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Maturity, speculation and corporate hedging:

An empirical study in oil and gas firms from 2000-2008

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Five key words: Maturity, Hedging, Speculation, Hedging determinants, Derivative usage

Purpose: This study aims at understanding what determines the derivative usage of companies and how selective hedging influences the derivative portfolios and most importantly, assessing the performance of maturity as a measure of hedging and meanwhile investigating the potential of maturity in distinguishing the hedging and speculating behaviour of firms.

Methodology: Tobit model (censored regression) and Heckman two-step estimation are employed in this study.

Theoretical perspectives: Relations between hedging and hedging determinants – tax convexity, costs of financial distress, financing costs, managerial risk aversion, information asymmetry, economies of scale and substitutes for hedging that impact corporate hedging practice.

Empirical foundation: Empirical data on US firms in the oil and gas industry during 2000-2008 are collected. Hedge ratio and durations are calculated based on the information of firm's derivative usage taken from their annual reports; financial and governance data are retrieved from *Compustat* and EDGAR.

Conclusions: Evidence partially supports the costs of financial distress, financing costs and economies of scale incentives for hedging. Maturity outperforms and supplements hedge ratio for showing stability, transparency and comprehensiveness in its relations with hedging determinants and selective hedging behaviour.

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Abstract

In this paper, we develop a new but also under-researched measure for firms' hedging practice: maturity. Comparison between the outputs of two sets of Tobit model using hedge ratio and maturity respectively shows that the costs of financial distress hypothesis and the financing costs hypothesis are partially supported by both hedge ratio and maturity. Besides, the economies of scale hypothesis receives supportive evidence when using maturity as the measure. Heckman two-step estimation suggests that the significant factors found in Tobit model are only significant determinants in the decision to hedge, while not in the extent of hedging. An independent variable accounting for firms' selective hedging behaviour is incorporated which is also found to be positively related to maturity in both Tobit model and Heckman two-step estimation. This finding is attributed to managers' overconfidence and optimism biases. In addition, robustness tests corroborate our findings. Hence, maturity effectively supplements hedge ratio when evaluating a firm's hedging practice.

I. Introduction

Companies in general are exposed to macroeconomic risks and those risks have direct consequences on the company's profit. Although it appears that shareholders can diversify their holding portfolios so that their returns only reflect the systematic risk of the companies, it is believed that hedging can still benefit companies and their shareholders in one way or another (Smith & Stulz, 1985). Thus it can be observed that firms widely engage in the trading of derivatives, stating that they attempt to minimize the downside risk of the financial performance. The fact that firms engage in derivatives trading for various reasons is not negligible. Aside from the pure hedging need, it is not uncommon for the management team to incorporate their market views when they set up the hedging positions, which results in inconsistent, unstable hedging positions (Stulz, 1996; Brown, Crabb & Haushalter, 2006; Adam & Fernando, 2006; Géczy, Minton & Schrand, 2007; Adam, Fernando & Salas, 2017). Due to the fact that the derivative usage has direct implications on a company's profit, and especially that setting up a hedging portfolio is not costless, it is both academically meaningful and practically useful to investigate firms' risk management behaviour.

1.1 The background

Though a few papers recognize that the use of derivatives does not necessarily imply a risk management (hedging strategy) but could also signify selective hedging (market timing strategy) instead (Mian, 1996; Géczy, Minto & Schrand, 1997; Graham & Rogers, 2002), traditional models generally overlook the fact that the use of derivatives can be motivated by speculative incentives other than pure hedging (Judge, 2006) and in those models optimal hedge ratios can be determined by firm's specific characteristics (Júnior, 2013). Nowadays, a common opinion that selectively hedged firms continuously alter the volume, timing and position of derivatives used to accommodate the market timing strategy is held by recent researchers (See, for example, Brown, Crabb & Haushalter, 2006; Adam & Fernando, 2006; Géczy, Minton & Schrand, 2007; Adam, Fernando & Salas, 2017).

Hitherto, a clarification of the difference between pure hedging and selective hedging becomes necessary and important. For a pure-hedger, the hedging portfolio will not be subject to great changes since once the amount to be hedged is determined, managers don't deliberately change it to cater for the upside potential, that is to say, management is willing to sacrifice the upside potential to hedge the downside risk. In this setting, the manager has selected the percentage of production that is to be hedged by calculating an optimal (minimum cash flow variance) hedge ratio based on the correlation of return on spot exposure and return on hedging instruments, and the upside potential is sacrificed. However for a selective hedger, the management's view of future price movements becomes an important determinant of its derivatives portfolio. Managers will attempt to earn abnormal returns by using those financial tools. In another word, pure-hedging is risk-avoiding while selective hedging aims at profit winning (Stulz, 1996).

1.2 Problematization and research problem formulation

While the proxy for the decision to hedge is usually a straightforward binary variable[1], the measures of the extent of hedging are not unanimous. However, no matter if it is total notional

[1] Usually a value of 1 will be assigned to the binary variable, if existence of hedging activities is identified by the researcher(s) and 0 otherwise.

book values of derivatives scaled by firm size (Berkman & Bradbury, 1996; Colquitt & Hoyt, 1997; Gay & Nam, 1998; Howton & Perfect, 1998; Allayannis & Ofek, 2001; Knopf, Nam & Thornton, 2002; Júnior, 2013) or the fraction of a firm's production that is hedged against commodity price risk for the year (Haushalter, 2000; Brown, Crabb & Haushalter, 2006), or even a ratio of portfolio delta divided by expected future production (Tufano, 1996; Adam & Fernando, 2006; Adam, Fernando & Salas, 2017), they all carry the same flaw of mixing up hedging-orientated derivatives usage and speculation-orientated derivatives usage. Hence the traditional measure of hedging activity, commonly chosen to be hedge ratio, is not an accurate measure of hedging but a biased measure that is contaminated by firms' speculative activity.

Moreover, the traditional measures solely focus on the volume aspect of corporate derivatives usage while the maturity aspect of derivatives held is generally neglected. Compared to derivatives maturity, debt maturity is far more well-researched. Previous studies have investigated the connection between debt maturity and debt overhang (Diamond & He, 2014); the association between tax aggressiveness and corporate debt maturity (Kubick & Lockhart, 2017); and the relationship between managerial ownership and maturity structure of corporate public debt (Tanaka, 2016); the joint determination of cash holding and maturity (Brick & Liao, 2017); the dependence of debt maturity choice on information asymmetry (Goyal & Wang, 2013); the use of debt maturity as a tool to mitigate underinvestment problem (Khaw & Lee, 2016); how corporate governance practice affects firms' debt maturity structure (Kim, 2015) and the influence of cash flow volatility on the use of debt of different maturities (Keefe & Yaghoubi, 2016) while no extant studies has investigated the maturity aspect of company's hedging policy.

The facts that the maturity of derivatives usage is much under-researched and that selective hedging behaviour can hardly be discerned merely from the amount of derivative in place make studying the hedging and selective hedging (speculation)[2] behaviour of firms from a maturity perspective an interesting topic which is worth researching in. Therefore, this study aims at understanding what determines the derivative usage of companies and how selective

[2] In this study, selective hedging and speculation are used interchangeably.

hedging influences the derivative portfolios and most importantly, assessing the performance of maturity as a measure of hedging and meanwhile investigating the potential of maturity in distinguishing the hedging and speculating behaviour of firms.

Although no previous study has attempted to use maturity as a measure of hedging policy, the choice of maturity as a measure of hedging does not emerge out of the void. Certain previous empirical studies have shown that hedging effectiveness increases with maturity (Ederington, 1979; Hill & Schneeweis, 1982; Geppert, 1995; Lien & Shrestha, 2007; Ghoddusi & Emamzadehfard, 2017). This fact becomes a supporting inspiration for us to propose this innovative measure. Companies with stronger need for hedging would theoretically take their derivatives position with longer maturity while companies that are more incentivized by the temptation to speculate on market trends would theoretically adopt shorter maturity for the derivatives since they need the flexibility to adjust the derivative portfolios more often than pure hedger. Hence maturity is believed to be capable of representing the extent of hedging at least in the same respect as the hedge ratio and could potentially supplement the traditional measure and separate the hedging behaviour of firms from their speculative derivatives usage.

Maturity is a qualified measure of hedging since it is as informative as hedge ratio in indicating whether a firm is a hedger (derivatives user) or not[3]. It thus can be used in the decision model. Furthermore, judging from the aspect of the extent of hedging, a firm's maturity by its nature is a continuous measure with variance in value, just as traditional hedge ratio, so it can be employed in the extent model. Most importantly, given the positive relationship between hedge ratio and hedging effectiveness, between maturity and hedging effectiveness, as well as between hedge ratio and maturity (Ghoddusi & Emamzadehfard, 2017), if it is the hedging effectiveness that matters when firms set up their hedging policy, and that hedge ratio is usually used as the proxy for the hedging intensity, then the similar argument can be applied to using maturity as the proxy for assessing a firm's hedging policy. Hence we expect to observe similar statistical functioning patterns shared by hedge ratio and

[3] If a firm enters into certain hedging transaction then it must have a hedging horizon for this transaction, and that is the maturity of the derivative contract.

maturity as the dependent variable in models. Although hedge ratio and maturity both have indicative power with regard to hedging, they are essentially different aspects of the derivatives portfolio thus may reveal different considerations when manager stipulate hedging policy, especially that hedge ratio only represents annual amount of hedged position but maturity shows the strategic planning horizon of management. Maturity is expected to be similar to hedge ratio to the extent that it is able to represent hedging policy, at the same time it is also different to hedge ratio thus enabling itself to supplement the traditional measure with new information.

Built on the above arguments, this paper derives the research problem that how does maturity perform as a measure of hedging policy? Relevant research questions can be concluded as (1) what are the relations between hedging determinants and maturity? (2) What is the relation between selective hedging behaviour and maturity? (3) How does maturity perform compared to hedge ratio?

