1.000
ROA	144	0.078	0.113	0.167	-0.613	0.332
ROE	144	0.118	0.136	0.184	-0.766	0.666
CONV	144	0.026	0.000	0.079	0.000	0.410
PREF	144	0.010	0.000	0.048	0.000	0.358
SIZE	144	8.246	8.427	2.545	2.097	12.718
TOBIN	144	1.709	1.476	0.827	0.730	5.498

firms in our sample hold derivatives to cover at most about half of their total assets.

VI, VI1, VI2 are the dummy variables to proxy for vertical integration. *VI* is the dummy variable that treats observations at the year of vertical integration as non-vertical integration and takes a value of one if the firm is vertically integrated, and zero otherwise.

If I use *VI* as a proxy for vertical integration, about 38 percent of firm-year observations are categorized as vertically integrated. *VI1* is an alternative vertical integration dummy variable that treats observations at the year of vertical integration as vertical integration and takes a value of one if the firm is vertically integrated and zero otherwise. Using this proxy, 57 percent of firm-year observations are categorized as vertical integration. I treat the vertical integration year differently because some firms become vertically integrated at the beginning of the year while others become vertically integrated at the middle or the end of the year. If a firm's vertical integration occurs at the end of a year then assigning a vertical integration dummy for this year's observation may bias estimates since there is no time to adjust the hedging policy in accordance with vertical integration. Additionally, a second vertical integration alternative dummy variable, *VI2***,** assigns a missing value for the observations at the year of vertical integration and takes a value of one if the firm is vertically integrated and zero otherwise. Given that there are 152 missing VI2 values, about 46 percent of firm-year observations are treated as vertical integration using this proxy.

HIGHVERTICAL8, HIGHVERTICAL9, HIGHVERTICAL10, HIGHVERTICAL15 are dummy variables to distinguish high vertical integration firms from low vertical integration firms at different cutoffs. Using the 8% cutoff, about 25 percent of firms fall into the high vertical integration category; the percentage decreases to about 23, 19 and 13 when 9%, 10% and 15% cutoffs are used, respectively. The mean of vertical relatedness coefficient is 0.10 for complete and partial hedging datasets together and it is 0.09 for complete hedging datasets. Therefore, depending on the dataset, 9% and 10% cutoffs are the best ones to use in the analysis.

I do have a large variation in firms' assets, given that the minimum and maximum of assets are $8 million and $333.795 billion, respectively. The mean of assets is $25.427 billion, which is substantially greater than the median of $4.445 billion. This skewness prompts me to use the log of assets as a firm size variable in the subsequent empirical analysis.

The debt ratio for the sample is not that high. The average is about 25 percent, which means that the minority of firms' assets are financed through debt. The low debt ratio may also mean low operational risk. Although there is a huge variation in market-to-book ratio, on average, firms in my sample are overvalued. Research and development expenses are only about 6 percent of total assets but it reaches 78 percent for research-oriented firms. In general, capital investment intensity is about half of firm size and may go up to 9 times firm size for some firms in the sample.

On average, about 47 percent of firms' outstanding shares are owned by institutions. That means my firms are closely monitored by external parties. The dividend yield is fairly high, about 14 percent. This is much higher than the 2 percent dividend yield of S&P 500. However, the median of 0 percent shows that most of the firms do not pay any dividend at all. 30 percent of firms have a convex tax function. The returns on assets and equity are almost same, about 10 percent, so generally speaking firms in the sample do not generate excess returns.

The total amount of hedging alternatives (preferred stocks and convertible bonds) makes up about 5 percent of the book value of total assets on average, almost same as the use of derivatives. So firms in the sample may substitute derivative hedging for other alternatives.

Tobin stands for the Tobin's Q and is a proxy for firm value which is basically calculated as the ratio of a firm's market value divided by its book value of total assets. The average of Tobin's Q for my sample is 2.189 with a standard deviation of 1.76. This value is comparable to that reported by Choi, Mao, and Upadhyay (2013). Their sample comes from the pharmaceutical and biotech industry which is a high-growth sector. About one-third of the firms in my sample operate in high-growth sectors such as drugs and telecommunication sectors. My Tobin's Q is higher than that reported in Allayannis and Weston (2001).

Chapter 5

EMPIRICAL TEST RESULTS

5.1 Univariate Test Results

In this section, I present the results of different univariate tests which identify the differences in derivative hedging amounts between pre- and post-vertical integration as well as high and low vertical integration firms. Additionally, the results of univariate tests of the difference in firms' characteristics of hedgers and non-hedgers, pre- and post-vertical integration, high and low vertical integration are reported. The methodology of the univariate tests in this section is explained in details in Section 3.2.1.

5.1.1 Derivative Use at Different Time Periods

Table 5.1 presents univariate comparisons of the mean and median values of derivative use of vertically related firms in Complete Hedging Data at different time periods[18]. In the last two columns, p-values of paired t-tests and sign tests are given. For most of the hedging variables in Table 5.1, the mean and median are not equal, which means they are skewed. Therefore, I perform both paired sample t-tests to check

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[18] I use this dataset because Partial Hedging Data has many missing observations for the *TOTALHEDGE* variable which may bias the estimates.

Table 5.1 Univariate Tests of Derivative Use in Different Time Periods

This table presents univariate comparisons of the mean and median values of derivative use of 143 vertically related firms in Complete Hedging Data at different time periods. Each Panel shows the comparison of mean and median values of two different time periods. The Difference column shows the difference in mean values of derivative use from one period to another. The last two columns presents the p-values of paired sample t-tests and paired sample sign tests that test the difference in means and medians between two time periods, respectively. FX is foreign exchange derivatives scaled by total assets. IR is interest rate derivatives scaled by total assets. COM is commodity derivatives scale by total assets. OTHER is other types of derivatives that cannot be categorized under FX, IR or COM. TOTALHEDGE is the total notional amount of derivatives scaled by total assets. T-1 stands for the time one year before vertical integration, T stands for the time of vertical integration, T+1 stands for one year after vertical integration and T+2 stands for two years after vertical integration. *, **, *** denote the significance at 10%, 5%, and 1%, respectively.

Variables	N	Mean	Median	Mean	Median	Difference	Paired T-Test	Sign Test
Panel A:		**Time T-1**		**Time T**		**Time T- Time T-1**		
FX	143	0.0307	0.0000	0.0303	0.0000	-0.0004	0.878	0.452
IR	143	0.0334	0.0000	0.0220	0.0000	-0.0115	0.086*	0.315
COM	143	0.0000	0.0000	0.0000	0.0000	0.0000	0.192	0.344
OTHER	143	0.0023	0.0000	0.0043	0.0000	0.0020	0.376	0.613
TOTALHEDGE	143	0.0675	0.0097	0.0572	0.0097	-0.0103	0.180	0.061*
Panel B:		**Time T-1**		**Time T+1**		**Time T+1 - Time T-1**		
FX	143	0.0307	0.0000	0.0296	0.0000	-0.0011	0.747	0.195
IR	143	0.0334	0.0000	0.0218	0.0000	-0.0117	0.101	0.138
COM	143	0.0000	0.0000	0.0000	0.0000	0.0000	0.224	0.227
OTHER	143	0.0023	0.0000	0.0008	0.0000	-0.0015	0.035**	0.274
TOTALHEDGE	143	0.0675	0.0097	0.0523	0.0078	-0.0152	0.061*	0.075*
Panel C:		**Time T-1**		**Time T+2**		**Time T+2 - Time T-1**		
FX	143	0.0307	0.0000	0.0289	0.0000	-0.0019	0.608	0.195
IR	143	0.0334	0.0000	0.0193	0.0000	-0.0141	0.052*	0.065*
COM	143	0.0000	0.0000	0.0000	0.0000	0.0000	0.197	0.910
OTHER	143	0.0023	0.0000	0.0001	0.0000	-0.0022	0.030**	0.055*
TOTALHEDGE	143	0.0675	0.0097	0.0484	0.0001	-0.0191	0.021**	0.0219**

Table 5.1 Continued

Variables	N	Mean	Median	Mean	Median	Difference	Paired T-Test	Sign Test
Panel D:		Time T		Time T+1		Time T+1 - Time T		
FX	143	0.0303	0.0000	0.0296	0.0000	-0.0007	0.737	0.225
IR	143	0.0220	0.0000	0.0218	0.0000	-0.0002	0.940	0.402
COM	143	0.0000	0.0000	0.0000	0.0000	0.0000	0.819	0.773
OTHER	143	0.0043	0.0000	0.0008	0.0000	-0.0035	0.121	0.019**
TOTALHEDGE	143	0.0572	0.0097	0.0523	0.0078	-0.0049	0.245	0.011**
Panel E:		Time T		Time T+2		Time T+1 - Time T		
FX	143	0.0303	0.0000	0.0289	0.0000	-0.0014	0.549	0.052
IR	143	0.0220	0.0000	0.0193	0.0000	-0.0027	0.432	0.238
COM	143	0.0000	0.0000	0.0000	0.0000	0.0000	0.336	0.746
OTHER	143	0.0043	0.0000	0.0001	0.0000	-0.0042	0.071*	0.003***
TOTALHEDGE	143	0.0572	0.0097	0.0484	0.0001	-0.0088	0.059*	0.025**

whether the decrease in the mean of derivative use in each time period following vertical integration is statistically significant and signed tests to check whether the decrease in the median of derivative use following vertical integration is statistically significant. Earlier, at Section 3.2.1.1, I explained the null and alternative hypotheses of univariate tests performed in this section in detail.

In Panel A, time T derivative uses are compared to time T-1 derivative uses, which is the year before vertical integration. This time period may not be enough for a firm to adjust its hedging policy according to vertical integration. For some firms, vertical integration happens at the end of year. In this case treating time T as the vertical integration year may result in drawing wrong conclusions about univariate test results. Keeping this in mind, I still observe a significant decrease in the median of total derivative use *(TOTALHEDGE)* from time T-1 to T at the 10 percent level. However, the decrease in the mean of total derivative use is not statistically significant.

Panel B compares time T-1 derivative use to time T+1 derivative use. The test results of this panel may be more reliable since more time is allowed for firms to adjust their hedging policy. The mean of hedging decreases from 0.0675 to 0.0523 and the median of hedging decreases from 0.0097 to 0.0078 from time T-1 to time T+1. Both paired sample t-test and sign test p-values confirm these decreases are significant at the 10 percent level. The decrease in mean mainly originates from the decrease in other types of derivatives use (OTHER). If the total hedging in time T-1 is compared to that in time T+2, as presented in Panel C, the decreases in both mean and median are more prominent and significant at the 5 percent level. These results reveal that firms substitute financial hedging for vertical integration as time passes.

I also perform the tests for the difference in hedging for post-vertical integration to make sure that my conclusions from previous comparisons are robust. In Panel D, I report the results of the univariate comparisons of derivative use at time T and T+1 which is the year just after vertical integration. The decrease in the mean of total hedging is not significant; however the p-value of the sign test, which is 0.011, indicates that the decrease in the median of total hedging from T to T+1 is significant at the 5 percent level. Panel E compares the hedging amount at the vertical integration year (T) to the hedging amount 2 years after vertical integration (T+2). In this case, the decrease in the mean of derivative use becomes significant at 10 percent whereas the significance level of the sign test stating a decrease in the median stays same as in Panel D.

5.1.2 Pre- and Post-Vertical Integration Derivative Use

Table 5.2 reports the univariate test results of pre- and post-vertical integration derivative use. The methodologies for these tests are explained earlier in Section 3.2.1.2. The comparisons in this section are different from those reported in Table 5.1 because the average of pre-vertical integration hedging levels is directly compared to the average of post-vertical integration hedging levels. Pre-vertical integration derivative use is calculated as the average of corresponding hedging at time T-2 and T-1. The difference between Panel A and B is the calculation of post-vertical integration hedging. In Panel A, post-vertical integration derivative use is calculated as the average of corresponding hedging at time T, T+1 and T+2, whereas in Panel B it is calculated as the average of corresponding hedging at time T+1 and T+2. In other words, I exclude time T from the post-vertical integration derivative use calculations in Panel B.

Panel A shows that the mean of derivative use at pre-vertical integration is 0.0627. It drops to 0.0526 at post-vertical integration. The difference in means between pre- and post-vertical integration derivative uses is -0.0101 which is significant at the 10 percent level as indicated by paired sample t-tests. This decrease in total hedging following vertical integration mainly arises from the significant decrease in the use of interest rate (IR) derivatives and other types of derivatives (OTHER). The p-value of the sign test is 0.0407 so I can reject the null hypothesis and accept the alternative at the 5 percent confidence level, which states that the median of post-vertical integration derivative use is less than the median of pre-vertical integration derivative use.

Looking at Panel B test results I can conclude the same as in Panel A, but the significance level of the paired t-tests drops to 5 percent and the significance level of the sign tests increases to 10 percent. These results show that including or excluding time T in the analysis does not have any significant impact on the conclusion that firms use derivatives less following vertical integration.

Table 5.2 Univariate Tests of Pre- and Post-Vertical Integration Derivative Use

This table presents univariate comparisons of the mean and median values of pre- and post-vertical integration derivative use of 143 vertically related firms in Complete Hedging Data. In Panel A time T is treated as a post-vertical integration year and in Panel B observations at time T are excluded from the univariate analysis. The Difference column shows the mean of post-vertical integration derivative use minus the mean of pre-vertical integration derivative use. The last two columns presents the p-values of paired sample t-tests in which the alternative hypothesis is the mean of post-vertical integration derivative use is less than the mean of pre-vertical integration derivative use, whereas the null hypothesis is the difference of the means is zero and p-values of paired sample sign tests in which the alternative hypothesis is the median of post-vertical integration derivative use is less than the median of pre-vertical integration derivative use, whereas the null hypothesis is difference of medians is zero. FX is foreign exchange derivatives scaled by total assets. IR is interest rate derivatives scaled by total assets. COM is commodity derivatives scaled by total assets. OTHER is other types of derivatives that cannot be categorized under FX, IR or COM. Total Hedging is the total notional amount of derivatives scaled by total assets. *, **, and *** denote the significance at 10%, 5%, and 1%, respectively.