1.3 Summary of methodology & findings

This study examines a possibility that maturity of a firm's hedging portfolio can be a substitute for the ratio of hedging position as a proxy representing for the firm's hedging policy. We add a pre-defined speculation indicator as RHS variable accounting for a firm's speculative motivation to use derivatives in our models and test the underlying relationships between hedging determinants, speculation, hedging position (hedge ratio) and maturity. To verify our argument, we compare the results between models using hedge ratio as the dependent variable and using maturity respectively.

In this paper, we adopt two types of statistical models to separately evaluate the decision to hedge and the extent of hedging. One is Tobit model and the other is the so-called Heckman two-step model. Our empirical analysis is based on hand-collected hedging data[4] on U.S. oil and gas companies from their SEC filings via EDGAR Search. Our data set covers 55 firms from 2000 through 2008 for a total sample of 445 firm-year observations. We obtain the

[4] We thank Håkan Jankensgård (our thesis supervisor) for granting us access to his data collection.

financial data from *Compustat*. The sourcing of hedging data is aimed at oil and gas industry since hedging is an industry-related practice and the hedging need is more pronounced in this industry due to the direct and large exposure of production to commodity price fluctuation.

Our results show that, in line with major existing studies, some determinants are significant for the decision to hedge but not the extent of hedging. Our findings are in favour of our proposal, that is, maturity effectively supplements hedge ratio and can even be a substitute for it when evaluating a firm's hedging policy. Our findings also partially support the financing costs (judging from quick ratio), the costs of financial distress (from leverage) and the economies of scale (when using maturity as the dependent variable) hypotheses. Finally, because neither maturity nor hedge ratio is able to distinguish the hedging behaviour and speculation behaviour of companies, both of them are measuring the derivative usage of firms instead of the hedging behaviour of firms.

1.4 Contributions

This study contributes to the existing researches in that: (1) we find and test an unprecedentedly new effective proxy for corporate hedging that is supplementary to traditional hedge ratio, (2) we add insights to an under-researched aspect of corporate risk management, (3) we continue the work of testing classical theories and provide more recent empirical results, (4) we also test the most recent new theory about the relation between financial distress and hedging, and (5) we shed lights on how speculation could influence a firm's derivatives usage by unprecedentedly employing a right-hand side speculation variable to investigate the potential relationship between selective hedging and the use of derivatives.

1.5 Outline

The remaining parts of this paper are organized as follows. Section II reviews the existing literature that is highly relevant to this study. Section III describes our data, variables and methodology used in this paper. Section IV presents results of our models and discussion of those results. Section V concludes.

II. Literature Review

The “modern finance” starts with the famous study from Modigliani and Miller (1958) in which they argue that in an efficient capital market, the value of a firm is only created by its operating assets that ultimately increase operating cash flow and therefore the firm’s capital structure and financial policy are irrelevant. A consequent argument of their theorem, as pointed out by Froot, Scharfstein & Stein (1994), is apparently that risk management is also irrelevant to value creation of a firm because it is composed of purely financial transactions that don’t affect the value of a company’s operating assets and hence no influence on the operating cash flow. However, due to the imperfection of the real capital market, the cost of external financing and other factors that are simplified in the M&M theorem, the argument that risk management is irrelevant to creating value becomes questionable. In reality, the M&M assumptions are relaxed and the market imperfections have given rise to the demand of risk management (Ramlall, 2010).

2.1 Classical theoretical framework

2.1.1 Tax incentives hypothesis

According to Smith and Stulz (1985), the convex nature of corporate income tax itself (i.e. its progressiveness) creates incentive to hedge. Since the tax liability is a convex function of firm's pre-tax value, the after-tax value of firm is a concave function. It is argued that if a firm’s pre-tax income falls in the progressive region, it can realize lower effective tax liability that follows the convex function of pre-tax value by reducing the variability of pre-tax value through hedging, and thus increase the after-tax firm value.

2.1.2 Costs of financial distress hypothesis

Financial distress is a situation where firms have difficulty in meeting their contractually fixed obligations and the deteriorating financial strength incurs direct and indirect costs for firms. Financial distress cost is modelled as a function of the probability of falling into distress and the costs of bankruptcy (Ogden, Jen & O’Connor, 2003, p.157-163). Hinged on those two factors, the costs of financial distress can be reduced by reducing either the expected costs of

bankruptcy or the probability of encountering financial distress. Hedging is believed to be able to reduce the probability of company falling into distress through the reduction in variability of company's cash flow (Smith & Stulz, 1985; Nance, Smith & Smithson, 1993). Thus it is hypothesized that firms that are more financially distressed tend to hedge more. It is also argued that hedging can be in line with shareholder's interest because it can contribute to the reputation of a firm by enabling it to meet its debt obligation, so the firm could benefit in new debt issuance (Smith & Stulz, 1985; Bessembinder, 1991). However, a recent study by Rampini, Sufi & Viswanathan (2014) develops a new opinion that a trade-off between financing decision and risk management (hedging) due to collateral constraints would induce more financially distressed firms to hedge less, which is opposite to the traditional prediction.

The idea that the causality between leverage and hedging is bilateral is brought up by Graham and Rogers (2002). They argue that hedging stabilizes the company's income which in turn increases the debt capacity of the company. Supplementary to tax convexity, the increased debt capacity also contributes to the tax incentive for hedging as interest payments are tax deductible. The same argument is supported by Stulz (1996) and he further discusses that risk management helps eliminate company's downside risk and achieve the optimal capital structure as well as optimal ownership structure.

2.1.3. Managerial risk aversion hypothesis

Smith and Stulz (1985) contend that since the expected utility of managers depends on the distribution of their firm's payoffs which can be changed by hedging activities, hedging can change managers' expected personal wealth as well. If managers are risk-averse individuals, hedging is of manager's interest in that it reduces their non-diversifiable firm-specific risk. It is argued that by designing manager compensation as a convex function of firm value, the incentive of using hedging to alleviate risk is reduced. The convexity depends on the specific characteristics of options used in the compensation package (Ramlall, 2010).

2.1.4. Financing costs hypothesis

Another incentive for hedging rests upon the financing costs associated with external

financing. According to pecking order theory (Myers & Majluf, 1984), firms prioritize internal funds over external funds to make investments as information asymmetry is more severe in regard to external financing and thus makes external financing more costly. In the studies of Fazzari, Hubbard and Peterson (1988) and Kaplan and Zingales (1997), investment-cash flow sensitivity is estimated to be significant in manufacturing firms even for those that are not financially constrained. Most recently, when controlling for investment opportunities, Lewellen and Lewellen (2016) report that investment and cash flow are strongly linked. Hence, the incentive for hedging is built upon the premises that internal funds that are important for making positive NPV investments are subjected to external risk and hedging could secure the internal funds and thus avoid underinvestment and costs of external financing (Froot, Scharfstein & Stein, 1993; Bessembinder, 1991; Nance, Smith & Smithson, 1993). Furthermore, Ramlall (2010) suggests that limited internal funds increases agency costs and thus the risk premium demanded by investors. Complementing retained earnings, the use of derivatives reduces the agency cost and thus the financing costs. By availing internal funds and reducing financing costs, hedging alleviates underinvestment problem.

2.1.5. Signalling managerial skill hypothesis

Aside from manager's risk aversion, the informational effect of hedging is also worth noticing. It is argued that with the presence of information asymmetry between shareholders and managers, good managers tend to use hedging which eliminates the uncontrollable risk to manifest his/her superior managerial skills. The mechanism functions in a way that hedging removes "noise" from the firm's profits, leaving the rest as a purer indicator of managerial ability (DeMarzo & Duffie, 1995).

2.1.6. Economies of scale hypothesis

Early empirical studies use firm size as a proxy for financial distress costs because it is believed that the probability of encountering financial distress is higher for small firms so their hedging demand is higher. However the empirical findings actually present a positive relation between firm size and hedging activities. In order to explain this result, researchers

propose the economies of scale hypothesis. Nance, Smith and Smithson (1993) contend that financial derivatives markets show significant economies of scale in the structure of transaction costs, so it is more likely and convenient for large firms to hedge with derivatives.

2.1.7 Substitutes for hedging hypothesis

As Smith and Stulz (1985) suggest, "hedging" in a more general sense can refer to both financial hedging (i.e. trading particular financial contracts such as futures, forwards, swaps or options) and operating hedging (e.g. cutting capital expenditure, relocating overseas production facilities, engaging in mergers, etc.) because both strategies can lead to risk reduction. As Ramlall (2010) describes, foreign debt, holdings of liquid assets, dividends reduction and issuance of convertible debt or preferred stocks can be resorted to as alternatives to using derivatives. Hence firms with those alternatives at hands are less likely to use derivatives for hedging.

2.2 Empirical findings

A number of empirical studies regarding the determinants of firms' financial hedging activities have been conducted (see, for example, Nance, Smith & Smithson, 1993; Mian, 1996; Berkman & Bradbury, 1996; Tufano, 1996; Géczy, Minton & Schrand, 1997; Colquitt & Hoyt, 1997; Haushalter, 2000; Allayannis & Ofek, 2001; Graham & Rogers, 2002; Adam & Fernando, 2006; Adam, Fernando & Salas, 2017). However, results of those studies are rather mixed.

2.2.1 Findings on tax incentives

Tax loss carry-forwards shows positive evidence in the research of Berkman and Bradbury (1996) while it fails to confirm the relation between hedging and tax incentive in Mian (1996), Tufano (1996) and Nance, Smith and Smithson (1993)'s study. Mian and Nance et al., however, document a positive relationship when using tax credits as proxy for tax convexity. This indicates that the relation is not as robust as hypothesized. Graham and Rogers (2002) use an explicit measure of tax convexity and find no evidence of relation between tax convexity and hedging. Similarly, using simulated marginal tax rate and a binary variable that

stands for progressivity, Haushalter (2000) finds no support for the hypothesis.