		Pre-Vertical Integration		Post-Vertical Integration		Difference	Paired T-Test	Sign Test
Variable	N	Mean	Median	Mean	Median	in Means	P-Values	P-Values
Panel A: Observations at Time T are excluded								
FX	143	0.0281	0.0000	0.0296	0.0000	0.0015	0.6015	0.5456
IR	143	0.0306	0.0000	0.0210	0.0000	-0.0096	0.0607*	0.1659
COM	143	0.0000	0.0000	0.0000	0.0000	0.0000	0.2261	0.6230
OTHER	143	0.0032	0.0000	0.0017	0.0000	-0.0015	0.0684*	0.2120
TOTAL HEDGING	143	0.0627	0.0172	0.0526	0.0119	-0.0101	0.0949*	0.0407**
Panel B: Observations at Time T are excluded								
FX	143	0.0281	0.0000	0.0292	0.0000	0.0011	0.1565	0.1191
IR	143	0.0306	0.0000	0.0206	0.0000	-0.0100	0.0628*	0.1121
COM	143	0.0000	0.0000	0.0000	0.0000	0.0000	0.2567	0.3770
OTHER	143	0.0032	0.0000	0.0004	0.0000	-0.0028	0.0188**	0.2120
TOTAL HEDGING	143	0.0627	0.0172	0.0504	0.0090	-0.0124	0.0577*	0.0608*

5.1.3 Pre- and Post-Vertical Integration Derivative Use of High and Low Vertical Integration Firms

Alternatively, I categorize firms as high and low vertical integration and examine the difference in their pre- and post-vertical integration derivative use separately. Table 5.3 presents the univariate comparison of the mean and median values of pre- and post-vertical integration derivative use of high and low vertical integration firms in Complete Hedging Data. I use the mean of the vertical relatedness coefficient, which is 9%, in the categorization of firms. According to this method, acquisitions with a vertical integration coefficient less than or equal to 9% are categorized as low vertical integration whereas acquisitions with a vertical relatedness coefficient greater than 9% are categorized as high vertical integration.

There are 53 high vertical integration firms in the sample. For those firms, the mean derivative use at pre-vertical integration is 0.069 and drops to 0.044 at post-vertical integration. The decrease in the mean is about 0.025 which is significant at 5 percent given that the p-value of the sign test is 0.0128. The medians of pre-and post-vertical integration are 0.028 and 0.013 and the decrease in median is significant at 10 percent according to the sign test.

90 of the firms in the sample are categorized as low vertical integration using the 9% cutoff. For low vertical integration firms, the decrease in neither mean nor median following vertical integration is significant. These test results confirm that the derivative use of high vertical integration firms is significantly less than that of low

vertical integration firms. One reason for this may be that the need to hedge is much less for high vertical integration firms since vertical integration at this level provides hedging mechanisms and firms substitute vertical integration for derivative hedging.

Table 5.3 Univariate Tests of Pre- and Post-Vertical Integration Derivative Use of High and Low Vertical Integration Firms

This table presents univariate comparisons of the mean and median values of pre- and post-vertical integration derivative use of high and low vertical integration firms in Complete Hedging Data. The data consists of 143 vertically integrated firms. Acquisitions with a vertical integration coefficient less than or equal to 9% are categorized as low vertical integration whereas acquisitions with vertical integration coefficient greater than 9% are categorized as high vertical integration. The Difference column shows the mean of post-vertical integration derivative use minus the mean of pre-vertical integration derivative use. The last two columns present the p-values of paired sample t-tests in which the alternative hypothesis is the mean of post-vertical integration derivative use is less than the mean of pre-vertical integration derivative use whereas the null hypothesis is the difference of the means is zero and p-values of paired sample sign tests in which the alternative hypothesis is the median of post-vertical integration derivative use is less than the median of pre-vertical integration derivative use whereas the null hypothesis is difference of medians is zero.*, **, and *** denote the significance at 10%, 5%, and 1% respectively.

		Pre-Vertical Integration		Post-Vertical Integration		Difference	Sign Test	Paired T-Test
Category	N	Mean	Median	Mean	Median	in Means	P-Values	P-Values
High Vertical Integration	53	0.0690	0.0280	0.0440	0.0131	-0.0251	0.0676*	0.0128**
Low Vertical Integration	90	0.0590	0.0094	0.0577	0.0096	-0.0013	0.1871	0.4267

5.1.4 Derivative Use of High and Low Vertical Integration Firms

In another alternative, I test the differences in mean and median of derivative uses of high and low vertical integration firms. These univariate test results are reported in Table 5.4, where the two last columns are the p-values of Wilcoxon rank sum tests and t-tests, respectively. At this time, all the firms in both Complete Hedging Data and Partial Hedging Data are used because the tests here do not require the sample to be paired. The vertical relatedness coefficient mean is 0.10 for this sample, so I categorize firms as low and high vertical integration using the 10% cutoff.

Table 5.4 Univariate Tests of Derivative Use of High and Low Vertical Integration Firms

This table presents univariate comparisons of the mean and median values of derivative use of high and low vertically integrated firms in both Complete Hedging Data and Partial Hedging Data. Acquisitions with a vertical integration coefficient less than or equal to 10% are categorized as low vertical integration whereas acquisitions with a vertical integration coefficient greater than 10% are categorized as high vertical integration. The Difference column shows the mean of derivative use of high vertical integration firms minus the mean of derivative use of low integration firm. The last two columns present the p-values from t-tests for the difference of means and the p-values from the Wilcoxon rank-sum tests for the difference of medians. Total Hedging is the total notional amount of derivatives scaled by total assets. *, **, and *** denote the significance at 10%, 5%, and 1%, respectively.

	Low Vertical Integration			High Vertical Integration			Difference	Wilcoxon	T-Test
Variable	N	Mean	Median	N	Mean	Median	In Means	P-Values	P-Values
Total Hedging	711	0.0612	0.0070	164	0.0377	0.0094	-0.0236	0.4884	0.0035***

The p-value of the t-test whose null hypothesis is the mean of derivative use of high vertical integration firms is the same as the mean of derivative use of low vertical integration firms at 0.0035. This low p-value means that I can reject the null hypothesis and conclude that the difference of derivative use between these two groups is significant at the 1 percent level. However, the p-value of the Wilcoxon rank-sum test shows that there is no significant difference in the median of derivative use between high and low vertical integration firms.

In conclusion, all the univariate test results regarding derivative use suggest that vertical integration may be a substitute for derivative hedging. However, this result should be verified by the multivariate tests where I introduce other factors that may affect a firm's hedging policy.

5.1.5 Sample Characteristics of Hedgers and Non-Hedgers

In Table 5.5, I present results from tests of differences between the means and medians of firm characteristics for hedgers and non-hedgers. A t-test is performed to reveal whether the mean of each variable is equal for hedgers and non-hedgers, and a Wilcoxon rank-sum test is performed to check the equality of medians between these two types of firms. The null and alternative hypotheses of the tests are explained in Section 3.2.1.5.

The results of both t-tests and Wilcoxon tests are quite consistent except for the variables concerning hedging substitutes, including convertible debt and preferred stock, and research and development expense which is a proxy for growth opportunity for a firm.

Firms using financial derivatives are significantly larger in size compared to non-hedgers. Large firms are more likely to be hedgers because they have sufficient resources to set up hedging strategies. This result is consistent with economies of scale in information and transaction costs.

Hedger firms have higher debt-to-asset ratios than non-hedgers. The cost of financial distress seems to be an important reason for hedging. There is no significant difference in the market-to-book ratio between hedgers and non-hedgers. This means the market does not value hedging. T-test results show that non-hedger firms are more

Table 5.5 Univariate Tests of Sample Characteristics of Hedgers and Non-Hedgers

This table shows univariate comparisons of hedgers and non-hedgers in Complete Hedging Dataand Partial Hedging Data The sample includes 726 firm-year observations for the period 1998-2013 The table also presents the p-values from t-tests for the difference in means and the p-values from Wilcoxon rank-sum tests for the difference in medians. ASSETS is the book value of total assets. LEV is long-term debt scaled by market value of equity. Non-Hedgers are firms which do not participate in any hedging activity during the fiscal year whereas Hedgers are firms which hold a nonzero derivative position at the end of the fiscal year. DA is debt-to-asset ratio, calculated as book value of total liabilities divided by book value of total assets. MB is market-to-book ratio calculated as market value of equity divided by book value of equity. R&D is research and development expenses scaled by total assets. PPE is the intensity of capital investment calculated as capital expenditures for property, plant, and equipment to firm size. INST is the percentage of a firm's total shares outstanding held by institutions. CR is the current ratio calculated as current assets divided by liabilities. DIV is the dividend payout ratio, calculated as dividends per share to common shareholders divided by earnings per share before extraordinary items. ROA is the return on assets calculated as operating income scaled by total assets. ROE is the return on equity calculated as operating income scaled by market value of equity. CONV is the book value of total convertible debt scaled by firm size. PREF is the book value of total preferred stock scaled by firm size. SIZE is the log of total assets. TOBIN is calculated as book value of total assets plus market value of common equity minus book value of common equity divided by book value of total assets.*, **, and *** denote the significance at 10%, 5%, and 1%,respectively.

	Non-Hedgers (1)			Hedgers (2)			(1) - (2)	Difference Tests	
Variable	N	Mean	Median	N	Mean	Median	Difference	t-test	Wilcoxon
ASSETS ($ mills)	276	10434	879	450	34020	11763	-23587	0.000***	0.000***
DA	276	0.212	0.164	450	0.259	0.229	-0.047	0.001***	0.000***
MB	276	3.366	2.342	450	3.425	2.711	-0.059	0.841	0.106
R&D	276	0.075	0.015	450	0.047	0.020	0.028	0.001***	0.954
PPE	276	0.362	0.184	450	0.601	0.231	-0.239	0.000***	0.000***
INST	276	0.457	0.518	450	0.473	0.647	-0.017	0.534	0.573
CR	276	3.044	2.398	450	2.110	1.611	0.934	0.000***	0.000***
DIV	276	0.097	0.000	450	0.162	0.025	-0.064	0.030**	0.000***
TAX	276	0.178	0.000	450	0.387	0.000	-0.209	0.000***	0.000***
ROA	276	0.041	0.094	450	0.132	0.131	-0.091	0.000***	0.000***
ROE	276	0.047	0.070	450	0.142	0.126	-0.095	0.000***	0.000***
CONV	276	0.039	0.000	450	0.052	0.000	-0.013	0.115	0.049**
PREF	276	0.006	0.000	450	0.002	0.000	0.004	0.044**	0.765
SIZE	276	6.935	6.779	450	9.246	9.373	-2.311	0.000***	0.000***
TOBIN	276	2.211	1.756	450	2.042	1.611	0.170	0.131	0.219
TOTAL HEDGE	276	0.000	0.000	440	0.096	0.062	-0.096	0.000***	0.000***
VR	276	0.086	0.046	450	0.109	0.070	-0.023	0.0149**	0.000***

research oriented but Wilcoxon p-values fail to support the same conclusion. The intensity of capital is significantly higher for hedgers, showing that they have more growth opportunities. The companies that have more growth opportunities available are more likely to hedge cash flows to assure the availability of funds (Pincus and Rajgopal, 2001).

Non-hedgers tend to have both more current assets relative to current liabilities and cash to meet short-term obligations. Hedger firms pay significantly higher dividends than non-hedger firms. The higher mean in tax convexity of hedgers proves the theory that the more convex the tax schedule is, the more likely firms are to engage in hedging.

According to t-test results, there is no difference in convertible debt holdings between two groups of firms, but the Wilcoxon test shows that hedgers hold more convertible debt compared to non-hedgers which is inconsistent with the theory. Since convertible debt is a substitute for financial hedging, the theory expects a positive relation between hedging and this variable. When I examine the difference of another substitute for hedging, preferred stock, the difference is significant at the 5 percent level according to t-tests and insignificant according to Wilcoxon rank sum tests. hedging firms have less preferred stock which is consistent with the theory.

Neither t-tests nor Wilcoxon tests show evidence that the two groups of firms are different with respect to the institutional ownership variable. Additionally, I do not find a significant difference in terms of Tobin's Q between hedgers and non-hedgers. Contrary to the theory, hedging does not add value to the firms in my sample.

However, hedger firms show significantly better performance in terms of returns on assets and returns on equity than users of financial derivatives.

5.1.6 Sample Characteristics of Pre- and Post- Vertical Integration

I also test the differences in firm characteristics between pre- and post-vertical firms. I use the same t-tests and Wilcoxon tests to reveal the differences. The results of these tests are presented in Table 5.6. The null and alternative hypotheses are discussed earlier in Section 3.2.1.5.

The size of firms at the post-vertical integration period is significantly larger than their size at the pre-vertical integration period. This is not a surprising result because acquiring a firm results in the growth of a firm's assets. Firms' long-term debt relative to market value of equity after vertical integration is significantly greater compared to the pre-vertical integration period. One possible reason for this difference may be the long-term debt financing used while acquiring the target firm.

The market-to-book ratio of the post-vertical integration period is significantly lower than the ratio of the pre-vertical integration period. This implies that vertical integration does decrease the value of a firm in the eyes of investors. According to the Wilcoxon test, the increase in the intensity of capital following vertical integration is significant at the 10 percent level but it is insignificant according to the t-test. The significant increase in the institutional ownership following vertical integration indicates that firms are more monitored compared to the pre-vertical integration period.

Table 5.6 Univariate Tests of Sample Characteristics of Pre- and Post-Vertical Integration Firms

This table shows univariate comparisons of firm characteristics of pre- and post-vertical integration firms in Complete Hedging Data and Partial Hedging Data The sample includes 726 firm-year observations for the period 1998-2013 The table also presents the p-values from t-tests for the difference in means and the p-values from Wilcoxon rank-sum tests for the difference in medians. ASSETS is the book value of total assets. LEV is long-term debt scaled by market value of equity. Non-Hedgers are firms which do not participate in any hedging activity during the fiscal year whereas Hedgers are firms which hold a nonzero derivative position at the end of the fiscal year. DA is debt-to-asset ratio, calculated as book value of total liabilities divided by book value of total assets. MB is market-to-book ratio calculated as market value of equity divided by book value of equity. R&D is research and development expenses scaled by total assets. PPE is the intensity of capital investment calculated as capital expenditures for property, plant, and equipment to firm size. INST is the percentage of a firm's total shares outstanding held by institutions. CR is the current ratio calculated as current assets divided by liabilities. DIV is the dividend payout ratio, calculated as dividends per share to common shareholders divided by earnings per share before extraordinary items. ROA is the return on assets calculated as operating income scaled by total assets. ROE is the return on equity calculated as operating income scaled by market value of equity. CONV is the book value of total convertible debt scaled by firm size. PREF is the book value of total preferred stock scaled by firm size. SIZE is the log of total assets. TOBIN is calculated as book value of total assets plus market value of common equity minus book value of common equity divided by book value of total assets.*, **, and *** denote the significance at 10%, 5%, and 1%,respectively.