2.2.2 Findings on costs of financial distress

No evidence is found in the study of Mian (1996). Ramlall (2010) believes that Mian has adopted the wrong proxy for financial distress as firm size should be an important determinant in its own right. Allayannis and Ofek (2001) employ ROA and leverage and find results opposite to the prediction of hypothesis. No significant relation between the proxies for financial distress and the likelihood of using currency derivative is found by Géczy, Minton and Schrand (1997) where interest coverage ratio and long-term debt ratio are used as proxy. Evidence in Haushalter's (2000) study confirms that the positive relation between hedging and financial leverage. By adopting a simultaneous equation system that takes the bidirectional relationship between hedging and leverage into account, Graham and Rogers (2002) corroborate the hypothesis that hedging and leverage are jointly determined.

2.2.3 Findings on managerial risk aversion

It is hypothesized that managers who have more stock holdings of their companies are more inclined to conduct risk management while managers who own more options have less motive to perform risk management (Smith & Stulz, 1985). A somewhat surprising fact is that only Tufano (1996) provides supportive evidence for this hypothesis using data from gold mining industry.

2.2.4 Findings on financing costs

It is hypothesized that firms with more growth opportunities but limited liquidity are more likely to hedge. Hedgers are not found to have higher market-to-book value in the Mian's (1996) study but they are found to have larger R&D expenditure in Allayannis and Ofek's (2001) research. Similarly, Géczy, Minton and Schrand (1997) also indicate that the ratio of R&D expenditure to sales is positively correlated with the probability of using derivative and quick ratio which stands for internally available funds is negatively correlated with the use of derivative. In Graham and Rogers' (2002) research, R&D expense and book-to-market ratio suggest opposite evidence to what the theory predicts but in line with Géczy, Minton and

Schrand (1997) - a positive relation between hedging and the product of debt and market-book ratio is found.

2.2.5 Findings on signalling managerial skill; economies of scale; hedging substitutes

Only Tufano (1996) has found evidence that firms with a greater percentage held by outside blockholders tend to manage less risk while using institutional ownership or blockholder ownership as indicator, none of the other empirical studies (Géczy, Minton & Schrand, 1997; Haushalter, 2000; Graham & Rogers, 2002) has documented any significant relationship between signaling effect and company's' hedging policy.

A number of researches present supportive evidence for economies of scale hypothesis (see, for example, Mian, 1996; Géczy, Minton & Schrand, 1997; Colquitt & Hoyt, 1997; Haushalter, 2000; Graham & Rogers, 2002; Adam & Fernando, 2006).

The most representative findings by Nance, Smith and Smithson (1993), Berkman and Bradbury (1996), Géczy, Minton and Schrand (1997) and Graham and Rogers (2002) unanimously show a negative relation between the substitutes and hedging.

2.3 Speculative motivation for derivatives usage

It should be pointed out that financial derivatives can be used not only for pure hedging purpose but also for speculation purpose. Ljungqvist (1994) identifies several incentives for non-financial firms to engage in speculative trading so it is possible that firms using derivatives are speculating rather than hedging. Adam, Fernando and Salas (2017) note that larger firms are believed to possess an informational advantage over smaller ones and thus have more incentive to speculate. A wealth transfer (asset substitution) motive for financially distressed firms to engage in selective hedging is asserted by Stulz (1996) and the argument is supported by Campbell and Kracaw (1999) that financially constrained firms have incentive to speculate, hoping to overcome the financial constraints. Adam, Fernando and Salas (2017) further argue that the compensation structure affects manager's risk tolerance and hence their willingness to speculate. In order to probe into the relationship between speculation and

hedging and to distinguish the two types of behaviours by firms, researchers define the term "selective hedging" as the practice of managers altering the size and timing of the firm's hedging programs based on their market views (Stulz, 1996; Adam & Fernando, 2006; Jankensgård, 2015; Adam, Fernando & Salas, 2017). A series of empirical studies attempt to derive an explicit mathematical measurement for selective hedging and hence to reveal the underlying relationship between the decision to speculation and its determinants (see, for example, Faulkender, 2005; Adam & Fernando, 2006; Brown, Crabb & Haushalter, 2006; Géczy, Minton & Schrand, 2007; Jankensgård, 2015; Adam, Fernando & Salas, 2017).

2.4 Hypotheses

In order to validate our proposal for using maturity as the measure of corporate hedging policies that can be supplementary to hedge ratio, several hypotheses need to be tested and their outputs need to be compared. Based on previous researches, all relevant hypotheses in this study can be summarized as bellow.

H1: Tax convexity is predicted to have a positive relation with hedging demand, thus positively related to maturity and hedge ratio of a firm's derivatives positions.

H2: Financial distress costs are predicted to have positive relations with hedging demand, thus positively related to maturity and hedge ratio of a firm's derivatives positions.

H3: Managerial risk aversion is predicted to have a positive relation with hedging demand, thus positively related to maturity and hedge ratio of a firm's derivatives positions.

H4: Financing costs are predicted to have positive relations with hedging demand, thus positively related to maturity and hedge ratio of a firm's derivatives positions.

H5: Economies of scale is predicted to have a positive relation with hedging demand, thus positively related to maturity and hedge ratio of a firm's derivatives positions.

H6: Substitutes for hedging are predicted to have negative relations with hedging demand, thus negatively related to maturity and hedge ratio of a firm's derivatives positions.

H7: Selective hedging behaviour is predicted to be negatively related to maturity of a firm's derivatives positions.

III. Methodology

This section describes how the relevant data used for the research is retrieved, how hypotheses are operationalized into variables, and how econometric methods are applied to process the data.

3.1 Sample

Data are collected on firms in U.S. oil and gas industry during a time horizon of 2000 to 2008.

The oil and gas industry is chosen in this study because this industry has some features that make it especially suitable for an analysis of firms' derivatives usage. First, the volatility of prices of oil and gas subjects the producers to the commodity price risk and has substantial influence on the variability of their cash flows. Second, oil and gas firms have available and relevant financial tools to hedge against this particular risk (e.g. futures and options for crude oil and natural gas on NYMEX, forwards and swaps in OTC markets). Third, the practice of incorporating the use of derivatives in a firm's risk management strategies is dispersed and not unusual among oil and gas industry (for instance, in 2004 the hedge ratio of sample firms ranges from zero to 94%), thus the variance of derivatives usage needed for conducting statistical analysis is satisfied.

The timespan of 2000 to 2008 can be divided into two sub-periods. 2000-2003 is characterized by a stable oil price while 2004-2008 is a time period in which oil price flies and the macroeconomic environment is tempting for firms to engage in speculation instead of hedging. Hence the data on corporate derivatives usage collected within the chosen time horizon is believed to be more informative with regard to distinguishing firms' hedging and speculating behaviours.

Data required for independent variables are collected from *Compustat* and EDGAR Search of SEC's website. After eliminating sample firms without any production within the time period, this research is left with an unbalanced panel data with 445 observations in total.

3.2 Dependent variables

This study introduces a new measure of hedging policy using maturity of derivatives, which hypothetically could distinguish between hedging behaviour and speculating behaviour among firms. Previous studies have shown that hedging effectiveness increases with maturity (Ederington, 1979; Hill & Schneeweis, 1982; Geppert, 1995; Lien & Shrestha, 2007; Ghoddusi & Emamzadehfard, 2017). If our proposal holds, despite the essential difference between volume and maturity aspects of derivatives, we would expect to find similar statistical functioning patterns shared by hedge ratio and maturity as dependent variable in models. Although strictly speaking, hedge ratio and maturity are measuring the general derivative usage of firms instead of their pure hedging activity, the two variables are still used to represent the hedging activity of firms as in traditional models to test the relations between determinants to hedge and hedging activity.

Although maturity is predicted to perform similarly to hedge ratio as regard to the prediction of coefficient signs of the majority of hedging determinants, the inherent differences between maturity and hedge ratio still can have influence on the coefficients themselves and the estimations. So maturity is also expected to reveal additional information beyond the traditional measure where, according to previous empirical studies, the findings of relations between hedge ratio and hedging determinants are not unanimous. Therefore using maturity to replace hedge ratio might be able to discover connections that is not confirmed by using hedge ratio or not shown to be robust in the traditional model and shed lights on the role of planning horizon in the strategic planning of hedging. In addition, maturity potentially can distinguish firms' speculating and hedging behaviour.

Since one of the aims of this study is to supplement the traditional measure of hedging policy with a new metric that could potentially distinguish between firm's hedging behaviour and speculative behaviours and contribute to a more transparent, clarifying and purified measure of the extent of hedging, both traditional proxy of hedging policy and the new proxy are used in the research and results obtained from using different dependent variables are compared in

order to gain insight of how well the new variable performs.

The traditional proxy for hedging policy is hedge ratio. In this study, the hedge ratio of firms during 2000-2008 is calculated as the hedged amount divided by total production. Data on sample firms' derivative usage are retrieved from annual reports and hedged amount is arrived at by adding together firm's long positions in puts and their positions in linear derivatives including forwards, futures and swaps. The weighted average maturity[5] of the derivative positions that firms hold each year is chosen to represent the new proxy for hedging policy. Binary variables which take on value 1 if the firm has a non-zero value of hedge ratio or maturity respectively and zero otherwise are also formulated in order to construct the decision model in Heckman two-stage estimation.

3.3 Independent variables

3.3.1 Tax incentives

Early studies have used tax loss carry-forwards, investment tax credits and foreign tax credits as proxies for tax convexity (Nance, Smith & Smithson, 1993; Berkman & Bradbury, 1996; Mian, 1996; Tufano, 1996; Géczy, Minton & Schrand, 1997). Graham and Rogers (2002) use an explicit measure of tax convexity – "dollar tax benefit from a five percent volatility reduction, scaled by sales revenue". In Haushalter's (2000) study, simulated marginal tax rates and a binary variable that stands for progressivity are employed.

In this study, the proxy for tax incentive is chosen to be *tax loss carry-forwards*[6]. We define a dummy variable which takes on value 1 if the firm has tax loss carry-forwards in presence and 0 otherwise. The predicted sign of its coefficient is positive.

3.3.2 Costs of financial distress

Researchers usually choose leverage/debt ratio, return on assets (ROA) and interest coverage

[5] In this study, maturity and duration are used interchangeably.

[6] We also considered investment tax credits when designing this study. However, when processing data from Compustat, we found that none of the sample firms has records under this item. As a result, we dropped the investment tax credits variable.

ratio in their studies (see, for example, Nance, Smith & Smithson, 1993; Mian, 1996; Berkman & Bradbury, 1996; Tufano, 1996; Géczy, Minton & Schrand, 1997; Colquitt & Hoyt, 1997; Haushalter, 2000; Allayannis & Ofek, 2001; Graham & Rogers, 2002; Adam & Fernando, 2006; Adam, Fernando & Salas, 2017). Both book-value and market-value measurements can be employed.

We follow the majority of literature and choose *leverage*, *ROA* and *interest coverage ratio*. Leverage ratio is calculated as the ratio of a firm's book value of debt to the sum of its market value of equity, book value of liabilities and book value of preferred stocks. ROA is computed as dividing a firm's EBIT with market value of total assets. To arrive at interest coverage ratio, EBIT is divided by interest expense. Theoretically their coefficients are positive, negative and negative, respectively.

3.3.3 Managerial risk aversion

Previous literature exhibits a variety of choices regarding the proxy for managers' risk aversion. The most chosen measures are managerial stock ownership and number of options granted to management (Berkman & Bradbury, 1996; Tufano, 1996; Géczy, Minton & Schrand, 1997; Haushaler, 2000; Allayannis & Ofek, 2001). Graham and Rogers (2002) use two interesting measures: Vega and delta of derivatives scaled by the CEO's salary plus bonus. Júnior (2013) takes corporate governance index. Adam, Fernando and Salas (2017) consider an array of corporate governance measures such as board size, staggered board dummy, CEO duality dummy and so on.

There are two proxies used in this study: one is the *management's stock ownership* (in percentage), the other is the *number of outstanding stock options* granted to management at the beginning of the year (in millions). The higher the management's stock ownership, the higher the demand for hedging while the higher the amount of options owned by managers, the lower the demand for hedging.

3.3.4 Financing costs

R&D expenses, quick ratio and market-to-book ratio of a firm's total assets are three prevalently-taken proxies among the past researches (Nance, Smith & Smithson, 1993; Mian, 1996; Géczy, Minton & Schrand, 1997; Allayannis & Ofek, 2001; Graham & Rogers, 2002; Adam & Fernando, 2006; Brown, Crabb & Haushalter, 2006; Júnior, 2013; Adam, Fernando & Salas, 2017). Graham and Rogers (2002) additionally use capital expenditure on property, plant and equipment. Tufano (1996) and Haushalter (2000) adopt more industry-specific proxies: the former uses exploration expenditures, the latter uses investment expenditures.

In this paper, three proxies[7] are adopted: (1) *Capital expenditure on PPE*, defined as a firm's capital expenditure on PPE scaled by firm size, (2) *quick ratio*, calculated as current assets divided by current liabilities and (3) *market-to-book ratio* of the firm's total assets. Except quick ratio, positive relation is expected for other two variables.

3.3.5 Economies of scale

Various studies choose firm size as the proxy and this measure becomes a standard independent variable in models (see, for example, Nance, Smith & Smithson, 1993; Mian, 1996; Géczy, Minton & Schrand, 1997; Colquitt & Hoyt, 1997; Haushalter, 2000; Graham & Rogers, 2002; Adam & Fernando, 2006; Adam, Fernando & Salas, 2017).

We are in line with those previous papers and take *firm size* as the proxy. This variable is defined as the natural logarithm of a firm's market value of total assets which equals its book value of total liabilities plus market value of total equity, with an expectation of positive relation.

3.3.6 Substitutes for hedging

Typical substitutes for financial hedging viewed by researchers are dividends, convertible debt and preferred stocks (Nance, Smith & Smithson, 1993; Berkman & Bradbury, 1996;

[7] Originally we considered R&D expenses as well. However, when processing data from Compustat, we found that there are too few observations with R&D expenditure, which will greatly reduce the sample size and will not be able to generate a meaningful result. Consequently we dropped this variable.

Géczy, Minton & Schrand, 1997; Graham & Rogers, 2002).

In this paper, we define hedging as using any type of financial derivatives by oil and gas firms against their price-change risk exposure. In order to account for effects brought by substitutes, we take three related proxies: (1) *dividend yield*, using dividends per share, (2) *convertible debt*, defined as book value of convertible debt scaled by firm size, and (3) *preferred stocks*, defined as book value of preferred stocks over firm size. Theoretical prediction of coefficient's sign is negative for all the three variables.

3.3.7 Selective hedging

In Adam, Fernando and Salas' (2017) study, selective hedging behaviour is measured by time variations of the volume of derivatives used by companies. Jankensgård (2015) uses a dummy variable which will equal zero if the change for amount, maturity, and style of the hedging portfolio simultaneously are smaller than predefined thresholds and one otherwise.

A binary variable (a value of 1 or 0) is used as the *speculation indicator*. To arrive at the speculation indicator variable, a sample firm's nine-year average and standard deviation of hedge ratio, both in an annual term, are firstly calculated. Then the difference between each year's actual hedge ratio and the average ratio is divided by the standard deviation, which is named "distance to mean". Finally, if the absolute value of this distance is larger than 1.5, a value of 1 will be assigned to that year's binary speculation variable. The underlying rationale is that the more volatile the hedge ratios of a firm, the more likely that the firm engages in selective hedging, since the management's market view is incorporated in the hedging strategy so that the annual hedge ratio could deviate from a stable one no matter the deviation is positive (hedge ratio increases) or negative (hedge ratio decreases). Furthermore, the threshold of 1.5 (in absolute value) standard deviation is set to exclude the deviations that are not large enough to be indicative of speculation.

When setting the threshold as 1.5, about 90% of the firm-time observations of the hedgers in our sample will be deemed non-speculative. The chosen threshold is hence rather strict.

Consider the wide presence of selective hedging, using a strict threshold will be able to make sure that the speculation defined are valid and there is a more obvious and considerable distinction between speculator and hedger. This study has also attempted looser (0.657[8]) and stricter (1.7 and 2.0) thresholds and the defined speculation has a consistent positive relation with hedging but with different statistical significance level. Since the variance in performance when different thresholds are used is small and using a distance to mean of 1.5 presents the most reasonable significance level (in the Tobit model and the first stage of Heckman two-step estimation), this threshold is hence adopted.

It is hypothesized in this study that firms with higher speculative demands would prefer derivatives with shorter maturity which provides more flexibility as they need to adjust the volume and maturity of their positions more frequently than pure hedgers to take advantage of market timing.

Table I lists all tested hypotheses, relevant proxies and our predictions of the sign of each coefficient. Table II summarizes information on dependent variables and independent variables in this paper.

[8] Median of the "distance to mean" variable (in absolute value) is about 0.653.

Table I. Summary of hypotheses, representing proxies and prediction of coefficient signs

	Hypothesis											
	Tax incentives		Financial distress costs		Managerial risk aversion		Financing costs		Economies of scale		Substitutes for hedging		Selective hedging	
Proxies	Hedge ratio	Maturity	Hedge ratio	Maturity	Hedge ratio	Maturity	Hedge ratio	Maturity	Hedge ratio	Maturity	Hedge ratio	Maturity	Hedge ratio	Maturity
Tax loss carry-forwards	+	+												
Leverage			+	+										
Interest coverage ratio			-	-										
ROA			-	-										
CAPEX on PPE							+	+						
Liquidity (Quick ratio)							-	-						
Market-to-book ratio							+	+						
Management ownership					+	+								
Options for management					-	-								
Firm size									+	+				
Dividend yield											-	-		
Convertible debt											-	-		
Preferred stocks											-	-		
Speculation indicator													/	-

In this study, two types of dependent variable are included: hedge ratio and maturity.

Table II. Summary of dependent and independent variables

Dependent variables	Definition
Hedge ratio	Extent of hedging: ratio of the hedged amount of production divided by total production
	Decision to hedge: binary variable = 1 if the firm enters into derivatives transaction, 0 otherwise
Maturity	Extent of hedging: weighted average duration of the firm's derivatives portfolio
	Decision to hedge: binary variable = 1 if the firm enters in to derivatives transaction, 0 otherwise.
Independent variables	
Tax loss carry-forwards	Binary variable = 1 if the firm has a record of tax loss carry-forward, 0 otherwise
Leverage	Ratio of the firm's book value of debt to the sum of its market value of equity, book value of liabilities and book value of preferred stocks
Interest coverage ratio	Ratio of the firm's EBIT to its interest expense
ROA	Ratio of the firm's EBIT to market value of its total assets
Capital expenditure on PPE	Ratio of the firm's capital expenditure on PPE to firm size
Quick ratio	Ratio of the firm's current assets to its current liabilities
Market-to-book ratio	Ratio of the firm's market value of total assets (market value of equity + book value of liabilities + book value of preferred stocks) to the book value of total assets (book values of equity, liabilities and preferred stocks)
Management stock ownership	Percentage of the stock ownership held by all directors and managers as a group
Outstanding options granted for management	Number of outstanding stock options (in millions) granted to management at the beginning of the fiscal year
Firm size	Natural logarithm of the firm's market value of total assets (book value of total liabilities + market value of total equity)
Dividend yield	Dividends per share
Convertible debt	Ratio of the firm's book value of convertible debt to firm size
Preferred stocks	Ratio of the firm's book value of preferred stocks to firm size
Speculation indicator	Binary variable = 1 if the firm is classified to be speculating based on the distance to its mean hedge ratio, 0 otherwise

3.4 Model specification

In this paper, the econometric methods applied to process the data are Tobit model and Heckman's (1979) two-stage estimation procedure. The model choices are in line with previous empirical studies (Allayannis & Ofek, 2001; Berkman & Bradbury, 1996; Tufano, 1996; Colquitt & Hoyt, 1997; Haushalter, 2000; Graham & Rogers, 2002; Adam, Fernando & Salas, 2017).