	Pre-Vertical Integ. (1)			Post-Vertical Integ. (2)			(1) - (2)	Difference Tests	
Variable	N	Mean	Median	N	Mean	Median	Difference	t-test	Wilcoxon
ASSETS ($ mills)	321	19171	3589	426	30141	6101	-10970	0.002***	0.003***
DA	321	0.232	0.207	426	0.250	0.220	-0.018	0.189	0.122
MB	321	4.090	2.927	426	2.863	2.238	1.227	0.000***	0.000***
R&D	321	0.055	0.018	426	0.059	0.021	-0.004	0.611	0.569
PPE	321	0.464	0.197	426	0.544	0.227	-0.081	0.154	0.053*
INST	321	0.417	0.520	426	0.502	0.644	-0.085	0.001***	0.001***
CR	321	2.670	1.790	426	2.382	1.743	0.288	0.065	0.200
DIV	321	0.149	0.000	426	0.132	0.000	0.017	0.550	0.270
TAX	321	0.327	0.000	426	0.291	0.000	0.036	0.291	0.291
ROA	321	0.106	0.128	426	0.091	0.118	0.016	0.155	0.056*
ROE	321	0.096	0.095	426	0.113	0.113	-0.017	0.116	0.013**
CONV	321	0.029	0.000	426	0.059	0.000	-0.030	0.000***	0.000***
PREF	321	0.002	0.000	426	0.004	0.000	-0.002	0.369	0.040**
SIZE	321	8.057	8.186	426	8.586	8.716	-0.529	0.001***	0.003***
TOBIN	321	2.293	1.852	426	1.947	1.542	0.346	0.001***	0.000***
VR	321	0.098	0.057	426	0.103	0.058	-0.005	0.595	0.564

T-test results show that there is no significant difference in performance between pre- and post-vertical integration firms. On the other hand, Wilcoxon tests show that pre-vertical integration firms are better performers in terms of returns on assets at the 10 percent significance level, but when return on equity is used as a proxy for performance, it shows the reverse at the 5 percent significance level.

Firms at the post-vertical integration period hold more convertible debt, preferred stock and less cash compared to firms at the pre-vertical integration period. Both tests confirm the difference in convertible debt at less than the 1 percent significance level. The difference in preferred stock is only confirmed by the Wilcoxon test at the 5 percent level, and the difference in cash is significant at 10 percent only according to the t-test. The decrease in cash following vertical integration is reasonable because it may be used up during the acquisition of a new firm.

I find a significant difference in terms of Tobin's Q between pre- and post-vertical integration firms. Both of the tests show that pre-vertical integration firms have a higher firm value compared to post-vertical integration ones at less than the 1 percent significance level. The differences in other variables that are not mentioned here are not significant.

5.1.7 Sample Characteristics of High and Low Vertical Integration Firms

My final univariate tests compare the firm characteristics of high and low vertical integration that are presented in Table 5.7. High vertical integration firms on average are larger in size, and have higher leverage and debt ratios compared to low vertical integration firms. The higher market-to-book ratio indicates that the market more greatly values low vertical integration firms. High vertical integration firms are more capital oriented whereas low vertical integration firms are more research oriented.

The current ratio of low vertical integration firms is greater than that of high vertical integration firms. This implies that low vertical integration firms care more about meeting short-term debt obligations, so they hold more current assets relative to current liabilities. Wilcoxon test also shows that low vertical integration firms prefer holding more cash instead of using it for investment purposes. A higher current ratio and holding more cash may be the signs that low vertical integration firms operate inefficiently. When the performance variable of the return on equity is examined, one can clearly see that high vertical integration firms are better performers.

The difference in Tobin's Q between high and low vertical integration firms is significant according to both Wilcoxon and the t-test. High vertical integration firms have lower firm values. T-tests show that low vertical integration firms hold more derivatives relative to high vertical integration firms, confirming the validity of my Hypothesis 2. As expected, high vertical integration firms have a higher vertical relatedness coefficient. For all other variables, the differences between two groups are insignificant.

In general, the univariate test results provide supporting evidences for the hypotheses tested in this study. In the next section, I present and explain multivariate test results.

Table 5.7 Univariate Tests of Sample Characteristics of High and Low Vertical Integration Firms

This table shows univariate comparisons of firm characteristics of high and low vertical integration firms in Complete Hedging Data and Partial Hedging Data. The sample includes 726 firm-year observations for the period 1998-2013. The table also presents the p-values from t-tests for the difference in means and the p-values from Wilcoxon rank-sum tests for the difference in medians. ASSETS is the book value of total assets. LEV is long-term debt scaled by market value of equity. DA is the debt-to-asset ratio, calculated as book value of total liabilities divided by book value of total assets. MB is the market-to-book ratio calculated as market value of equity divided by book value of equity. R&D is research and development expenses scaled by total assets. PPE is the intensity of capital investment calculated as capital expenditures for property, plant, and equipment to firm size. INST is the percentage of a firm's total shares outstanding held by institutions. CR is the current ratio calculated as current assets divided by liabilities. DIV is the dividend payout ratio, calculated as dividends per share to common shareholders divided by earnings per share before extraordinary items. ROA is the return on assets calculated as operating incomes scaled by total assets. ROE is the return on equity calculated as operating income scaled by market value of equity. CONV is the book value of total convertible debt scaled by firm size. PREF is the book value of total preferred stock scaled by firm size. SIZE is the log of total assets. TOBIN is calculated as book value of total assets plus market value of common equity minus book value of common equity divided by book value of total assets.*, **, and *** denote the significance at 10%, 5%, and 1%,respectively.

	Low Vertical (1)			High Vertical (2)			(1) - (2)	Difference Tests	
Variable	N	Mean	Median	N	Mean	Median	Difference	t-test	Wilcoxon
ASSETS ($ mills)	606	20555	3765	141	46367	22285	-25812	0.000***	0.000***
DA	606	0.234	0.206	141	0.275	0.239	-0.040	0.018**	0.024**
MB	606	3.557	2.701	141	2.673	2.186	0.884	0.013**	0.001***
R&D	606	0.061	0.024	141	0.039	0.003	0.022	0.022**	0.001***
PPE	606	0.420	0.194	141	0.895	0.681	-0.475	0.000***	0.000***
INST	606	0.472	0.617	141	0.436	0.524	0.036	0.282	0.149
CR	606	2.585	1.922	141	2.165	1.356	0.420	0.033**	0.000***
DIV	606	0.145	0.000	141	0.114	0.000	0.030	0.404	0.170
TAX	606	0.314	0.000	141	0.277	0.000	0.037	0.392	0.392
ROA	606	0.097	0.120	141	0.100	0.124	-0.003	0.844	0.697
ROE	606	0.098	0.099	141	0.142	0.143	-0.044	0.001***	0.000***
CONV	606	0.038	0.000	141	0.079	0.000	-0.041	0.000***	0.001***
PREF	606	0.003	0.000	141	0.005	0.000	-0.002	0.392	0.557
SIZE	606	8.151	8.233	141	9.254	10.012	-1.104	0.000***	0.000***
TOBIN	606	2.153	1.755	141	1.853	1.407	0.299	0.028**	0.000***
TOTALHEDGING	584	0.062	0.011	132	0.043	0.010	0.019	0.028**	0.675
VR	606	0.072	0.041	141	0.222	0.158	-0.149	0.000***	0.000***

5.2 Multivariate Test Results

This section first discusses potential endogeneity issues in the sample frame and then presents the results of Heckman's selection model to test the decision to hedge and the extent of hedging. Additionally, I present the results of pooled OLS regression, firm fixed-effect regression, and firm random-effect regression of hedging's effect on firm value.

5.2.1 Potential Endogeneity Issues in Sample Frame

In this research, I collect five years of hedging data for each firm where it is possible. As explained earlier, the five years consist of the effective year of the vertical merger, the two years before and the two years after. This process permits us to observe the difference in hedging amounts between the pre- and post-vertical integration periods. However, in the multivariate analysis endogeneity may be an issue since I only collect data on hedging for firms that are vertically integrated.

One possible solution to this problem would be to collect hedging information about another sample of merging firms that are not vertically integrated, and show that derivative use by these firms does not fall during the periods when vertically integrated firms' derivative use falls. However, such a procedure would still be subject to the usual criticisms that accompany attempts to match firms on sets of characteristics (e.g., does the selection of the matching criteria itself produce endogeneity). In addition, creating such a dataset would be both labor-intensive and time-consuming; it would require identifying matched firms that engaged in derivative hedging within the same five-year intervals as the integrating firms, and hand-collecting hedging data for them from EDGAR. Instead, I use a procedure similar to other recent studies[19] related to hedging that shows that the same firm can be categorized as a hedger or a non-hedger each year based on its derivative use in each year. I treat the behavior of firms in the pre-vertical integration years the same as the behavior of non-vertically integrating firms. Essentially I assume that firms do not plan to become integrated several years in advance, and that they also alter their hedging behavior in anticipation of the future merger. Thus observations on a firm that eventually hedges during the pre-integration period are treated as if they are from non-integrating firms[20].

I also categorize my firms as low and high vertical integration firms. Low vertical integration firms are those that have low vertical relatedness coefficients, and their behaviors are almost the same as non-mergers. For these firms, the dummy variable for integration is zero during the entire five year period. On the other hand,

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[19] See Choi et al., 2013; Ertugrul et al., 2012; Pincus and Rajgopal, 2001

[20] Professor Katrina Jessoe of University of California at Davis presented her working paper entitled "Validating causal inference using high-frequency data: An energy experiment" at the 2014 American Economic Association meetings. While the author has not produced a draft available to the public as yet, Professor William Latham of the University of Delaware attended Jessoe's presentation and told me of her results (W. Latham, personal communication, 13 February, 2015). The paper presents tests using precisely the same analytical framework as mine and shows that the procedure does overcome the endogeneity problem.

high vertical integration firms have high vertical relatedness coefficients; these are the real representatives of vertically integrated firms. In this case, the dummy variable for high vertical integration is still zero for the pre-merger firm-year observations whereas it is one for the years following the merger. Under this approach, there are more observations for non-vertical acquisitions than vertical acquisitions.

5.2.2 Determinants of Decision to Hedge and Extent of Hedging

Prior research[21] shows that the determinants of the decision to hedge differ from the determinants of the extent of hedging, given that a firm hedges. For example, large firms are more likely to hedge since they can bear the expensive start-up costs of a hedging program. However, small firms may benefit more from hedging once they engage in hedging since the cost of financial distress is high for large firms (Ertugrul, Sezer, and Sirman, 2008).

In my analyses, I use Heckman's selection model which corrects for potential selection bias, and is a combination of a probit model and self-selection regression. The probit model examines the determinants that affect a firm's decision to hedge whereas self-selection regression examines the determinants that affect the extent of hedging. A two-step procedure is used in the estimation of coefficients. The methodology of this section is explained in detail in Section 3.2.2.1.

[21] See Haushalter (2000), Barton (2001), Pincus and Rajgopal (2001).

5.2.2.1 Heckman's Selection Model with Vertical Integration Dummies Decision to Hedge—First Model Specification

Table 5.8 presents the probit regression which is estimated at the first stage of Heckman’s selection model using the observations in Complete Hedging Dataset. In this regression, the dependent variable is the *HEDGER* which takes a value of one if a firm participated in hedging activity and, zero otherwise.

All three vertical integration dummy variables are statistically significant suggesting that becoming vertically integrated negatively affects a firm’s decision to hedge. Treating the year of vertical integration differently or assigning missing vertical integration dummies to this year do not have much impact on the conclusion. In addition to univariate tests, the negative relationship between the likelihood of hedging and vertical integration confirms the validity of Hypothesis 1, which states that vertical integration is a substitute for derivative hedging. This result is consistent with the results of the frequency of participation in hedging which is presented in Table 4.8.

Table 5.8 First Step of Heckman's Selection Model: Participation in Hedging Activity – First Model Specification

This table presents the estimates of the first step of Heckman's selectivity model, the probit regression results using Complete Hedging Data. The dependent variable is HEDGER which takes a value of one if a firm participates in hedging and zero otherwise. VI is a dummy variable that takes a value of one if the observation is at time T+1 and T+2, and zero otherwise. VI1 is a dummy variable that takes a value of one if the observation is at time T, T+1 and T+2, and zero otherwise. VI2 is a dummy variable that takes a value of one if the observation is at time T+1 and T+2, missing if it is at time T, and zero if it is at time T-1 and T-2. T-2 stands for the time 2 years before vertical integration, T-1 stands for the time 1 year before vertical integration, T stands for the time of vertical integration, T+1 stands for 1 year after vertical integration and T+2 stands for two years after vertical integration. The numbers are coefficients and p-values (in parentheses). ASSETS is the book value of total assets. DA is the debt-to-asset ratio, calculated as book value of total liabilities divided by book value of total assets. MB is the market-to-book ratio calculated as market value of equity divided by book value of equity. R&D is research and development expenses scaled by total assets. PPE is the intensity of capital investment calculated as capital expenditures for property, plant, and equipment to firm size. INST is the percentage of a firm's total shares outstanding held by institutions. CR is the current ratio calculated as current assets divided by liabilities. DIV is the dividend payout ratio, calculated as dividends per share to common shareholders divided by earnings per share before extraordinary items. CONV is the book value of total convertible debt scaled by firm size. PREF is the book value of total preferred stock scaled by firm size. SIZE is the log of total assets. *, **, and *** denote the significance at 10%, 5%, and 1% respectively.

	Equation (1)	**Equation (2)**	**Equation (3)**	**Equation (4)**
VI	-0.342*			
	(0.057)			
VI1		-0.444**		
		(0.016)		
VI2			-0.514**	
			(0.018)	
VR				-0.055
				(0.953)
DA	0.920*	0.870*	0.54	0.911*
	(0.068)	(0.086)	(0.326)	(0.071)
MB	0.034*	0.031*	0.031*	0.036**
	(0.056)	(0.080)	(0.096)	(0.038)
RD	2.204**	2.356**	2.369**	2.154**
	(0.013)	(0.009)	(0.024)	(0.015)
PPE	0.233	0.207	0.215	0.213
	(0.109)	(0.150)	(0.178)	(0.141)
INST	-1.387***	-1.358***	-1.332***	-1.403***
	(0.000)	(0.000)	(0.000)	(0.000)

Table 5.8 Continued

	Equation (1)	Equation (2)	Equation (3)	Equation (4)
CR	0.067	0.061	0.064	0.069
	(0.194)	(0.245)	(0.275)	(0.186)
DIV	-0.29	-0.299	-0.33	-0.295
	(0.176)	(0.163)	(0.166)	(0.173)
TAX	0.691***	0.717***	0.806***	0.701***
	(0.000)	(0.000)	(0.000)	(0.000)
CONV	1.670*	1.824**	1.914*	1.486
	(0.063)	(0.046)	(0.059)	(0.101)
PREF	-2.239	-2.088	-2.941	-1.844
	(0.707)	(0.720)	(0.708)	(0.726)
SIZE	0.587***	0.596***	0.596***	0.582***
	(0.000)	(0.000)	(0.000)	(0.000)
Intercept	*yes*	*yes*	*yes*	*yes*
Industry & Year Dummies	*yes*	*yes*	*yes*	*yes*
No. of Obs.	*603*	*603*	*483*	*603*
Pseudo R2 (From Probit)	*0.3428*	*0.3465*	*0.3569*	*0.3382*

Although vertical integration dummies have a significant impact on the decision to hedge, I am not able to find any significant relation between hedging and the vertical relatedness coefficient since the p-value is 0.953. As defined earlier, the vertical relatedness coefficient measures the opportunity for vertical integration between two industries. A higher vertical integration coefficient means more use of the input of an industry in the production of an output of another industry. So having a higher vertical relatedness coefficient does not influence the likelihood of a firm's participation in hedging activity.