The fact that the dependent variables (hedge ratio, maturity) are censored, that is, not for all

observations a positive outcome is observed, causes a concentration of observations at zero values. The censoring of dependent variables at zero values leads to the choice of Tobit model in which robust covariance is employed to control for heteroscedasticity while Heckman's two-stage estimation procedure corrects for the selection bias in the sample.

In the simplest form of Tobit model, a latent variable y_i^* is assumed and it is linearly determined by x_i via correspondent parameter β. The error term that captures the residual variations, μ_i, is assumed to follow a normal distribution. Whenever the latent variable y_i^* estimated is greater than zero, the observable variable y_i is set equal to the predicted value y_i^* and zero otherwise. This can be described as:

$$y_i = \begin{cases} y_i^*, \text{if } y_i^* > 0 \\ 0, \text{if } y_i^* \leq 0 \end{cases}$$

$$y_i^* = \beta x_i + \mu_i, \mu_i \sim N(0, \sigma^2)$$

The foundations for Heckman two-step estimation are

$$Z_i = W_i\gamma + \mu_i$$

$$y_i = X_i'\beta + \varepsilon_i$$

$$E(y_i|Z_i = 1) = X_i'\beta + \rho\sigma\lambda_i(W_i\gamma)$$

Z_i is a binary variable which takes value 1 or 0 depending on the predicted probability in the first stage's Probit model; μ_i and ε_i are error terms following a bivariate normal distribution:

$\begin{bmatrix} \varepsilon_i \\ \mu_i \end{bmatrix} \sim N \begin{bmatrix} \sigma^2 & \rho\sigma \\ \rho\sigma & 1 \end{bmatrix}$, ρ - correlation coefficient, σ - the scale parameter

$\lambda_i(W_i\gamma) = \phi(W_i\gamma)/\Phi(W_i\gamma)$ is the Inverse Mills Ratio, calculated from the first stage model and accounts for the selection bias. ϕ and Φ are the standard normal density and cumulative distribution function, respectively.

In the first stage of Heckman two-step estimation, a Probit model is formulated for the probability of using derivatives. Estimation of the model yields results that can be used to predict the probability of using derivatives for each firm. In the second stage, a transformation of the predicted probabilities in the first stage is incorporated as an additional explanatory variable in order to correct for self-selection since the second model is an OLS model estimated conditional on that the firms use derivatives.

Moreover, econometric treatments on the potential simultaneity between leverage and hedging are also required. The panel data property of the data obtained demands standard econometric panel data treatments which correct for the time variations and cross-sectional variations of the relationship between determinants of hedging, speculative behaviour and proxies for derivative usage.

Above mentioned methods are technical procedures that are undertaken to process the data, but generally speaking, two sets of relations are examined and compared in this paper, namely, the relationship between hedge ratios (traditional proxy for hedging policy) and determinants of hedging along with speculation and the relationship between weighted average maturity of derivative positions and determinants of hedging along with speculation.

IV. Model results and analyses

4.1 Univariate analysis

4.1.1 Descriptive statistics

Table III and IV together give a first-look description of hedgers and non-hedgers. Table V concludes the T-test results of a comparison between hedgers and non-hedgers. Table VI, VII and VIII depict short- and long-maturity hedgers.

Table III. Descriptive statistics of hedgers, judging from hedge ratio

	HEDGE_RATIO	BINARY__TAX_LOSS_CARRY_F	CAPEX_SCALED	CONVERTIBLE_DEBT__SCALED	DIVIDEND_YIELD	INTEREST_COVERAGE	LEVERAGE	LOG_FIRM_SIZE	MARKET_TO_BOOK_VALUE	NO_OUTSTANDING_OPTIONS__	PERCENTAGE_MANAGEMENT_OW	PREFERRED_STOCKS__SCALED	QUICK_RATIO	ROA	SPECULATION_BINARY
Mean	0.41	0.53	0.17	0.02	0.19	11.62	0.32	3.14	1.52	4.68	0.15	0.01	0.96	0.02	0.13
Median	0.36	1.00	0.14	0.00	0.00	4.03	0.28	3.08	1.39	2.53	0.09	0.00	0.94	0.06	0.00
Maximum	3.08	1.00	0.74	0.50	2.48	719.90	0.83	4.81	3.78	27.23	0.90	0.28	3.02	0.31	1.00
Minimum	0.00	0.00	0.00	0.00	0.00	-34.90	0.00	0.45	0.52	0.00	0.00	0.00	0.05	-1.25	0.00
Std. Dev.	0.34	0.50	0.12	0.06	0.38	61.54	0.17	0.81	0.58	5.50	0.19	0.03	0.44	0.17	0.34
Obs.	215	215	215	215	215	215	215	215	215	215	215	215	215	215	215

A hedger is identified if its hedge ratio is non-zero, and thus a value of 1 will be given to the firm's binary variable regarding the decision to hedge. We exclude those firms whose hedge ratios cannot be computed due to the lack of its productions.

Table IV. Descriptive statistics of non-hedgers, judging from hedge ratio

	HEDGE_RATIO	BINARY__TAX_LOSS_CARRY_F	CAPEX_SCALED	CONVERTIBLE_DEBT__SCALED	DIVIDEND_YIELD	INTEREST_COVERAGE	LEVERAGE	LOG_FIRM_SIZE	MARKET_TO_BOOK_VALUE	NO_OUTSTANDING_OPTIONS__	PERCENTAGE_MANAGEMENT_OW	PREFERRED_STOCKS__SCALED	QUICK_RATIO	ROA	SPECULATION_BINARY
Mean	0.00	0.40	0.14	0.02	0.10	8.12	0.21	2.41	1.54	3.03	0.22	0.01	1.87	0.01	0.05
Median	0.00	0.00	0.13	0.00	0.00	2.87	0.21	2.50	1.30	1.56	0.14	0.00	1.28	0.05	0.00
Maximum	0.00	1.00	0.46	0.31	1.09	402.29	0.70	4.53	5.02	26.97	0.68	0.30	12.80	0.32	1.00
Minimum	0.00	0.00	0.00	0.00	0.00	-101.96	0.00	0.42	0.33	0.00	0.01	0.00	0.04	-0.80	0.00
Std. Dev.	0.00	0.49	0.09	0.07	0.26	54.51	0.17	0.92	0.86	4.55	0.18	0.05	2.08	0.16	0.21
Obs.	63	63	63	63	63	63	63	63	63	63	63	63	63	63	63

A non-hedger is identified if its hedge ratio is zero, and thus a value of 0 will be given to the firm's binary variable regarding the decision to hedge.

Table V. T-test results of a comparison between hedgers and non-hedgers

BINARY__TAX_LOSS_CARRY_F	CAPEX_SCALED	CONVERTIBLE_DEBT__SCALED	DIVIDEND_YIELD	INTEREST_COVERAGE	LEVERAGE	LOG_FIRM_SIZE	MARKET_TO_BOOK_VALUE	NO_OUTSTANDING_OPTIONS_	PERCENTAGE_MANAGEMENT_OW	PREFERRED_STOCKS__SCALED	QUICK_RATIO	ROA	SPECULATION_BINARY
Predicted relation of means between hedgers and non-hedgers:													
H > NH	H > NH	H < NH	H < NH	H < NH	H > NH	H > NH	H > NH	H < NH	H > NH	H < NH	H < NH	H < NH	H > NH
Comparison between hedgers and non-hedgers:													
H > NH	H > NH	H < NH	H > NH	H > NH	H > NH	H > NH	H < NH	H > NH	H < NH	H < NH	H < NH	H > NH	H > NH
P-value for t-test statistic (one-tail):													
0.0030	**0.0032**	0.3862	0.1364	0.2636	**0.0000**	**0.0000**	0.2394	**0.0432**	**0.0000**	0.2135	**0.0054**	0.4923	**0.0262**

All variables are defined in Table II. P-values that are less than 10 percent are in bold.

Table VI. Descriptive statistics of short-maturity hedgers

	Duration	Hedge ratio	Bi tax loss carry forwards	CAPEX scaled	Convertible debt scaled	Dividend yield	Interest coverage	leverage	Log firm size	MV/BV	No. outstanding options	Percentage management ownership	Preferred stock scaled	Quick ratio	ROA	Binary speculation
Mean	1.00	0.35	0.48	0.17	0.02	0.13	5.15	0.30	2.92	1.52	3.87	0.19	0.01	1.01	0.00	0.16
Median	1.00	0.30	0.00	0.15	0.00	0.00	4.08	0.27	2.83	1.42	2.02	0.11	0.00	0.97	0.07	0.00
Maximum	1.00	1.36	1.00	0.55	0.50	1.50	44.30	0.83	4.77	3.71	23.23	0.90	0.28	2.58	0.31	1.00
Minimum	1.00	0.00	0.00	0.00	0.00	0.00	-34.90	0.00	0.45	0.65	0.24	0.00	0.00	0.17	-1.25	0.00
Std. Dev.	0.00	0.29	0.50	0.10	0.08	0.29	11.87	0.18	0.81	0.59	4.67	0.22	0.04	0.46	0.24	0.37
Obs.	89	89	89	89	89	89	89	89	89	89	89	89	89	89	89	89

For a hedger whose weighted average duration is not greater than 1 year (12 months), i.e. 0 < duration ≤ 1.00, it will be defined as a short-maturity hedger. In our data set, no firm has duration between 0 and 1.00.

Table VII. Descriptive statistics of long-maturity hedgers

	Duration	Hedge ratio	Bi tax loss carry forwards	CAPEX scaled	Convertible debt scaled	Dividend yield	Interest coverage	leverage	Log firm size	MV/BV	No. outstanding options	Percentage management ownership	Preferred stock scaled	Quick ratio	ROA	Binary speculation
Mean	1.52	0.45	0.57	0.17	0.01	0.23	16.08	0.33	3.29	1.52	5.21	0.13	0.00	0.93	0.03	0.12
Median	1.37	0.43	1.00	0.13	0.00	0.00	3.88	0.29	3.18	1.39	3.05	0.07	0.00	0.91	0.05	0.00
Maximum	4.77	3.08	1.00	0.74	0.28	2.48	719.90	0.77	4.81	3.78	27.23	0.70	0.13	3.02	0.17	1.00
Minimum	1.03	0.00	0.00	0.00	0.00	0.00	-25.52	0.02	1.44	0.52	0.00	0.00	0.00	0.05	-0.52	0.00
Std. Dev.	0.49	0.37	0.50	0.13	0.04	0.38	79.27	0.17	0.77	0.57	5.96	0.16	0.02	0.43	0.10	0.32
Obs.	127	127	127	127	127	127	127	127	127	127	127	127	127	127	127	127

For a hedger whose weighted average duration is greater than 1 year (12 months), i.e. duration > 1.00, it will be defined as a long-maturity hedger.

Table VIII. T-test results of a comparison between short-maturity and long-maturity hedgers

Hedge ratio	Bi tax loss carry forwards	CAPEX scaled	Convertible debt scaled	Dividend yield	Interest coverage	leverage	Log firm size	MV/BV	No. outstanding options	Percentage management ownership	Preferred stock scaled	Quick ratio	ROA	Binary speculation
Predicted relation of means between short-maturity and long-maturity hedgers:														
S < L	S < L	S < L	S > L	S > L	S > L	S < L	S < L	S < L	S > L	S < L	S > L	S > L	S > L	S > L
Comparison between short-maturity and long-maturity hedgers:														
S < L	S < L	S < L	S > L	S < L	S < L	S < L	S < L	S > L	S < L	S > L	S > L	S > L	S < L	S > L
P-value for t-test statistic (one-tail):														
0.0010	**0.0217**	0.1118	0.2477	**0.0011**	0.1015	**0.0491**	**0.0000**	0.3562	**0.0240**	**0.0156**	**0.0104**	0.1723	0.3898	0.4964

All variables are defined in Table II. P-values that are less than 10 percent are in bold.

Results of the T-test confirm that many characteristics of hedgers and non-hedgers are statistically significantly different from each other. Among those variables that the difference between two groups' means are statistically significant at a level of 5 percent, tax loss carry-forwards binary, leverage, capital expenditure on PPE, quick ratio, firm size and speculation indicator have a relation between hedging firms and non-hedging firms that is matched with the theory's prediction. In our samples, firms engaging in hedging typically have more records of a tax convexity item, higher leverage ratio, more growth opportunities, less liquidity, larger size and are more suspected as behaving speculatively. However, though the same significant at a 5 percent level, the relations of the differences between hedgers' and non-hedgers' managerial stock ownership and between their number of outstanding stock options granted to management are opposite to the theoretical predictions. This suggests that hedgers in our samples generally have a smaller portion of ownership under their management members' control and they grant more stock options to their management than non-hedgers.

Supplementary to the descriptions of hedgers and non-hedgers, Table VI and Table VII provide depictions of characteristics of short-maturity ($0 < \text{duration} \leq 1$ year) derivatives users and long-maturity (duration > 1 year) derivatives users. The criteria for drawing the line between short- and long-term is analogous to the criteria for defining short- and long-term debt in which obligations with longer than 1-year (12 months) maturity is considered as long-term debt. According to implications from theories, since maturity is positively associated with hedging effectiveness, the long-term derivatives users should have stronger hedging demand than short-term users thus the incentive factors should be more obvious among long-term hedgers. The statistical comparison, summarized in Table VIII, supports the theories in that firms which adopt longer term hedging strategy have larger hedge ratio, more tax convexity, higher leverage, less preferred stock, and larger in size while contradictory to the theories, they have lower management stock ownership but higher option ownership and higher dividend yield. Whether the findings are systematic or not needs to be further examined with more sophisticated models.

4.1.2 Correlation Matrix

Table IX presents the correlation matrix of 16 variables employed in our regression models, excluding the two binary dependent variables.

Multicollinearity issues among some independent variables are manifested in the correlation matrix. There is a strong and positive correlation (0.57) between number of options granted to directors and officers and firm size while a strong and negative correlation (-0.58) between the percentage stock ownership of directors and officers and the firm size is identified. This indicates that bigger firms are associated with lower insider ownership and higher stock options granted to management team. The underlying rationale could be that small firms' major owners are the founders and their equity is not yet extensively diluted thus insider ownership is often large in small firms. In the same regards, there is less principal-agent conflict of interest in small firms since the owner and management are most likely to be the same people. However the agency problem is more severe in big firms due to the extensive diversification of ownership thus more incentive plans and stock option grants are adopted in order to align the interest of shareholders and management. Moreover, firm size is also strongly positively associated with dividend yield (0.41), which suggests that larger firms pay more dividends. A probable explanation is that large firms are in the mature stage of their business and have more excess capital after investments to return to shareholders.

Another important indication is that hedge ratio is strongly (0.42) positively correlated with duration of derivatives. This suggests that the innovative measure of hedging this study investigates to supplement the traditional measure is relevant and reasonable. No matter whether the usage of derivative is resulted from incentives to hedge or speculate, they have implications on the durations chosen for the derivatives.

Table IX. Correlation matrix of 16 variables, excluding binary dependent variables

	BINARY__TAX_LOSS_CARRY_F	CAPEX_SCALED	CONVERTIBLE_DEBT__SCALED	DIVIDEND_YIELD	HEDGE_RATIO	INTEREST_COVERAGE	LEVERAGE	LOG_FIRM_SIZE	MARKET_TO_BOOK_VALUE	NO_OUTSTANDING_OPTIONS__	PERCENTAGE_MANAGEMENT_OW	PREFERRED_STOCKS__SCALED	QUICK_RATIO	ROA	SPECULATION_BINARY	DURATION
BINARY__TAX_LOSS_CARRY_F	1.00															
CAPEX_SCALED	0.20	1.00														
CONVERTIBLE_DEBT__SCALED	0.00	0.06	1.00													
DIVIDEND_YIELD	-0.26	-0.29	-0.12	1.00												
HEDGE_RATIO	0.13	0.13	0.03	-0.02	1.00											
INTEREST_COVERAGE	0.03	-0.07	-0.06	0.02	0.02	1.00										
LEVERAGE	-0.07	0.24	0.19	-0.04	0.11	-0.17	1.00									
LOG_FIRM_SIZE	-0.03	-0.16	-0.10	**0.41**	0.05	0.03	0.13	1.00								
MARKET_TO_BOOK_VALUE	-0.03	-0.27	0.00	0.11	0.06	0.22	-0.37	0.21	1.00							
NO_OUTSTANDING_OPTIONS__	-0.13	-0.23	-0.10	0.40	0.01	-0.02	0.15	**0.57**	-0.06	1.00						
PERCENTAGE_MANAGEMENT_OW	0.11	0.11	0.03	-0.26	0.07	-0.08	-0.14	**-0.58**	-0.06	-0.33	1.00					
PREFERRED_STOCKS__SCALED	0.13	-0.02	0.15	-0.11	0.01	-0.05	0.02	-0.15	-0.07	-0.06	0.07	1.00				
QUICK_RATIO	-0.20	-0.17	0.03	0.02	-0.20	-0.00	-0.19	-0.17	-0.09	-0.03	0.10	-0.01	1.00			
ROA	-0.01	-0.29	-0.26	0.16	0.01	0.18	-0.11	0.23	0.14	0.16	-0.02	-0.05	-0.04	1.00		
SPECULATION_BINARY	-0.01	-0.04	-0.01	-0.05	0.24	-0.03	-0.05	-0.07	0.03	-0.04	0.05	0.18	-0.06	0.07	1.00	
DURATION	0.10	0.14	-0.05	0.13	**0.42**	0.01	0.25	0.35	-0.02	0.14	-0.18	-0.11	-0.28	0.08	0.18	1.00

All variables are defined in Table II.

4.2 Tobit model results

Table X presents the results of Tobit models using hedge ratio and duration as dependent variable, respectively. The results are also applied to investigate the simultaneity between leverage and hedging as shown in Appendix A. Selective results from Appendix A are also presented here.

Table X. Results of Tobit models

Independent variables	Panel A (DV: Hedge ratio)	Panel B (DV: Duration)
Binary: tax loss carry-forwards	0.083144	0.144015
	(1.609916)	(1.502143)
CAPEX	0.370698*	0.716389*
	(1.794501)	(1.709524)
Convertible debt	0.276032	-0.011638
	(0.748103)	(-0.016372)
Dividend yield	0.090609	0.260058**
	(1.240676)	(2.083281)
Interest coverage	0.000621**	0.001232**
	(2.072110)	(2.501046)
Leverage	0.416657***	0.997974***
	(2.838675)	(3.283089)
Log firm size	0.032940	0.159218***
	(1.559567)	(4.632703)
Market-to-Book ratio	0.065307	-0.049444
	(1.238336)	(-0.597036)
No. outstanding options	0.000618	-0.014689
	(0.101893)	(-1.468560)
Percentage mgmt. ownership	0.289482	0.168034
	(1.413807)	(0.655868)
Preferred stock	-0.660498	-2.719919**
	(-1.008851)	(-2.407427)
Quick ratio	-0.192785***	-0.354929***
	(-4.333917)	(-4.878916)
ROA	0.004167	0.100660
	(0.032956)	(0.402452)
Speculation (threshold: 1.5)	0.341388***	0.611267***
	(2.696512)	(3.199323)
Intercept	-0.200526	-0.266176
	(-0.938647)	(-0.765266)
No. total observations	278	278
No. uncensored obs.	215	216
	31	

Log likelihood	-142.1099	-277.8326

Panel A represents Tobit model using hedge ratio as dependent variable. Panel B represents Tobit model using duration as dependent variable. All variables are defined in Table II. Coefficients are presented with z-statistics in parentheses. The symbols ***, **, and * denote statistical significance at the 1%, 5%, and 10%-levels, respectively.