The debt ratio, which is a proxy for financial leverage, is statistically significant at the 10 percent level except for in Equation (3). This result supports the financial distress costs hypothesis that states that the higher a firm's debt ratio, the greater the probability of financial distress, so a firm is more likely to hedge to prevent the cost of financial distress. Additionally, these findings accord with the expectation stated in Hypothesis 3.

Market-to-book ratio, which is one of the proxies for growth opportunities, is positive and significant at the 10 percent level in Equation (1) and (2) and at the 5 percent level in Equation (4). Another proxy for growth opportunities, research and development expense, is also positively significant but at the 5 percent level in all four model specifications. However, the intensity of capital investment, which is another proxy for growth opportunities, is insignificant in all four equations. In general, the positive significant coefficients of two proxies of growth opportunities suggest that firms are more likely to engage in hedging if they have more growth opportunities. This result supports my expectation stated in Hypothesis 4.

It is surprising that neither the current ratio nor the dividend payout ratio is significant in the probit model. This result is contrary to the results of univariate analysis and theory predictions. Univariate results show that non-hedgers have a higher current ratio and lower dividend payout ratio. However, the probit analysis fails to provide any evidence in support of Hypothesis 5, which expects a negative relationship between current ratio and hedging and a positive relationship between dividend payout ratio and hedging since the higher a firm's dividend ratio, the higher its need to hedge to reduce the financial distress and agency costs of debt.

Univariate analysis revealed that hedgers have more tax-loss carryforwards because it is a proxy for tax function convexity and firms that have a more convex tax schedule benefit from more reduction in expected taxes. Probit regression results also show strong evidence that the indicator variable of tax-loss carryforwards positively affect the decision to hedge. This finding is consistent with Hypothesis 6 that predicts firms with more tax-preferred items are more likely to engage in derivative hedging. Furthermore, it supports the idea that firms hedge to make their effective tax schedule convex in order to benefit from greater reductions in expected taxes.

The coefficient of institutional ownership is negative and significant suggesting that the likelihood of hedging increases with institutional ownership. This result supports the argument that managers have more incentive to hedge cash flow volatility to facilitate the market's assessment of their skill if the firm has less external monitoring. However, it contradicts the theory that asserts institutional ownership affects hedging positively because external monitoring likely increases pressure on managers to dampen volatility. It seems that hedging is not beneficial to institutional investors.

Univariate tests show that the difference in size between hedgers and non-hedgers is significant with a p-value of 0.000. According to probit regression results, the null hypothesis that firm size does not influence the decision to hedge is also rejected at the 0.000 percent level. Therefore, this result provides strong evidence to support Hypothesis 8 that there is a positive relationship between firm size and the probability of using financial derivatives. While this finding is contrary to the theoretic explanation that small firms are more likely to engage in hedging activities because costs of financial distress are less than proportional to firm size, it strongly supports the economies of scale argument related to establishing hedging programs. The positive relation between size and the decision to hedge is also found by other studies such as Mian (1996), Geczy et al. (1997), Horng and Wei (1999), and Ertugrul, Sezer, and Sirmans (2008).

As for hedging substitutes, surprisingly the results show that there is a positive relation between convertible debt and the decision to hedge, contradicting the argument that convertible debt can be used as a substitute for hedging. However, this finding is consistent with the result of univariate tests. In addition, the relation between preferred stock, which is assumed to be another substitute for hedging, and the probability of hedging is insignificant. Therefore, the results of probit regressions fail to provide supporting evidence of Hypothesis 9 in which a negative relationship between hedging substitutes and derivative hedging is expected.

Extent of Hedging—First Model Specification

The decision on the extent of hedging is another important risk management policy. Therefore, in addition to the factors of the decision to hedge, I investigate the potential factors that can affect the extent of hedging. Table 5.9 presents the results obtained from the self-selection regression which are estimated at the second stage of Heckman's selection model. In this regression, the dependent variable is the *TOTALHEDGE* that is the total notional amount of derivatives scaled by total assets. The differences between the results of the probit model and the self-selection regression are in accordance with the argument that the determinants of the hedging decision may be different from the determinants of the extent of hedging.

None of the coefficient estimates of vertical integration dummies are significant in the second stage of Heckman's selection model. The probit regression results showed that firms are less likely to hedge after becoming vertically integrated. However, the results here show that the extent of hedging is not influenced by vertical integration.

The coefficient estimates of debt ratio and market-to-book ratio remain positive but become more significant in all four model specifications. In the probit regression, research and development expense is significant but in the selection model

Table 5.9 Second Step of Heckman's Selection Model: Extent of Hedging—First Model Specification

This table presents the estimates of the second step of Heckman's selectivity model, the self-selection regression results using Complete Hedging Data and Partial Hedging Data. The dependent variable is TOTALHEDGE that is the total notional amount of derivatives scaled by total assets. The numbers are coefficients and p-values (in parentheses). HIGHVERTICAL8 is a dummy variable that takes a value of one if the vertical relatedness coefficient of acquisition exceeds 8%, and zero otherwise. HIGHVERTICAL9 is a dummy variable that takes a value of one if the vertical relatedness coefficient of acquisition exceeds 9%, and zero otherwise. HIGHVERTICAL10 is a dummy variable that takes a value of one if the vertical relatedness coefficient of acquisition exceeds 10%, and zero otherwise. HIGHVERTICAL15 is a dummy variable that takes a value of one if the vertical relatedness coefficient of acquisition exceeds 15%, and zero otherwise. ASSETS is the book value of total assets. DA is the debt-to-asset ratio, calculated as book value of total liabilities divided by book value of total assets. MB is the market-to-book ratio calculated as market value of equity divided by book value of equity. R&D is research and development expenses scaled by total assets. PPE is the intensity of capital investment calculated as capital expenditures for property, plant, and equipment to firm size. INST is the percentage of a firm's total shares outstanding held by institutions. CR is the the current ratio calculated as current assets divided by liabilities. DIV is the dividend payout ratio, calculated as dividends per share to common shareholders divided by earnings per share before extraordinary items. CONV is the book value of total convertible debt scaled by firm size. PREF is the book value of total preferred stock scaled by firm size. SIZE is the log of total assets. *, **, and *** denote the significance at 10%, 5%, and 1% , respectively.

	Equation (1)	Equation (2)	Equation (3)	Equation (4)
VI	-0.005			
	(0.644)			
VI1		-0.008		
		(0.461)		
VI2			-0.003	
			(0.818)	
VR				-0.092*
				(0.063)
DA	0.200***	0.201***	0.176***	0.191***
	0.000	0.000	0.000	0.000
MB	0.004**	0.004**	0.005**	0.004**
	(0.003)	(0.005)	(0.002)	(0.004)
RD	0.02	0.03	(0.01)	0.02
	(0.717)	(0.664)	(0.827)	(0.742)
PPE	-0.022**	-0.022**	-0.019**	-0.018**
	(0.002)	(0.001)	(0.009)	(0.013)
INST	0.027*	0.028*	0.019	0.029**
	(0.062)	(0.054)	(0.267)	(0.042)

Table 5.9 Continued

	Equation (1)	Equation (2)	Equation (3)	Equation (4)
CR	0.002	0.001	0.003	0.001
	(0.631)	(0.697)	(0.451)	(0.679)
DIV	0.015	0.015	0.019	0.016
	(0.140)	(0.144)	(0.117)	(0.119)
TAX	-0.033**	-0.033**	-0.033**	-0.034***
	(0.001)	(0.001)	(0.004)	(0.001)
CONV	-0.240***	-0.237***	-0.244***	-0.228***
	0.000	0.000	0.000	0.000
PREF	-0.139	-0.111	0.622	-0.054
	(0.895)	(0.915)	(0.670)	(0.958)
Mills Lambda	-0.037**	-0.038**	-0.038**	-0.039**
	(0.002)	(0.001)	(0.005)	(0.001)
Intercept	*yes*	*yes*	*yes*	*yes*
Year Dummies	*yes*	*yes*	*yes*	*yes*
No. of Obs.	*603*	*603*	*483*	*603*

this proxy for growth opportunities becomes insignificant. On the other hand, intensity of capital becomes negative and significant at the 5 percent level, suggesting that the more capital investment a firm does, the less derivative hedging it uses. The intensity of capital is also a proxy for growth opportunities. The theory predicts a positive relationship between hedging and this variable but the current finding contracts the expectations.

Contrary to the probit results, selection model results provide evidence that higher institutional ownership leads to a higher level of hedging. In regards to liquidity level, neither the current ratio nor the dividend payout ratio affects the level of hedging. The positive coefficient of tax convexity proxy in probit regression becomes negative contradicting my expectations. This does not support the idea that the firms with convex effective tax schedules hedge more in order to benefit from greater reduction in expected taxes.

The sign of convertible debt, which is one of the hedging substitutes, is negative and significant at the 0.000 percent level as the theory predicts. The coefficients of preferred stock stay insignificant as they are in the probit regression.

The significant Inverse Mills ratio shows the extent to which conditional hedging is shifted up (or down) due to the selection or truncation effect. The ratios in my regressions can be interpreted as a firm with sample average characteristics that selects hedging using fewer derivatives than a firm drawn at random from the population with the average set of characteristics. Thus, there is a negative selection or truncation effect in my data.

In summary, the results of the Heckman's two-step model confirm my main hypothesis that vertical integration is a substitute for derivative hedging. It also provides evidence consistent with extant theories of financial distress, underinvestment costs, corporate taxes and other hedging substitutes.

5.2.2.2 Heckman's Selection Model with High Vertical Integration Dummies

In this model specification, I introduce high vertical integration dummies (*VERTICAL8, VERTICAL9 VERTICAL10, VERTICAL15*) instead of vertical integration dummies (*VI, VI1 VI2*) to see how the decision to hedge and the extent of hedging are affected if a firm is categorized as a high vertical integration firm. The results of this second model specification are presented in Tables 5.10 and 5.11. Table 5.10 shows the estimates from the probit regressions while the estimates of self-selection regression are presented in Table 5.11.

The probit test results show that high vertical integration has no effect on a firm's participation decision in hedging regardless of the cutoff used to define high vertical integration. However, in the self-selection regression *VERTICAL8* and *VERTICAL10* become significant at the 10 and 5 percent levels, respectively, whereas other dummy variables for high vertical integration are not significant. The p-value of *VERTICAL8*, which represents the high vertical integration firms using the 8% cutoff, is 0.081. This barely supports the idea that high vertical integration leads to less derivative hedging. The cutoff point is important while categorizing the firms as high

Table 5.10 First Step of Heckman's Selectivity Model: Participation in Hedging Activity—Second Model Specification

This table presents the estimates of the first step of Heckman's selectivity model, the probit regression results using Complete Hedging Data and Partial Hedging Data. The dependent variable is HEDGER which takes a value of one if a firm participates in hedging and zero otherwise. The numbers are coefficients and p-values (in parentheses). HIGHVERTICAL8 is a dummy variable that takes a value of one if the vertical relatedness coefficient of acquisition exceeds 8%, and zero otherwise. HIGHVERTICAL9 is a dummy variable that takes a value of one if the vertical relatedness coefficient of acquisition exceeds 9%, and zero otherwise. HIGHVERTICAL10 is a dummy variable that takes a value of one if the vertical relatedness coefficient of acquisition exceeds 10%, and zero otherwise. HIGHVERTICAL15 is a dummy variable that takes a value of one if the vertical relatedness coefficient of acquisition exceeds 15%, and zero otherwise. ASSETS is the book value of total assets. DA is the debt-to-asset ratio, calculated as book value of total liabilities divided by book value of total assets. MB is the market-to-book ratio calculated as market value of equity divided by book value of equity. R&D is research and development expenses scaled by total assets. PPE is the intensity of capital investment calculated as capital expenditures for property, plant, and equipment to firm size. INST is the percentage of a firm's total shares outstanding held by institutions. CR is the current ratio calculated as current assets divided by liabilities. DIV is the dividend payout ratio, calculated as dividends per share to common shareholders divided by earnings per share before extraordinary items. CONV is the book value of total convertible debt scaled by firm size. PREF is the book value of total preferred stock scaled by firm size. SIZE is the log of total assets. *, **, and *** denote the significance at 10%, 5%, and 1% , respectively.

	Equation (2)	Equation (3)	Equation (4)	Equation (5)
HIGHVERTICAL8	0.067			
	(0.750)			
HIGHVERTICAL9		0.115		
		(0.598)		
HIGHVERTICAL10			0.303	
			(0.205)	
HIGHVERTICAL15				0.283
				(0.295)
DA	1.144**	1.153**	1.108**	1.173**
	(0.038)	(0.036)	(0.045)	(0.033)
MB	0.034*	0.034*	0.035*	0.034*
	(0.074)	(0.073)	(0.065)	(0.070)
RD	1.934*	1.947**	1.865*	1.834*
	(0.050)	(0.049)	(0.060)	(0.065)
PPE	0.338**	0.338**	0.340**	0.331**
	(0.026)	(0.026)	(0.025)	(0.029)
INST	-1.056**	-1.071**	-1.094***	-1.091***
	(0.001)	(0.001)	(0.001)	(0.001)

Table 5.10 Continued

	Equation (2)	Equation (3)	Equation (4)	Equation (5)
CR	0.025	0.024	0.022	0.029
	(0.606)	(0.617)	(0.641)	(0.541)
DIV	-0.107	-0.105	-0.104	-0.089
	(0.617)	(0.623)	(0.628)	(0.680)
TAX	0.771***	0.769***	0.767***	0.766***
	(0.000)	(0.000)	(0.000)	(0.000)
CONV	0.11	0.095	0.064	-0.021
	(0.893)	(0.908)	(0.938)	(0.980)
PREF	-6.056	-5.937	-5.693	-5.444
	(0.433)	(0.438)	(0.455)	(0.461)
SIZE	0.524***	0.526***	0.531***	0.528***
	(0.000)	(0.000)	(0.000)	(0.000)
Intercept	*yes*	*yes*	*yes*	*yes*
Industry & Year Dummies	*yes*	*yes*	*yes*	*yes*
No. of Obs.	*521*	*521*	*521*	*521*
Pseudo R2	*0.4023*	*0.4026*	*0.4046*	*0.4041*

Table 5.11 Second Step of Heckman's Selectivity Model: Extent of Hedging—Second Model Specification

This table presents the estimates of the second step of Heckman's selectivity model, the self-selection regression results using Complete Hedging Data and Partial Hedging Data. The dependent variable is TOTALHEDGE that is the total notional amount of derivatives scaled by total assets. The numbers are coefficients and p-values (in parentheses). HIGHVERTICAL8 is a dummy variable that takes a value of one if the vertical relatedness coefficient of acquisition exceeds 8%, and zero otherwise. HIGHVERTICAL9 is a dummy variable that takes a value of one if the vertical relatedness coefficient of acquisition exceeds 9%, and zero otherwise. HIGHVERTICAL10 is a dummy variable that takes a value of one if the vertical relatedness coefficient of acquisition exceeds 10%, and zero otherwise. HIGHVERTICAL15 is a dummy variable that takes a value of one if the vertical relatedness coefficient of acquisition exceeds 15%, and zero otherwise. ASSETS is the book value of total assets. DA is the debt-to-asset ratio, calculated as book value of total liabilities divided by book value of total assets. MB is the market-to-book ratio calculated as market value of equity divided by book value of equity. R&D is research and development expenses scaled by total assets. PPE is the intensity of capital investment calculated as capital expenditures for property, plant, and equipment to firm size. INST is the percentage of a firm's total shares outstanding held by institutions. CR is the the current ratio calculated as current assets divided by liabilities. DIV is the dividend payout ratio, calculated as dividends per share to common shareholders divided by earnings per share before extraordinary items. CONV is the book value of total convertible debt scaled by firm size. PREF is the book value of total preferred stock scaled by firm size. SIZE is the log of total assets. *, **, and *** denote the significance at 10%, 5%, and 1% , respectively.