The binary variable of tax loss carry-forwards, which stands for potential tax convexity and is assumed to contribute to incentives to hedge, is not found to be significantly related to hedge ratio or duration. Although it is positively related to hedge ratio at almost 10% significance level, the coefficient is essentially too small to have practical implications. Thus consistent with the research of Graham and Rogers (2002) but contrary to the research of Berkman and Bradbury (1996), this study cannot confirm the tax incentive to hedge.

Capital expenditure on PPE scaled by firm size, which is taken to represent growth opportunities of firms, is found to be positively related to both hedge ratio and duration at 10% significance level. One unit increase in capital expenditure variable is associated with 0.72 unit increase in the predicted value of maturity of derivative portfolio and 0.37 unit increase in the predicted value of hedge ratio. However, similar to Mian's (1996) finding that hedgers do not have higher market-to-book ratios, the other proxy for growth opportunities – the ratio of firm's market value to book value, is not significant in determining either hedge ratio or duration at all. Therefore, mixed evidences are found for the argument that firms with more growth opportunities have more incentive to hedge.

In regard to the capital constraint (quick ratio) of firms, consistent with studies by Berkman and Bradbury (1996), Haushalter (2000) and Tufano (1996), liquidity is found to be negatively and significantly related to both hedge ratio and derivatives' weighted average maturity thus if duration is an accurate measure of hedging, the hypothesis that firms with more financial constraints have more incentive to hedge can be confirmed. Until now, hedge ratio and maturity have been performing at the same pace, which indicates that what the two proxies are actually measuring have many overlapping. That the two measures have many things in common is an encouraging signal since the study aims to develop a new measure of hedging policy that is not only accurate in what it is measuring but also supplements the old measure in other aspects.

The competing theories that more financially distressed firms are more inclined to hedge than less financially distressed peers (Smith & Stulz, 1985) and that more financially distressed firms are less incentivized to hedge because of collateral constraints (Rampini, Sufi & Viswanathan, 2014) are examined with leverage ratio, interest coverage ratio and return on asset and it has been thoroughly illustrated in the Appendix A that leverage is found to be positively and highly significantly related to hedging no matter hedging policy is measured with hedge ratio or maturity. This finding corroborates the former theory but contradicts the latter and it is in accordance with previous studies of Graham and Rogers (2002), Berkman and Bradbury (1996), and Haushalter (2000). Meanwhile, a contradictory finding is the positive and significant (at 5% level) relationship between interest coverage and hedging although the coefficients are too small to have meaningful practical implications.

While in Berkman and Bradbury's (1996) research, the results are consistent that corporate derivatives usage is positively associated with leverage but negatively associated with interest coverage, the mixed evidences found in this research entail further examinations to clarify the relation between risk of financial distress and hedging policy. A potential explanation is that extreme values in this variable distort the results and this is examined by winsorizing[9] the interest coverage variable. After winsorizing this variable, interest coverage is no longer significant while other findings remain the same. Profitability, measured by return on asset, is not a significant determinant in hedging. Hence based on the results of Tobit models, the role that financial distress plays in influencing firms' hedging policy is not crystal clear. Whether risk of asset substitution and debt overhang is a practical concern that creates greater demands for hedging is probably better reflected in Heckman's two-stage estimation in which the decision to hedge and extent of hedging are separated.

Managerial incentive to hedge, measured by directors' and officers' stock ownership and the option holdings of directors and officers, in contrast with researches of Berkman and Bradbury

[9] Regressions with winsorized interest coverage variable are not presented here. Results are available upon request.

(1996) and Tufano (1996), is not found to be related to hedging regardless which measure is used, casting doubt on whether manager's risk-aversion contributes to the incentive to hedge. A likely explanation could be that since stocks can be seen as call options for which the firm's asset is the underlying, managers can be deemed as holding options against the company's asset and this might even induce them to risk more instead of hedging the risk.

Nance, Smith and Smithson (1993) document that firms which hedge employ fewer hedging substitutes but among all the hedging substitutes, none is found to be significantly related to hedge ratio, while dividend yield is positively related to derivative portfolio's maturity at 5% significance level and preferred stock is negatively related to maturity at 5% (closer to 1%) significance level. While the negative relation between preferred stock and maturity corroborates the theory that the existence of hedging substitutes reduces the need for hedging (Ramlall, 2010), the positive relation between dividend yield and maturity seems to give a paradoxical indication. One plausible explanation is that stock dividends are sticky, that is to say, companies try to avoid cutting dividends as much as possible even if it could mean that they have to save costs from somewhere else. Hence higher dividend yield puts more strains on company's spending, which could contribute to their incentives to hedge and therefore the dividend payments of firms might be an important determinant of the chosen maturity of derivatives. The different performance of hedge ratio and duration with regards to hedging substitutes is the first signal that the there is indeed a discrepancy of what those two proxies actually measure and which one is a more accurate, transparent and pure measure of hedging is yet to be found out. Furthermore, it suggests that maturity contains additional information than hedge ratio, which can be potentially supplementing the traditional measure.

Contradictory to the empirical study of Berkman and Bradbury (1996), this research does not find supportive evidence for the economies of scale effect in increasing the extent of hedging when the traditional measure of hedging is used. However, when the new measure of hedging is used, the natural logarithm of firm asset value is shown to be positively related to maturity at 1% significance level. As hedging effectiveness increases with hedging horizon thus firms with higher hedge demands tend to hedge for longer time, this finding, on the contrary to the results

found with hedge ratio, supports the theory that bigger firms have more resources, capabilities and demands for hedge so that the chosen horizon of hedging is longer for bigger firms. In this regard, maturity as a new measure of hedging performs distinctively to the traditional measure. A possible implication is that bigger firms do not incline to hedge more because of their abundant resources but they can sustain longer hedging horizons.

One important and interesting finding from the Tobit regressions is that the binary variable that stands for the selective hedging (speculation) behavior of firms is positively related to both hedge ratio and maturity at 1% significance level. Speculation is associated with 0.34 unit higher predicted value of hedge ratio and 0.61 year longer in the predicted value of maturity. This finding is contradictory to the prediction that speculation requires more flexibility hence shorter derivative maturity. However if combined with the argument that bigger firms are more likely to engage in speculating (Adam, Fernando & Salas, 2017), this supports the finding above that firm size is positively associated with maturity.

Since stronger hedging need is believed to demand longer hedging horizon and the result indicates that speculation also entails longer horizon, the new measure of hedging might not be able to distinguish the hedging behavior and speculation behavior of companies and constructs a more transparent, accurate measure of hedging policy. Therefore, like hedge ratio, maturity is also contaminated by the speculative behavior of firms although how such contamination influences maturity is clearly identified. More accurately put, both hedge ratio and maturity are measuring the derivatives usage of firms instead of the hedging behavior of firms.

4.3 Heckman two-step estimation

Table XI. Results of Heckman two-stage estimations

	Panel C (DV: Hedge ratio)		Panel D (DV: Duration)	
Independent variables	Selection step	Response step	Selection step	Response step
Binary: tax loss carry-forwards	0.203114	-0.025354	0.283206	0.010034
	(0.947379)	(-0.122071)	(1.285196)	(0.094948)
CAPEX	-0.185368	0.525315	0.205426	0.732775
	(-0.181737)	(0.532621)	(0.189756)	(1.596131)
Convertible debt	-0.359124	0.553079	-0.533473	0.273128

	(-0.229167)	(0.371160)	(-0.333403)	(0.362194)
Dividend yield	0.249756	-0.024385	0.313396	0.120663
	(0.760525)	(-0.077578)	(0.930727)	(0.832152)
Interest coverage	0.002830	-0.000647	0.002941	-0.000144
	(1.416783)	(-0.324408)	(1.428340)	(-0.152321)
Leverage	1.549010**	-0.338246	1.985476***	0.067542
	(2.324260)	(-0.499524)	(2.803321)	(0.160103)
Log firm size	0.734407***	-0.301541	0.744030***	0.016813
	(4.153853)	(-1.470700)	(4.119992)	(0.123934)
Market-to-Book ratio	-0.193921	0.180064	-0.168093	0.009190
	(-1.144080)	(1.098864)	(-0.968617)	(0.106064)
No. outstanding options	-0.032513	0.016153	-0.037472	0.001230
	(-1.343789)	(0.680954)	(-1.529602)	(0.107121)
Percentage mgmt. ownership	0.755126	-0.076290	0.725399	-0.194470
	(1.163593)	(-0.120107)	(1.089052)	(-0.617828)
Preferred stock	-1.777378	0.148021	-2.503718	-1.869188
	(-0.602402)	(0.051441)	(-0.798397)	(-1.260631)
Quick ratio	-0.565443***	0.121501	-0.544661***	-0.010494
	(-3.654245)	(0.692577)	(-3.445624)	(-0.081642)
ROA	-0.521019	0.287156	-0.453736	0.358946
	(-0.800340)	(0.451479)	(-0.690043)	(1.208682)
Speculation (threshold: 1.5)	0.825742**	0.043651	1.220261***	0.223522
	(2.345430)	(0.125490)	(2.945808)	(1.112386)
Intercept	-1.000435	1.185473	-1.293172*	1.158788**
	(-1.553146)	(1.647463)	(-1.930080)	(2.013797)
No. total observations	278	215	278	216
Log likelihood	-428.1742		-404.5874	

Panel C represents Heckman 2-step estimation using binary-hedging as selection variable in the first step and hedge ratio as dependent variable in the second step. Panel D represents Heckman 2-step estimation using binary-duration as selection variable in the first step and maturity as dependent variable in the second step. All variables are defined in Table II. Coefficients are presented with t-statistics in parentheses. The symbols ***, **, and * denote statistical significance at the 1%, 5%, and 10%-levels, respectively.