	Equation (1)	**Equation (2)**	**Equation (3)**	**Equation (4)**
HIGHVERTICAL8	-0.017*			
	(0.081)			
HIGHVERTICAL9		-0.017		
		(0.103)		
HIGHVERTICAL10			-0.027**	
			(0.014)	
HIGHVERTICAL15				0.001
				(0.940)
DA	0.208***	0.208***	0.206***	0.215***
	(0.000)	(0.000)	(0.000)	(0.000)
MB	0.004**	0.004**	0.004**	0.004**
	(0.003)	(0.003)	(0.003)	(0.004)
RD	0.07	0.07	0.07	0.07
	(0.188)	(0.192)	(0.188)	(0.214)
PPE	-0.019**	-0.019**	-0.018**	-0.021***
	(0.001)	(0.002)	(0.004)	(0.001)
INST	0.025*	0.025*	0.025*	0.023*
	(0.068)	(0.067)	(0.063)	(0.092)

Table 5.11 Continued

	Equation (1)	Equation (2)	Equation (3)	Equation (4)
CR	0.001	0.002	0.002	0.002
	(0.630)	(0.617)	(0.614)	(0.522)
DIV	0.015	0.015	0.015	0.017*
	(0.130)	(0.130)	(0.143)	(0.089)
TAX	-0.031***	-0.031***	-0.031***	-0.032***
	(0.000)	(0.000)	(0.001)	(0.000)
CONV	-0.213***	-0.216***	-0.208***	-0.235***
	(0.000)	(0.000)	(0.000)	(0.000)
PREF	0.637**	0.635**	0.660**	0.607**
	(0.009)	(0.009)	(0.006)	(0.013)
Mills Lambda	-0.051***	-0.051***	-0.051***	-0.053***
	(0.000)	(0.000)	(0.000)	(0.000)
Intercept	*yes*	*yes*	*yes*	*yes*
Year Dummies	*yes*	*yes*	*yes*	*yes*
No. of Obs.	*716*	*716*	*716*	*716*

and low. As reported earlier, the mean of the vertical relatedness coefficient in Complete and Partial Hedging Data is 0.10 so the significant coefficient estimate of the dummy variable that categorizes firms as high vertical integration using the 10 percent cutoff is not surprising. This is consistent with the univariate test results reported in Table 5.4. This finding also supports Hypothesis 2 that asserts high vertical integration firms use less derivative hedging compared to low vertical integration firms. This may be explained by the idea that high vertical integration provides a better operational hedge for the firms. As a result, they reduce the amount of financial hedging.

All the variables except convertible debt stay significant as they are at the first step of the first model specification. Therefore, the outcomes of probit regressions the second model specification still support the financial distress cost, underinvestment, tax and economies of scale hypotheses. The signs and the significances of the coefficients, except preferred stock in the selection model, are also the same as the selection regression of the first model specification. Contrary to expectation but consistent with univariate test results, the coefficients of preferred stock are positive and significant at the 5 percent level. In addition, inverse Mills' ratios stay significant, indicating that there is selectivity in the decision to hedge in all four equations.

5.2.2.3 Heckman's Selection Model with High Vertical Integration Dummies using Post-Vertical Integration Data

The pre-vertical integration years are categorized as low vertical integration firm-years according to the second model specification. I want to confirm the significance of the high vertical integration dummy at the 10% cutoff with only post-vertical integration data for a robustness check. Since this dataset only includes observations after becoming vertically integrated, running the model with this data is more appropriate. In Table 5.12 the estimates from the probit regressions with post-vertical integration data are presented, and the estimates of self-selection regressions with post-vertical integration data are shown in Table 5.13.

None of the high vertical integration dummies in the probit model are significant when the model is estimated using both pre- and post-vertical integration observations. However, the coefficient of *VERTICAL10* becomes significant and positive as shown in Table 5.12 when the pre-vertical integration observations are excluded from the analysis. This result suggests that high vertical integration firms are more likely to participate in hedging. The second step of Heckman's selection shows that VERTICAL10 is still negative and significant at the 5 percent level with a p-value of 0.013, but the significance of VERTICAL8 disappears. This result once again proves that 10 percent is a good cutoff for distinguishing high vertical integration firms from low. Further, it supports the idea that high vertical integration firms at this cutoff use less derivative hedging compared to low vertical integration firms.

Table 5.12 First Step of Heckman's Selectivity Model: Participation in Hedging Activity—Second Model Specification with Post-Vertical Integration Data

This table presents the estimates of the first step of Heckman's selectivity model, the probit regression results using post-vertical integration observations in Complete Hedging Data and Partial Hedging Data. The dependent variable is HEDGER which takes a value of one if a firm participates in hedging and zero otherwise. The numbers are coefficients and p-values (in parentheses). HIGHVERTICAL8 is a dummy variable that takes a value of one if the vertical relatedness coefficient of acquisition exceeds 8%, and zero otherwise. HIGHVERTICAL9 is a dummy variable that takes a value of one if the vertical relatedness coefficient of acquisition exceeds 9%, and zero otherwise. HIGHVERTICAL10 is a dummy variable that takes a value of one if the vertical relatedness coefficient of acquisition exceeds 10%, and zero otherwise. HIGHVERTICAL15 is a dummy variable that takes a value of one if the vertical relatedness coefficient of acquisition exceeds 15%, and zero otherwise. ASSETS is the book value of total assets. DA is the debt-to-asset ratio, calculated as book value of total liabilities divided by book value of total assets. MB is the market-to-book ratio calculated as market value of equity divided by book value of equity. R&D is research and development expenses scaled by total assets. PPE is the intensity of capital investment calculated as capital expenditures for property, plant, and equipment to firm size. INST is the percentage of a firm's total shares outstanding held by institutions. CR is the current ratio calculated as current assets divided by liabilities. DIV is the dividend payout ratio, calculated as dividends per share to common shareholders divided by earnings per share before extraordinary items. CONV is the book value of total convertible debt scaled by firm size. PREF is the book value of total preferred stock scaled by firm size. SIZE is the log of total assets. *, **, and *** denote the significance at 10%, 5%, and 1% , respectively.

	Equation (1)	Equation (2)	Equation (3)	Equation (4)
HIGHVERTICAL8	0.171			
	(0.576)			
HIGHVERTICAL9		0.236		
		(0.464)		
HIGHVERTICAL10			0.825**	
			(0.026)	
HIGHVERTICAL15				0.598
				(0.113)
DA	0.8	0.852	0.739	0.909
	(0.333)	(0.303)	(0.377)	(0.275)
MB	0.050	0.052	0.058	0.052
	(0.168)	(0.157)	(0.115)	(0.151)
RD	2.476*	2.543*	2.534*	2.195
	(0.071)	(0.066)	(0.072)	(0.114)
PPE	0.327*	0.325	0.347*	0.314
	(0.099)	(0.100)	(0.080)	(0.113)
INST	-1.500**	-1.531**	-1.643**	-1.602**
	(0.003)	(0.003)	(0.001)	(0.002)

Table 5.12 Continued

	Equation (1)	Equation (2)	Equation (3)	Equation (4)
CR	0.058	0.055	0.038	0.071
	(0.384)	(0.407)	(0.575)	(0.282)
DIV	-0.413	-0.41	-0.398	-0.374
	(0.166)	(0.169)	(0.195)	(0.218)
TAX	0.993**	0.980**	0.966**	0.970**
	(0.002)	(0.002)	(0.002)	(0.002)
CONV	0.936	0.917	0.86	0.554
	(0.456)	(0.467)	(0.512)	(0.671)
PREF	-5.147	-5.135	-5.142	-4.555
	(0.514)	(0.514)	(0.554)	(0.559)
SIZE	0.549***	0.554***	0.588***	0.562***
	0.000	0.000	0.000	0.000
Intercept	*yes*	*yes*	*yes*	*yes*
Industry & Year Dummies	*yes*	*yes*	*yes*	*yes*
No. of Obs.	*248*	*248*	*248*	*248*
Pseudo R2	*0.3731*	*0.374*	*0.3882*	*0.3813*

Table 5.13 Second Step of Heckman's Selectivity Model: Extent of Hedging—Second Model Specification with Post-Vertical Integration Data

This table presents the estimates of the second step of Heckman's selectivity model, the self-selection regression results using post-vertical integration observations in Complete Hedging Data and Partial Hedging Data. The dependent variable is TOTALHEDGE that is the total notional amount of derivatives scaled by total assets. The numbers are coefficients and p-values (in parentheses). HIGHVERTICAL8 is a dummy variable that takes a value of one if the vertical relatedness coefficient of acquisition exceeds 8%, and zero otherwise. HIGHVERTICAL9 is a dummy variable that takes a value of one if the vertical relatedness coefficient of acquisition exceeds 9%, and zero otherwise. HIGHVERTICAL10 is a dummy variable that takes a value of one if the vertical relatedness coefficient of acquisition exceeds 10%, and zero otherwise. HIGHVERTICAL15 is a dummy variable that takes a value of one if the vertical relatedness coefficient of acquisition exceeds 15%, and zero otherwise. ASSETS is the book value of total assets. DA is the debt-to-asset ratio, calculated as book value of total liabilities divided by book value of total assets. MB is the market-to-book ratio calculated as market value of equity divided by book value of equity. R&D is research and development expenses scaled by total assets. PPE is the intensity of capital investment calculated as capital expenditures for property, plant, and equipment to firm size. INST is the percentage of a firm's total shares outstanding held by institutions. CR is the the current ratio calculated as current assets divided by liabilities. DIV is the dividend payout ratio, calculated as dividends per share to common shareholders divided by earnings per share before extraordinary items. CONV is the book value of total convertible debt scaled by firm size. PREF is the book value of total preferred stock scaled by firm size. SIZE is the log of total assets. *, **, and *** denote the significance at 10%, 5%, and 1% , respectively.

	Equation (1)	Equation (2)	Equation (3)	Equation (4)
HIGHVERTICAL8	-0.017			
	(0.104)			
HIGHVERTICAL9		-0.016		
		(0.129)		
HIGHVERTICAL10			-0.028**	
			(0.013)	
HIGHVERTICAL15				0.005
				(0.717)
DA	0.221***	0.220***	0.216***	0.235***
	0.000	0.000	0.000	0.000
MB	0.004*	0.004*	0.004*	0.00
	(0.083)	(0.089)	(0.087)	(0.145)
RD	0.11	0.11	0.10	0.12
	(0.133)	(0.132)	(0.164)	(0.121)
PPE	-0.017**	-0.017**	-0.014*	-0.021**
	(0.016)	(0.019)	(0.058)	(0.006)
INST	0.026	0.027	0.026	0.025
	(0.159)	(0.145)	(0.154)	(0.185)

Table 5.13 Continued

	Equation (1)	Equation (2)	Equation (3)	Equation (4)
CR	-0.002	-0.002	-0.001	-0.001
	(0.701)	(0.697)	(0.731)	(0.738)
DIV	0.019*	0.019*	0.019	0.021*
	(0.095)	(0.097)	(0.103)	(0.074)
TAX	0.763	-0.037**	-0.036**	-0.038**
	(0.001)	(0.001)	(0.002)	(0.001)
CONV	-0.144**	-0.146**	-0.139**	-0.166**
	(0.007)	(0.006)	(0.008)	(0.002)
PREF	0.652**	0.650**	0.674**	0.620**
	(0.004)	(0.004)	(0.002)	(0.006)
Mills Lambda	-0.041**	-0.041**	-0.039**	-0.046***
	(0.004)	(0.003)	(0.006)	(0.001)
Intercept	*yes*	*yes*	*yes*	*yes*
Year Dummies	*yes*	*yes*	*yes*	*yes*
No. of Obs.	*407*	*407*	*407*	*407*

All other variables except debt ratio and market-to-book ratio stay significant at the expected direction in the probit model. Because of the insignificant debt ratio, financial cost theory is not supported by the post-vertical integration data. The most apparent difference between this and the previous selection regression result is the insignificant institutional ownership variable.

In summary, overall the results of Heckman's two-step model are consistent with my hypotheses in this research. The decision to hedge is significantly affected by vertical integration confirming the notion that vertical integration may be a substitute for derivative hedging while managing firm risk. The less frequent use of derivatives of high vertical firms relative to low vertical firms supports this hypothesis in a different way. Other extant theories of hedging (i.e., financial distress cost, underinvestment cost, economies of scale and corporate tax theories) are also proved to be true with the data in this research.

5.2.3 Comparisons with Previous Studies

In general, both univariate and multivariate test results are consistent with the theories related to hedging motivations and provide additional evidence to support current literature. I find that vertical integration is a substitute for derivative hedging in mitigating corporate risk, confirming the theory stated by Hirshleifer (1988). My findings are also in line with Klein et al. (1978), Williamson (1979), and Carlton (1979) that suggest vertical integration is a risk management tool. Aid et al. (2011) is the only study that shows both theoretically and numerically the substitutability of vertical integration and forward hedging. However, it does not show this empirically. Also, it only covers the French electric industry. My research adds to this paper, providing broader evidence for substitutability of vertical integration and derivative hedging using a sample containing different industries.

My results are consistent with the studies that test financial distress cost theory using debt ratio as a proxy. Such literature includes Nance et al. (1993), Dolde (1995), Berkman and Bradbury (1996), Gay and Nam (1998), Horng and Wei (1999), Haushalter (2000), Graham and Rogers (2002), Ertugrul et al. (2008).

Nance et al. (1993), Mian (1996), Allayannnis and Ofek (2001), Graham and Rogers (2002) use market-to-book ratio, a widely used proxy for underinvestment cost, and find no relation between hedging and this proxy. However, my analyses show a positive relation between market-to-book ratio and hedging confirming the theory and consistent with other research such as Gay and Nam (1998), Knopf et al. (2002) and Singh and Upneja (2008). Another proxy for growth opportunities, research and development expense, is also in line with studies that find the expected positive sign such as Dolde (1995), Geczy et al. (1996), and Allayannis and Ofek (2001).

The results of this study show strong evidence that tax-loss carryforwards positively affects the decision to hedge. This finding is consistent with the theory as well as the findings in Berkman and Bradbury (1996). Other studies that find no relation between this proxy and hedging include Nance et al. (1993), Tufano (1996), Fok et al. (1997), and Graham and Rogers (2002).

Chapter 6

CONCLUSIONS AND FUTURE WORK

The main aim of this study is to find out whether vertical integration is used as a substitute for derivative hedging in mitigating the firm's risk. I also critically examine the key determinants of the decision to hedge and the extent of hedging using Heckman's selection model.

In this study, I develop nine hypotheses: (1) Vertical integration is a substitute for derivative hedging; (2) High vertical integration firms use less derivative hedging compared to low vertical integration firms; (3)There is a positive relationship between leverage and derivative hedging; (4) There is a positive relationship between growth opportunities and derivative hedging; (5) There is a negative relationship between the liquidity level of a firm and derivative hedging; (6) There is a positive relationship between income taxes and derivative hedging; (7) There is a negative relationship between the proportion of institutional shareholdings and derivative hedging; (8) There is a positive relationship between firm size and derivative hedging; (9) There is a negative relationship between hedging substitutes and derivative hedging.

My sample consists of 198 vertically integrated firms reported in Thomson Financial's SDC Platinum Mergers and Acquisitions database from 1998 to 2013. The firms in my sample operate in 28 distinct industry sectors, which makes my sample very diverse compared to other current research (e.i., Hankins, 2009; Aid et al., 2011). The data on hedging practices are gathered from the 10-K report of each company for 256 vertical takeovers using the EDGAR system and firm characteristics variables are from the COMPUSTAT database.

The results of the univariate tests show that there is a significant decrease in firms' derivative use following a vertical integration. The difference in derivative use between high and low vertical integration firms is also highly significant. When the pre- and post-vertical integration derivative use of high and low vertical integration firms is separately examined, I find that there is a significant decrease in the mean of derivative use of high vertical integration firms following vertical integration. However, low vertical integration firms do not reduce the derivative use after the acquisition. These results can be explained by the fact that the need to hedge is much less for high vertical integration firms since vertical integration at this level provides hedging mechanisms and firms substitute vertical integration for derivative hedging.

The univariate test results related to firm characteristics variables show that there are significant differences between hedgers and non-hedgers. Hedgers are larger in size, have higher debt ratios, intensity of capital and tax-loss carryforwards, but they have less current assets and pay higher dividends. All these findings are consistent with the extant theories of hedging. In general, the differences in hedging substitutes, institutional ownership and firm value are not significant between hedgers and non-hedgers. Additionally, significant differences in firm characteristics are found between pre- and post-vertical integration firms as well as low and high vertical integration firms.

The results of Heckman's selection models also show that vertical integration negatively affects the decision to hedge. Moreover, the significant coefficients of high vertical integration dummies in the selectivity model prove that the extent of hedging is negatively affected by being a high vertical integration firm. This result again confirms the hedging aspect of vertical integration. All these findings prove the substitutability of vertical integration and derivative hedging.

As regards the tests on the other determinants of the decision to hedge and the extent of hedging, I find consistent evidence for the extant theories of corporate hedging. In general, the results of probit and the selection regression of Heckman's model support all the hypotheses except Hypothesis 5. Financial distress costs, underinvestment costs, and corporate taxes are the major considerations for vertically integrated firms while making hedging decisions.

In summary, my study makes a significant contribution to existing literature by empirically showing substitutability of vertical integration and derivative hedging. It is also is much broader than previous studies that have concentrated on single industries. In general, the findings here are consistent with the extant theories of finance such as financial cost, underinvestment cost, economies of scale and corporate tax theories.

One of the limitations of my study is the potential endogeneity issue in the sample frame discussed in Section 5.2.1. One possible solution to this problem would be to collect hedging information about another sample of merging firms that are not vertically integrated, and show that derivative use by these firms does not fall during the periods when vertically integrated firms’ derivative use falls. Although such a procedure would still be subject to the usual criticisms that accompany attempts to match firms on sets of characteristics (e.g., does the selection of the matching criteria itself produce endogeneity) and would be labor-intensive, confirming the results of this study with this method would provide robustness for the future researchers. The current research is not also designed to evaluate the cost of each strategy, vertical integration and hedging, but only tests whether or not firms substitute vertical integration for derivative hedging. Future research that answers the following question will also make significant contribution to the current literature: Is vertical integration better than derivative hedging in mitigating corporate risk?

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Appendix

A ADDITIONAL TABLES

A.1 Definitions and Source of Variables

Table A1 gives detailed information about the definitions and the sources of varibles.

Table A1 Definitions and Sources of Variables

Variable		Definition	Source
Hedging Variables			
HEDGER (it)	=	Dummy variable that equals to 1 if firm i holds a nonzero derivative position at fiscal t year-end, and 0 otherwise	10-K, Annual Report
TOTALHEDGE (it)	=	Notional amount of derivatives scaled by total assets, both measured at fiscal t year-end	10-K, Annual Report
Vertical Integration Variables			
VI (it)	=	Dummy variable that equals to 1 if firm I is vertically related,the year of vertical integration takes the value of 0	BEA
VI1 (it)	=	Dummy variable that equals to 1 if firm I is vertically related,the year of vertical integration takes the value of 1	BEA
VI2 (it)	=	Dummy variable that equals to 1 if firm I is vertically related,the year of vertical integration is excluded	BEA
VR (it)	=	Vertical relatedness coefficient calculated using I/O table published by Bureu of Economic Analysis	BEA
HIGHVERTICALl8 (it)	=	Dummy variable that takes a value of one if vertical relatedness coefficient exceeds 8%, and zero otherwise.	BEA
HIGHVERTICAL9 (it)	=	Dummy variable that takes a value of one if vertical relatedness coefficient exceeds 9%, and zero otherwise.	BEA
HIGHVERTICAL10 (it)	=	Dummy variable that takes a value of one if vertical relatedness coefficient exceeds 10%, and zero otherwise.	BEA
HIGHVERTICAL15 (it)	=	Dummy variable that takes a value of one if vertical relatedness coefficient exceeds 15%, and zero otherwise.	BEA

Table A1 Continued

Variable		Definition	Source
DA (it)	=	Debt-to-asset ratio,ratio of debt to assets	Compustat
Investment/Growth Opportunity			
MB (it)	=	Market-to-book ratio, ratio of market value of equity to book value of equity of firm I, each measured at fiscal t year-end	Compustat
RD (it)	=	Research and development expense scaled by total assets, both measured at fiscal t year-end	Compustat
PPE (it)	=	Intensity of capital investment, ratio of property, plant and equipment at the year end to size	Compustat
Institutional Ownership			
INST *(it)*	=	Percentage of fim i's total shares outstanding held by institutions in year t	Thomson Reuters
Liquidity			
CR (it)	=	Current ratio, ratio of current assets to liabilities	Compustat
DIV (it)	=	Dividend payout ratio, dividends per share to common shareholders of firm i in fiscal year t divided by earnings per share before extraordinary items in year t	Compustat
Income Taxes			
TAX (it)	=	Dummy variable that equals 1 if firm I is profitable (i.e income before extraordinary items > 0) in year t and has NOL tax carryforwards at fiscal t year-end, and 0 otherwise	Compustat
Profitability			
ROA *(it)*	=	Operating income scale by total assets	Compustat
ROE *(it)*	=	Operating income scaled by the market value of equity	Compustat
Hedging Substitutes			
CONV *(it)*	=	Ratio of book value of total convertible debt as of fiscal year end to size	Compustat
PREF *(it)*	=	Ratio of book value of total preferred stock as of the end of fiscal year to size	Compustat
CASH *(it)*	=	Firm I's cash scaled by its market value of equity at fiscal t year-end	Compustat

Table A1 Continued

Variable		Definition	Source
Other Controls			
YEAR (it)	=	The dummy variable for the years	
INDUSTRY (it)	=	The dummy variable for industries	
SIZE (it)	=	Log of total assets	Compustat
Firm Value			
TOBIN (it)	=	BV total assets-BV common equity+MV common equity)/BV total assets	Compustat

A.2 Vertical Acquisitions Used in This Study

Table A2 lists the 198 vertical acquisitions used in this study.

Table A2 Vertical Acquisitions Used in This Study

N	Effective Date	Target Name	Acquiror Name	Target Primary NAIC Description	Acquiror Primary NAIC Description	VR Coefficient (6-Digit IO)	VR Coefficient (4-Digit IO)
1	4/30/1998	3-D Geophysical Inc	Western Atlas Inc	Support Activities for Oil and Gas Operations	Crude Petroleum and Natural Gas Extraction	0.0205	0.0205
2	6/1/1998	Continental Can Co Inc	Dean Foods Co *(formerly Suiza Foods Corp)*	Metal Can Manufacturing	Dairy Product (except Dried or Canned) Merchant Wholesalers	0.0698	0.0624
3	6/15/1998	Lancit Media Entertainment Ltd	RCN Corp	Motion Picture and Video Production	Wired Telecommunications Carriers	0.1014	0.1041
4	6/18/1998	American Waste Services	Waste Management Inc. *(formerly*	Solid Waste Collection	Other Nonhazardous Waste Treatment and Disposal	0.1299	0.1299
5	6/27/1998	Republic Automotive Parts Inc	Keystone Automotive Inds Inc	Gasoline Engine and Engine Parts Manufacturing	Motor Vehicle Supplies and New Parts Merchant Wholesalers	0.0624	0.0628
6	7/9/1998	Echlin Inc	Dana Holding Corp. *(formerly Dana Corp)*	Gasoline Engine and Engine Parts Manufacturing	All Other Motor Vehicle Parts Manufacturing	0.0938	0.1036
7	7/16/1998	Waste Management Inc	Waste Management Inc. *(formerly*	Solid Waste Collection	Other Nonhazardous Waste Treatment and Disposal	0.1299	0.1299
8	7/28/1998	ARCO Chemical Co	Lyondell Petrochemical	Ethyl Alcohol Manufacturing	All Other Basic Organic Chemical Manufacturing	0.1539	0.2133
9	7/28/1998	Mayor's Jewelers Inc	Mayors Jewellers Inc *(formerly Jan*	Jewelry, Watch, Precious Stone, and Precious Metal	Jewelry (except Costume) Manufacturing	0.1012	0.0710
10	7/31/1998	Whitehall Corp	Timco Aviation Services Inc. *(formerly*	Aircraft Manufacturing	Industrial Machinery and Equipment Merchant Wholesalers	0.0461	0.0332
11	8/7/1998	RP Scherer Corp	Cardinal Distribution Inc. *(formerly*	Pharmaceutical Preparation Manufacturing	Drugs and Druggists' Sundries Merchant Wholesalers	0.0485	0.0485
12	8/12/1998	Seragen Inc(Boston University)	Ligand Pharmaceuticals Inc	In-Vitro Diagnostic Substance Manufacturing	Biological Product (except Diagnostic) Manufacturing	0.1864	0.1864

Table A2 Continued

N	Effective Date	Target Name	Acquiror Name	Target Primary NAIC Description	Acquiror Primary NAIC Description	VR Coefficient (6-Digit IO)	VR Coefficient (4-Digit IO)
13	8/20/1998	Lecg Inc	Navigant Consulting Inc. *(formerly*	Administrative Management and General	Office Administrative Services	0.0303	0.0273
14	10/6/1998	General Signal Corp	SPX Corp	Relay and Industrial Control Manufacturing	Machine Tool (Metal Forming Types) Manufacturing	0.0258	0.0214
15	12/3/1998	Clearview Cinema Group Inc	CSC HOLDINGS LLC *(formerly Cablevision*	Motion Picture Theaters (except Drive-Ins)	Cable and Other Subscription Programming	0.1014	0.1041
16	12/14/1998	Fritzi of California Mnfr Corp	Kellwood Co	Women's, Girls', and Infants' Cut and Sew Apparel	Women's, Children's, and Infants' Clothing and Accessories Merchant	0.0494	0.0497
17	12/23/1998	Peoples Telephone Co Inc	Davel Communications Inc	Wired Telecommunications Carriers	All Other Telecommunications	0.0477	0.0477
18	1/26/1999	LeaRonal Inc	Rohm & Haas Co	All Other Basic Organic Chemical Manufacturing	Plastics Material and Resin Manufacturing	0.1894	0.3327
19	3/1/1999	Shiva Corp	Intel Corp	Other Communications Equipment	Semiconductor and Related Device Manufacturing	0.0394	0.2067
20	3/9/1999	Tele-Communications Inc	AT&T Corp	Cable and Other Subscription Programming	Wired Telecommunications Carriers	0.1998	0.1998
21	3/11/1999	Vincam Group Inc	Automatic Data Processing Inc	Temporary Help Services	Data Processing, Hosting, and Related Services	0.0253	0.0253
22	3/18/1999	Rutherford-Moran Oil Corp	Chevron Corp	Crude Petroleum and Natural Gas Extraction	Petroleum Refineries	0.5872	0.5262
23	3/19/1999	GeneMedicine Inc	Urigen Pharmeceuticals, Inc *(formerly*	Biological Product (except Diagnostic) Manufacturing	Research and Development in the Physical, Engineering and	0.0190	0.0190
24	3/24/1999	Rubbermaid Inc	Newell Rubbermaid Inc *(formerly Newell*	Folding Paperboard Box Manufacturing	Other Pressed and Blown Glass and Glassware Manufacturing	0.0131	0.0123
25	3/30/1999	Ocean Energy Inc	Devon OEI Operating Inc *(formerly Seagull*	Crude Petroleum and Natural Gas Extraction	Natural Gas Distribution	0.2976	0.2976
26	5/3/1999	Vanguard Cellular Systems Inc	AT&T Corp	Wireless Telecommunications Carriers (except	Wired Telecommunications Carriers	0.0477	0.0477
27	6/21/1999	Morton International Inc	Rohm & Haas Co	All Other Basic Inorganic Chemical Manufacturing	Plastics Material and Resin Manufacturing	0.0195	0.3327
28	7/2/1999	Norrell Corp	SFN Group Inc. *(formerly Interim Services*	Temporary Help Services	Human Resources and Executive Search Consulting Services	0.0197	0.0206

Table A2 Continued

N	Effective Date	Target Name	Acquiror Name	Target Primary NAIC Description	Acquiror Primary NAIC Description	VR Coefficient (6-Digit IO)	VR Coefficient (4-Digit IO)
29	7/29/1999	NeXstar Pharmaceuticals Inc	Gilead Sciences Inc	Pharmaceutical Preparation Manufacturing	Biological Product (except Diagnostic) Manufacturing	0.1864	0.1864
30	7/30/1999	Gulfstream Aerospace Corp	General Dynamics Corp	Aircraft Manufacturing	Search Detection Navigation Guidance Aeronautical and	0.0857	0.0483
31	8/11/1999	Metra Biosystems Inc	Quidel Corp	Research and Development in the Physical,	In-Vitro Diagnostic Substance Manufacturing	0.0190	0.0190
32	8/31/1999	SUGEN Inc	Pharmacia & Upjohn Inc	Research and Development in the Physical,	Pharmaceutical Preparation Manufacturing	0.0190	0.0190
33	9/1/1999	CAI Wireless Systems Inc	MCI Inc *(formerly MCI WorldCom)*	Cable and Other Subscription Programming	Wired Telecommunications Carriers	0.1998	0.1998
34	9/14/1999	Meridian Data	Quantum Corp	Electronic Computer Manufacturing	Computer Storage Device Manufacturing	0.0907	0.2102
35	9/23/1999	Metro Networks Inc	Dial Global, Inc *(formerly Westwood One*	All Other Telecommunicatio ns	Radio Networks	0.2169	0.2169
36	9/23/1999	American Telecasting	SPRINT Corp *(formerly Sprint Nextel Corp)*	Cable and Other Subscription Programming	Wired Telecommunications Carriers	0.1998	0.1998
37	9/24/1999	Diamond Multimedia Systems Inc	Sonicblue Inc. *(formerly S3 Inc.)*	Electronic Computer Manufacturing	Semiconductor and Related Device Manufacturing	0.1518	0.2272
38	9/28/1999	People's Choice TV Corp	Sprint Corp. *(formerly Sprint Nextel Corp)*	Cable and Other Subscription Programming	Wired Telecommunications Carriers	0.1998	0.1998
39	9/30/1999	SunPharm Corp	GelTex Pharmaceutical s Inc	Pharmaceutical Preparation Manufacturing	Biological Product (except Diagnostic) Manufacturing	0.1864	0.1864
40	10/1/1999	Sheridan Energy Inc	Calpine Corp	Crude Petroleum and Natural Gas Extraction	Other Electric Power Generation	0.0667	0.0667
41	10/1/1999	SkyTel Communications Inc	MCI Inc *(formerly MCI WorldCom)*	Wireless Telecommunicatio ns Carriers (except	Wired Telecommunications Carriers	0.0477	0.0477
42	10/7/1999	RIBI ImmunoChem Research Inc	Corixa Corp	Research and Development in the Physical,	Biological Product (except Diagnostic) Manufacturing	0.0190	0.0190
43	10/12/1999	Data General Corp	EMC Corp	Electronic Computer Manufacturing	Computer Storage Device Manufacturing	0.0907	0.2102
44	11/18/1999	RiboGene Inc	questcor Pharmaceutical s Inc *(formerly*	Research and Development in the Physical,	Biological Product (except Diagnostic) Manufacturing	0.0190	0.0190

Table A2 Continued

N	Effective Date	Target Name	Acquiror Name	Target Primary NAIC Description	Acquiror Primary NAIC Description	VR Coefficient (6-Digit IO)	VR Coefficient (4-Digit IO)
45	11/20/1999	DSP Communications Inc	Intel Corp	Radio and Television Broadcasting and	Semiconductor and Related Device Manufacturing	0.1286	0.2067
46	11/23/1999	US Bioscience Inc	MedImmune Inc	Pharmaceutical Preparation Manufacturing	Biological Product (except Diagnostic) Manufacturing	0.1864	0.1864
47	11/26/1999	Abacus Direct Corp	DoubleClick Inc	Direct Mail Advertising	Internet Service Providers	0.0416	0.0416
48	12/7/1999	Outdoor Systems Inc	Infinity Broadcasting Corp	Display Advertising	Radio Networks	0.1683	0.1683
49	12/8/1999	Destia Communications Inc	Viatel Inc	Wired Telecommunications Carriers	Wireless Telecommunications Carriers (except Satellite)	0.0477	0.0477
50	12/10/1999	KTI Inc	Casella Waste Systems Inc	Materials Recovery Facilities	Solid Waste Collection	0.1299	0.1299
51	12/10/1999	Wireless One Inc	MCI Inc. (formerly MCI WorldCom)	Cable and Other Subscription Programming	Wired Telecommunications Carriers	0.1998	0.1998
52	1/5/2000	Crystal Gas Storage Inc	El Paso Corp/ DE *(formerly El Paso Energy*	Crude Petroleum and Natural Gas Extraction	Natural Gas Distribution	0.4399	0.2976
53	1/12/2000	AdForce Inc	ModusLink Global Solutions Inc	Advertising Agencies	Software Publishers	0.0406	0.0347
54	2/1/2000	Innovative Valve Technologies	Flowserve Corp	Industrial Machinery and Equipment	Pump and Pumping Equipment Manufacturing	0.0623	0.0663
55	2/1/2000	Aseco Corp	MCT Inc *(formerly Micro Component*	Semiconductor and Related Device Manufacturing	Instrument Manufacturing for Measuring and Testing	0.0256	0.1339
56	2/25/2000	Medco Research Inc	King Pharmaceuticals Inc	Pharmaceutical Preparation Manufacturing	Medicinal and Botanical Manufacturing	0.0927	0.1864
57	3/1/2000	Yankee Energy System Inc	Northeast Utilities	Pipeline Transportation of Refined Petroleum	Electric Power Distribution	0.0179	0.0299
58	3/13/2000	Yesmail.com Inc	ModusLink Global Solutions Inc	Advertising Agencies	Software Publishers	0.0406	0.0347
59	4/10/2000	Four Media Co	Liberty Media LLC *(formerly Liberty Media*	Teleproduction and Other Postproduction	Cable and Other Subscription Programming	0.2619	0.1041
60	5/18/2000	All Communications Corp	Glowpoint, Inc *(formerly View Tech Inc)*	Telephone Apparatus Manufacturing	Other Electronic Parts and Equipment Merchant Wholesalers	0.0660	0.0542

Table A2 Continued

N	Effective Date	Target Name	Acquiror Name	Target Primary NAIC Description	Acquiror Primary NAIC Description	VR Coefficient (6-Digit IO)	VR Coefficient (4-Digit IO)
61	5/30/2000	Varco International Inc	Varco International Inc. *(formerly*	Oil and Gas Field Machinery and Equipment	Industrial Machinery and Equipment Merchant Wholesalers	0.0613	0.0669
62	5/31/2000	Celestial Seasonings Inc	Hain Celestial Group Inc. *(formerly Hain*	Dried and Dehydrated Food Manufacturing	Packaged Frozen Food Merchant Wholesalers	0.0721	0.0579
63	6/8/2000	Faroudja Inc	Sage Inc	Audio and Video Equipment Manufacturing	Semiconductor and Related Device Manufacturing	0.0217	0.2067
64	6/15/2000	MediaOne Group Inc	AT&T Corp	Cable and Other Subscription Programming	Wired Telecommunications Carriers	0.0208	0.1998
65	6/16/2000	Metamor Worldwide Inc	PSINet Inc	Temporary Help Services	Internet Service Providers	0.0204	0.0134
66	6/30/2000	US WEST Inc	Qwest Commun Intl Inc	All Other Telecommunicatio ns	Wired Telecommunications Carriers	0.1585	0.0477
67	7/3/2000	Savoir Technology Group Inv	Avnet Inc	Computer and Computer Peripheral	Other Electronic Parts and Equipment Merchant Wholesalers	0.0307	0.0262
68	7/10/2000	Arvin Industries Inc	Meritor Automotive Inc	Gasoline Engine and Engine Parts Manufacturing	Automobile Manufacturing	0.5442	0.4640
69	8/7/2000	Cybergold Inc	MyPoints.com Inc	Advertising Agencies	Internet Service Providers	0.0458	0.0416
70	8/31/2000	Jones Pharmaceutical Inc	King Pharmaceutical s Inc	Pharmaceutical Preparation Manufacturing	Medicinal and Botanical Manufacturing	0.0927	0.1864
71	10/11/2000	Anesta Corp	Cephalon Inc	Biological Product (except Diagnostic) Manufacturing	Pharmaceutical Preparation Manufacturing	0.0318	0.1864
72	10/13/2000	Trimark Holdings Inc	Lions Gate Entertainment Corp	Motion Picture and Video Distribution	Motion Picture and Video Production	0.1041	0.2829
73	11/8/2000	EnergyNorth Inc	Eastern Enterprises	Pipeline Transportation of Refined Petroleum	Natural Gas Distribution	0.1192	0.1351
74	11/15/2000	Gatefield Corp	Actel Corp	Electronic Computer Manufacturing	Semiconductor and Related Device Manufacturing	0.1006	0.2272
75	11/28/2000	Cerprobe Corporation	Kulicke & Soffa Industries Inc	Instrument Manufacturing for Measuring and	Semiconductor and Related Device Manufacturing	0.0256	0.1339
76	12/7/2000	CapRock Communications Corp	McLeodUSA LLC *(formerly McLeodUSA Inc)*	Wireless Telecommunicatio ns Carriers (except	Wired Telecommunications Carriers	0.1585	0.0477

Table A2 Continued

N	Effective Date	Target Name	Acquiror Name	Target Primary NAIC Description	Acquiror Primary NAIC Description	VR Coefficient (6-Digit IO)	VR Coefficient (4-Digit IO)
77	12/18/2000	Biomatrix Inc	Genzyme Corp *(formerly Genzyme*	Medicinal and Botanical Manufacturing	Biological Product (except Diagnostic) Manufacturing	0.1006	0.1864
78	12/19/2000	OnePoint Communications Corp	Verizon Communications Inc	Wired Telecommunications Carriers	Wireless Telecommunications Carriers (except Satellite)	0.1585	0.0477
79	12/20/2000	Newgen Results Corporation	TeleTech Holdings Inc	All Other Business Support Services	Employee Leasing Services	0.0331	0.0201
80	2/2/2001	@plan.inc	DoubleClick Inc	Other Services Related to Advertising	Internet Service Providers	0.0458	0.0416
81	3/15/2001	Guest Supply Inc	Sysco Corp	Toilet Preparation Manufacturing	General Line Grocery Merchant Wholesalers	0.0407	0.0536
82	6/19/2001	McNaughton Apparel Group Inc	Jones Group Inc. *(formerly Jones Apparel*	Women's, Girls', and Infants' Cut and Sew Apparel	Women's and Girls' Cut and Sew Blouse and Shirt Manufacturing	0.0199	0.0944
83	7/12/2001	Aronex Pharmaceuticals Inc	Agenus Inc *(formerly Antigenics Inc.)*	Pharmaceutical Preparation Manufacturing	Biological Product (except Diagnostic) Manufacturing	0.0318	0.1864
84	7/19/2001	Rosetta Inpharmatics Inc	Merck & Co Inc	Research and Development in Biotechnology	Pharmaceutical Preparation Manufacturing	0.0387	0.0190
85	7/19/2001	Sawtek Inc	TriQuint Semiconductor Inc	Radio and Television Broadcasting and	Semiconductor and Related Device Manufacturing	0.1023	0.2067
86	10/4/2001	Richton International Corp	Deere & Co	Farm and Garden Machinery and Equipment	Farm Machinery and Equipment Manufacturing	0.0588	0.0669
87	10/19/2001	Mediaplex Inc	Coversant Inc *(formerly ValueClick Inc.)*	All Other Business Support Services	Advertising Agencies	0.0134	0.0119
88	11/1/2001	Louis Dreyfus Natural Gas	Boomerang Systems, Inc. *(formerly*	Crude Petroleum and Natural Gas Extraction	Electric Bulk Power Transmission and Control	0.0647	0.0667
89	12/5/2001	Vysis Inc(BP PLC)	Abbott Laboratories	In-Vitro Diagnostic Substance Manufacturing	Pharmaceutical Preparation Manufacturing	0.0825	0.1864
90	1/30/2002	Westvaco Corp	Mead Corp	Pulp Mills	Paperboard Mills	0.0161	0.0771
91	2/25/2002	Chadmoore Wireless Group Inc	Nextel Communications Inc	Wireless Telecommunications Carriers (except	Satellite Telecommunications	0.1585	0.1648
92	3/20/2002	Matrix Pharmaceutical Inc	Chiron Corp	Pharmaceutical Preparation Manufacturing	Biological Product (except Diagnostic) Manufacturing	0.0318	0.1864

Table A2 Continued

N	Effective Date	Target Name	Acquiror Name	Target Primary NAIC Description	Acquiror Primary NAIC Description	VR Coefficient (6-Digit IO)	VR Coefficient (4-Digit IO)
93	4/5/2002	Gaylord Container Corp	Temple-Inland Inc	Setup Paperboard Box Manufacturing	Paperboard Mills	0.1857	0.3341
94	5/23/2002	Be Free Inc	Coversant Inc *(ValueClick Inc.)*	All Other Business Support Services	Advertising Agencies	0.0134	0.0119
95	6/26/2002	Gerber Childrenswear(Gerber)	Kellwood Co	Men's and Boys' Cut and Sew Apparel Contractors	Women's, Children's, and Infants' Clothing and Accessories Merchant	0.0242	0.0497
96	7/24/2002	PhoneTel Technologies Inc	Davel Communications Inc	Wired Telecommunications Carriers	All Other Telecommunications	0.1585	0.0477
97	8/22/2002	Glyko Biomedical Ltd	BioMarin Pharmaceutical Inc	In-Vitro Diagnostic Substance Manufacturing	Pharmaceutical Preparation Manufacturing	0.0825	0.1864
98	10/4/2002	Truetime Inc	Symmetricom Inc	Radio and Television Broadcasting and	Telephone Apparatus Manufacturing	0.1037	0.0754
99	1/1/2003	Syncor International Corp	Cardinal Distribution Inc. *(formerly*	Medical, Dental, and Hospital Equipment and	Drugs and Druggists' Sundries Merchant Wholesalers	0.0307	0.0262
100	1/23/2003	Triangle Pharmaceuticals Inc	Gilead Sciences Inc	Pharmaceutical Preparation Manufacturing	Biological Product (except Diagnostic) Manufacturing	0.0318	0.1864
101	6/4/2003	3TEC Energy Corp	Plains Expl & Prodn Co	Support Activities for Oil and Gas Operations	Crude Petroleum and Natural Gas Extraction	0.0176	0.0205
102	8/21/2003	Diacrin Inc	GenVec Inc	Biological Product (except Diagnostic) Manufacturing	Pharmaceutical Preparation Manufacturing	0.0318	0.1864
103	9/15/2003	SangStat Medical Corp	Genzyme Corp	Pharmaceutical Preparation Manufacturing	Biological Product (except Diagnostic) Manufacturing	0.0318	0.1864
104	12/16/2003	Brass Eagle Inc	Outdoor Sports Gear, Inc. (formerly K2	Sporting and Recreational Goods and	Sporting and Athletic Goods Manufacturing	0.0524	0.0710
105	1/23/2004	Right Mgmt Consultants Inc	ManpowerGroup Inc. *(formerly Manpower Inc)*	Administrative Management and General	Employee Leasing Services	0.0160	0.0206
106	2/10/2004	BioReliance Corp	Life Technologies Corp *(formerly*	Research and Development in Biotechnology	Biological Product (except Diagnostic) Manufacturing	0.0584	0.0190
107	3/24/2004	Image Systems Corp	Communications System Inc	Radio and Television Broadcasting and	Telephone Apparatus Manufacturing	0.1037	0.0754
108	5/28/2004	NPTest Holding Corp	Credence Systems Corp	Semiconductor and Related Device Manufacturing	Instrument Manufacturing for Measuring and Testing	0.0256	0.1339

Table A2 Continued

N	Effective Date	Target Name	Acquiror Name	Target Primary NAIC Description	Acquiror Primary NAIC Description	VR Coefficient (6-Digit IO)	VR Coefficient (4-Digit IO)
109	6/10/2004	OneSource Information Services	InfoGroup Inc. *(formerly infoUSA Inc)*	Internet Service Providers	Direct Mail Advertising	0.0458	0.0416
110	7/7/2004	ALARIS Medical Systems Inc	Cardinal Distribution Inc. *(formerly*	Surgical and Medical Instrument Manufacturing	Drugs and Druggists' Sundries Merchant Wholesalers	0.0445	0.0487
111	7/17/2004	New England Bus Service Inc	Deluxe Corp	Manifold Business Forms Printing	Blankbook, Looseleaf Binders, and Devices Manufacturing	0.0145	0.0770
112	10/20/2004	Inveresk Research Group Inc	Charles River Labs Intl Inc	Pharmaceutical Preparation Manufacturing	Research and Development in Biotechnology	0.0387	0.0190
113	11/30/2004	Millennium Chemicals Inc	Lyondell Chemical Co	All Other Basic Inorganic Chemical Manufacturing	All Other Basic Organic Chemical Manufacturing	0.0182	0.2133
114	12/21/2004	ILEX Oncology Inc	Genzyme Corp	Pharmaceutical Preparation Manufacturing	Biological Product (except Diagnostic) Manufacturing	0.0318	0.1864
115	3/4/2005	Starcraft Corp	Quantum Fuel Systems Technologies	Automobile Manufacturing	Gasoline Engine and Engine Parts Manufacturing	0.5442	0.4640
116	6/14/2005	Salmedix Inc	Cephalon Inc	Research and Development in the Physical,	Pharmaceutical Preparation Manufacturing	0.0387	0.0190
117	7/1/2005	Great Lakes Chemical Corp	Chemtura Corp *(formerly Crompton Corp)*	All Other Basic Inorganic Chemical Manufacturing	Adhesive Manufacturing	0.0233	0.1634
118	7/1/2005	Bone Care Intl Inc	Genzyme Corp	Pharmaceutical Preparation Manufacturing	Biological Product (except Diagnostic) Manufacturing	0.0318	0.1864
119	7/1/2005	Kaneb Pipe Line Partners LP	Nu Star Energy L.P. *(formerly Valero LP)*	Petroleum Bulk Stations and Terminals	Pipeline Transportation of Crude Oil	0.0279	0.0270
120	8/1/2005	Western Wireless Corp	Alltel Corp	Wireless Telecommunications Carriers (except	Wired Telecommunications Carriers	0.1585	0.0477
121	8/12/2005	US Unwired Inc	SPRINT Corp *(formerly Sprint Nextel Corp)*	Wireless Telecommunications Carriers (except	Wired Telecommunications Carriers	0.1585	0.0477
122	8/12/2005	Nextel Communications Inc	SPRINT Corp (f*ormerly Sprint Nextel Corp)*	Satellite Telecommunications	Wired Telecommunications Carriers	0.1585	0.0477
123	9/16/2005	Saucony Inc	Stride Rite Corp	Rubber and Plastics Footwear Manufacturing	Other Footwear Manufacturing	0.0271	0.2054
124	9/30/2005	InKine Pharmaceutical Co	Salix Pharmaceuticals Ltd	Biological Product (except Diagnostic) Manufacturing	Pharmaceutical Preparation Manufacturing	0.0318	0.1864

Table A2 Continued

N	Effective Date	Target Name	Acquiror Name	Target Primary NAIC Description	Acquiror Primary NAIC Description	VR Coefficient (6-Digit IO)	VR Coefficient (4-Digit IO)
125	10/6/2005	BioSource International Inc	Life Technologies Corp *(formerly*	In-Vitro Diagnostic Substance Manufacturing	Biological Product (except Diagnostic) Manufacturing	0.0805	0.1864
126	10/20/2005	IWO Holdings Inc	SPRINT Corp *(formerly Sprint Nextel Corp)*	Wireless Telecommunicatio ns Carriers (except	Wired Telecommunications Carriers	0.1585	0.0477
127	12/15/2005	AlgoRx Pharmaceuticals Inc	Anesiva, Inc. *(formerly Corgentech Inc.)*	Medicinal and Botanical Manufacturing	Biological Product (except Diagnostic) Manufacturing	0.1006	0.1864
128	12/30/2005	Captiva Software Corp	EMC Corp	Software Publishers	Computer Storage Device Manufacturing	0.1191	0.0765
129	1/4/2006	Maxim Pharmaceuticals Inc	EpiCept Corp	Biological Product (except Diagnostic) Manufacturing	Pharmaceutical Preparation Manufacturing	0.0318	0.1864
130	2/1/2006	Alamosa Holdings Inc	SPRINT Corp *(formerly Sprint Nextel Corp)*	Wireless Telecommunicatio ns Carriers (except	Wired Telecommunications Carriers	0.1585	0.0477
131	4/3/2006	Abgenix Inc	Amgen Inc	Research and Development in the Physical,	Biological Product (except Diagnostic) Manufacturing	0.0584	0.0190
132	6/26/2006	Nextel Partners Inc	SPRINT Corp *(formerly Sprint Nextel Corp)*	Wireless Telecommunicatio ns Carriers (except	Wired Telecommunications Carriers	0.1585	0.0477
133	7/1/2006	Ubiquitel Inc	SPRINT Corp *(formerly Sprint Nextel Corp)*	Wireless Telecommunicatio ns Carriers (except	Wired Telecommunications Carriers	0.1585	0.0477
134	8/15/2006	MAI Systems Corp	SoftBrands Inc	Electronic Computer Manufacturing	Software Publishers	0.0901	0.0765
135	8/16/2006	Predix Pharmaceuticals Inc	EPIX Pharmaceutical s Inc	Biological Product (except Diagnostic) Manufacturing	Pharmaceutical Preparation Manufacturing	0.0318	0.1864
136	9/18/2006	RSA Security Inc	EMC Corp	Software Publishers	Computer Storage Device Manufacturing	0.1191	0.0765
137	11/17/2006	Myogen Inc	Gilead Sciences Inc	Pharmaceutical Preparation Manufacturing	Biological Product (except Diagnostic) Manufacturing	0.0318	0.1864
138	12/1/2006	Sentigen Holding Corp	Life Technologies Corp *(formerly*	Research and Development in Biotechnology	Biological Product (except Diagnostic) Manufacturing	0.0584	0.0190
140	1/9/2007	Banta Corp	RR Donnelley & Sons Co	Digital Printing	Commercial Lithographic Printing	0.0145	0.0770
141	2/20/2007	VitalStream Holdings Inc	Internap Network Services Corp	Internet Service Providers	Telecommunications Resellers	0.0565	0.0247

Table A2 Continued

N	Effective Date	Target Name	Acquiror Name	Target Primary NAIC Description	Acquiror Primary NAIC Description	VR Coefficient (6-Digit IO)	VR Coefficient (4-Digit IO)
142	3/30/2007	Tut Systems Inc	Motorola Solutions, Inc *(formerly*	Telephone Apparatus Manufacturing	Radio and Television Broadcasting and Wireless	0.1037	0.0754
143	6/28/2007	VIASYS Healthcare Inc	CARDINAL DISTRIBUTION INC (formerly	Irradiation Apparatus Manufacturing	Drugs and Druggists' Sundries Merchant Wholesalers	0.0724	0.0500
144	7/23/2007	Terayon Communication Sys Inc	Motorola Solutions, Inc *(formerly*	Other Communications Equipment	Radio and Television Broadcasting and Wireless	0.0223	0.0754
145	8/9/2007	K2 Inc	Alltrista Corp *(formerly Jarden Corp)*	Sporting and Athletic Goods Manufacturing	Other Miscellaneous Nondurable Goods Merchant Wholesalers	0.0524	0.0710
146	9/17/2007	Opsware Inc	Hewlett Packard Co	Software Publishers	Electronic Computer Manufacturing	0.0901	0.0765
147	10/1/2007	Neoware Inc	Hewlett Packard Co	Software Publishers	Electronic Computer Manufacturing	0.0901	0.0765
148	10/15/2007	Keystone Automotive Inds Inc	LKQ Corp	Motor Vehicle Supplies and New Parts Merchant	Motor Vehicle Parts (Used) Merchant Wholesalers	0.0307	0.0262
149	11/5/2007	Lamson & Sessions Co	Thomas & Betts Corp	Noncurrent-Carrying Wiring Device Manufacturing	Current-Carrying Wiring Device Manufacturing	0.0246	0.0459
150	11/15/2007	Washington Group Intl Inc	URS Corp	New Multifamily Housing Construction	Engineering Services	0.0332	0.0323
151	11/16/2007	Florida Rock Industries Inc	Vulcan Materials Co	Ready-Mix Concrete Manufacturing	Crushed and Broken Limestone Mining and Quarrying	0.0399	0.0560
152	11/21/2007	Tektronix Inc	Danaher Corp	Instrument Manufacturing for Measuring and	Instruments and Related Products Manufacturing for Measuring,	0.0245	0.0278
153	12/31/2007	Coley Pharmaceutical Group Inc	Pfizer Inc	Research and Development in the Physical,	Pharmaceutical Preparation Manufacturing	0.0387	0.0190
154	1/28/2008	EqualLogic Inc	Dell Inc	Computer Storage Device Manufacturing	Electronic Computer Manufacturing	0.1879	0.2102
155	3/6/2008	Document Sciences Corp	EMC Corp	Software Publishers	Computer Storage Device Manufacturing	0.1191	0.0765
156	6/6/2008	Specialized Health Prod Intl	CR Bard Inc	Surgical and Medical Instrument Manufacturing	Surgical Appliance and Supplies Manufacturing	0.0308	0.0610
157	6/10/2008	Encysive Pharmaceuticals Inc	Pfizer Inc	Biological Product (except Diagnostic) Manufacturing	Pharmaceutical Preparation Manufacturing	0.0318	0.1864

Table A2 Continued

N	Effective Date	Target Name	Acquiror Name	Target Primary NAIC Description	Acquiror Primary NAIC Description	VR Coefficient (6-Digit IO)	VR Coefficient (4-Digit IO)
158	6/27/2008	Kosan Biosciences Inc	Bristol-Myers Squibb Co	Biological Product (except Diagnostic) Manufacturing	Pharmaceutical Preparation Manufacturing	0.0318	0.1864
159	12/23/2008	Pharmacopeia Inc	Ligand Pharmaceuticals Inc	Research and Development in Biotechnology	Biological Product (except Diagnostic) Manufacturing	0.0584	0.0190
160	12/30/2008	Alpharma Inc	King Pharmaceuticals Inc	Pharmaceutical Preparation Manufacturing	Medicinal and Botanical Manufacturing	0.0927	0.1864
161	3/31/2009	Corrpro Cos Inc	Argion Corp *(formerly Insituform*	Engineering Services	Water and Sewer Line and Related Structures Construction	0.0783	0.0812
162	9/1/2009	Medarex Inc	Bristol-Myers Squibb Co	Biological Product (except Diagnostic) Manufacturing	Pharmaceutical Preparation Manufacturing	0.0318	0.1864
163	9/15/2009	Nashua Corp	Cenveo Inc	Paper (except Newsprint) Mills	Commercial Lithographic Printing	0.1715	0.2050
164	10/5/2009	Telava Networks Inc	Unilava Corp	Other Services Related to Advertising	Wired Telecommunications Carriers	0.0254	0.0299
165	11/3/2009	Schering-Plough Corp	Merck & Co Inc	Drugs and Druggists' Sundries Merchant	Pharmaceutical Preparation Manufacturing	0.0517	0.0485
166	11/19/2009	Liberty Entertainment Inc	DirecTV Group Inc	Wired Telecommunications Carriers	Satellite Telecommunications	0.1585	0.0477
167	12/18/2009	Avigen Inc	MediciNova Inc	Pharmaceutical Preparation Manufacturing	Research and Development in Biotechnology	0.0387	0.0190
168	12/23/2009	Neurogen Corp	Ligand Pharmaceuticals Inc	Pharmaceutical Preparation Manufacturing	Biological Product (except Diagnostic) Manufacturing	0.0318	0.1864
169	1/27/2010	Sun Microsystems Inc	Oracle Corp	Electronic Computer Manufacturing	Software Publishers	0.0901	0.0765
170	4/21/2010	Facet Biotech Corp	Abbott Laboratories	Biological Product (except Diagnostic) Manufacturing	Pharmaceutical Preparation Manufacturing	0.0318	0.1864
171	5/3/2010	Switch & Data Facilities Co	Equinix Inc	Wired Telecommunications Carriers	Telecommunications Resellers	0.1585	0.0477
172	5/14/2010	Varian Inc	Agilent Technologies Inc	K2 Inc	Instrument Manufacturing for Measuring and Testing	0.0134	0.0278
173	6/25/2010	XTO Energy Inc	Exxon Mobil Corp	Crude Petroleum and Natural Gas Extraction	Petroleum Refineries	0.7101	0.5262