In the first stage of Heckman two-step regressions, it is the likelihood of using derivatives that is predicted regardless whether hedge ratio or maturity is used as the dependent variable. Essentially, the binary variables of both measures take on value 1 if the firm chooses to use derivative and zero otherwise. Naturally, the firms with a hedge ratio of zero will have a weighted average maturity of zero. Therefore, the results of the two selection equations are quite similar. It is also not surprising that the value of coefficients of the statistically significant

variables predicted in the two selection equations are very close since both selection equations are basically predicting the same thing - the probability of hedging.

Leverage is positively related to having a hedge ratio that is non-zero and to having a duration that is non-zero at 5% and 1% significance level respectively. Similar to findings of researches by Allayannis and Ofek (2001), Géczy, Minton and Schrand (1997), Graham and Rogers (2002) Mian (1996) and Nance, Smith and Smithson (1993), firm size is found to be positively related to the decision to hedge at 1% significance level in this study. Quick ratio is negatively associated with having a hedge ratio that is non-zero and with having a duration that is non-zero at 1% significance level. Another important factor is speculation, it is positively related to having a hedge ratio that is non-zero at 5% significance level and positively related to having a duration that is non-zero at 1% significance level. The results of Heckman's first-stage estimation confirm the effects of financial distress, financing costs and economies of scales on incentivizing firms to hedge.

The findings in the first stage of Heckman two-step regressions are to a great extent similar to the findings from Tobit models discussed above. To be more specific, most variables that are significant in both Tobit models are still significant in the selection equations while those variables that are significant in only one model are no longer significant in the selection equations, except firm size. This implies that duration and hedge ratio have certain similarities and also some major discrepancies in their own right. It can be safely concluded from Heckman first stage estimation that leverage, firm size, quick ration are vital determinants of the decision to hedge. To put it more specifically, those factors together with speculation are important determinants of the decision to use derivatives. While the first step of Heckman two-stage estimation identifies that firm size is a significant determinant of hedging, this is only manifested in the Tobit model where maturity is used to represent hedging whereas it is not found when hedge ratio is used. Moreover, dividend yield and preferred stocks are only significant in the Tobit model when duration is the dependent variable. Hence new information is uncovered by adopting maturity as a proxy for hedging. At last, capital expenditure and interest coverage are not significant determinants of the decision to hedge.

In the second stage of Heckman two-stage regression, conditional on firms hedge (having a hedge ratio that is non-zero or having a duration that is non-zero), none of the factors suggested by theories appears to be significant. This implies that those factors are important determinants of whether firms choose to use derivatives or not; when firms already decide to use derivatives, those factors are not meaningful determinants of how intensively firms use derivatives and how long the hedging horizon the firm choose. The finding is in line with Allayannis and Ofek's (2001) study where firm size is an important determinant of firm's decision to use foreign currency derivatives while determinants of the amount of hedging are different.

4.4 Robustness tests

To check the robustness of the results obtained, this study carries out a few more empirical tests with variations from the original models specified in Table X.

4.4.1 Test 1: speculation defined as more than 50% change

A different process of classifying speculation behavior is conducted so the first test is to control for the robustness of the speculation variable. The process to classify firm's selective hedging behavior is to compare firm's hedge ratios on a year-on-year basis and in this setting, the binary variable of speculation takes on value 1 when the absolute value of percentage change in one year's hedge ratio compared to the previous year's hedge ratio is larger than 50% and 0 otherwise. The reason why change in hedge ratio is chosen instead of amount hedged (Jankensgård, 2015) is that hedge ratio directly controls for the amount change demanded by changes in firm's production. The threshold of 50%, similar to 1.5 number of standard deviation threshold used before to identify speculation, is more or less randomly chosen and subjected to further examination.

Table XII. Robustness tests, using Tobit models

	Test 1: threshold-50%		Test 2: threshold-1.7		Test 2: threshold-2.0		Test 3: split period 2000-2003		Test 3: split period 2004-2008	
Independent variables	Panel E (DV: Hedge ratio)	Panel F (DV: Duration)	Panel G (DV: Hedge ratio)	Panel H (DV: Duration)	Panel I (DV: Hedge ratio)	Panel J (DV: Duration)	Panel K (DV: Hedge ratio)	Panel L (DV: Duration)	Panel M (DV: Hedge ratio)	Panel N (DV: Duration)
Binary: tax loss carry -forwards	0.106945* (1.911973)	0.126684 (1.306045)	0.093281* (1.734126)	0.158428* (1.644755)	0.081680 (1.617202)	0.129224 (1.348100)	0.044983 (0.692659)	0.039987 (0.258463)	0.086251 (1.104599)	0.196130 (1.631181)
CAPEX	0.386488* (1.719012)	0.541060 (1.312118)	0.271335 (1.310801)	0.550325 (1.301229)	0.343591* (1.709910)	0.689370* (1.671406)	-0.214564 (-0.581772)	0.736579 (0.655780)	0.202176 (0.758514)	0.434164 (0.846749)
Convertible debt	-0.003716 (-0.007875)	-0.552778 (-0.722930)	0.302900 (0.845179)	0.029878 (0.041472)	0.278199 (0.792194)	-0.039687 (-0.053185)	1.105626** (2.209166)	0.757842 (0.757713)	-0.738173 (-0.909935)	-1.393340 (-1.110356)
Dividend yield	0.093625 (1.319186)	0.253895** (2.005281)	0.081274 (1.089748)	0.242526* (1.899299)	0.084374 (1.149384)	0.244151* (1.949156)	-0.116694 (-1.382283)	-0.139355 (-0.702453)	0.141854** (1.996794)	0.370226*** (2.630752)
Interest coverage	0.000241 (0.550767)	0.000686 (1.140414)	0.000615** (2.095719)	0.001217** (2.480962)	0.000580* 1.955834	0.001147** (2.237844)	0.001010*** (3.892819)	0.001737*** (3.489601)	-0.001515 (-1.437750)	-0.000640 (-0.338198)
Leverage	0.513371*** (3.268426)	0.864329*** (3.140142)	0.396924*** (2.652261)	0.959796*** (3.253137)	0.403142*** (2.787663)	0.960474*** (3.006656)	0.342206* (1.904074)	0.998111* (1.834756)	0.485020** (2.109995)	0.996800*** (2.734993)
Log firm size	0.018591 (0.833794)	0.127143*** (3.369843)	0.032958 (1.563324)	0.159339*** (4.749816)	0.022182 (1.180549)	0.148050*** (3.938839)	0.089847* (1.935316)	0.446247*** (3.445319)	0.034169 (0.430910)	0.275855*** (2.719789)
Market-to-Book ratio	0.122119** (1.999641)	-0.011905 (-0.134867)	0.054342 (1.076102)	-0.067919 (-0.819769)	0.052819 (1.079251)	-0.055950 (-0.650997)	-0.052494 (-0.893875)	-0.111099 (-0.809216)	0.102768* (1.713401)	-0.046822 (-0.461319)
No. outstanding options	0.001319 (0.229202)	-0.011442 (-1.147794)	0.001280 (0.222598)	-0.013671 (-1.324829)	0.002015 (0.359064)	-0.013656 (-1.299338)	0.005550 (0.719889)	-0.009013 (-0.519230)	-0.000973 (-0.113592)	-0.014401 (-1.308478)
Percentage mgmt. ownership	0.263129 (1.101438)	0.145500 (0.505107)	0.244720 (1.264055)	0.094569 (0.363903)	0.237630 (1.364912)	0.122409 (0.447970)	0.286948* (1.884269)	0.558822* (1.672320)	0.552269 (1.451166)	0.036938 (0.087869)
Preferred stock	0.156349 (0.203942)	-1.157534 (-1.009196)	-0.976607 (-1.462888)	-3.146579*** (-2.603018)	-1.546688** (-1.997293)	-2.754775** (-2.303210)	0.379725 (0.599728)	-1.997865 (-1.392615)	-3.319616** (-2.522018)	-3.207093 (-1.328773)
Quick ratio	-0.201100*** (-3.975313)	-0.383878*** (-4.864752)	-0.202716*** (-4.453780)	-0.373347*** (-5.183964)	-0.191924*** (-4.454079)	-0.370403*** (-5.090752)	-0.137580*** (-2.840674)	-0.277777*** (-2.692916)	-0.269967*** (-4.241238)	-0.458467*** (-4.649962)
ROA	0.142309 (0.894982)	0.312046 (1.163745)	0.005115 (0.041557)	0.110290 (0.448660)	0.077877 (0.622220)	0.219339 (0.807133)	0.335600* (1.718667)	-0.031127 (-0.053565)	0.087983 (0.564376)	0.387457 (1.463070)
Speculation										
Threshold: 50%	0.033692 (0.573984)	0.155108* (1.729055)								
Threshold: 1.5							0.207921* (1.810876)	0.552121* (1.775263)	0.503975** (2.414992)	0.726187*** (3.200450)
Threshold: 1.7			0.537988*** (2.690943)	0.891150*** (3.129732)						
Threshold: 2.0					0.757874*** (3.015507)	0.636765** (2.563915)				
Intercept	-0.183244 (-0.772417)	-0.266176 (-0.765266)	-0.139852 (-0.672561)		-0.076728 (-0.398512)	-0.090934 (-0.246507)	-0.090886 (-0.455654)	-0.586172 (-0.993180)	0.008166 (0.024380)	0.238113 (0.535092)
No. total obs.	247	248	278	278	278	278	122	122	156	156

No. uncensored obs.	194	195	215	216	215	216	88	89	127	127
Log likelihood	-133.4391	-246.5889	-138.5790	-276.3865	-133.1182	-283.8274	-44.35222	-121.4994	-76.62809	-148.5976

Panel E, G, I, K and M represent Tobit models using hedge ratio as dependent variable. Panel F, H, J, L and N represent Tobit models using duration as dependent variable. Panel E and F define the binary variable of speculation equals to 1 if the absolute value of percentage change of a firm's hedge ratio in 2 successive financial years is larger than 50% and 0 otherwise. Panel G and H change the speculation threshold to 1.7, whereas Panel I and J increase it to 2.0. Panel K and L are restricted to the 2000-2003 period, whereas Panel M and N are restricted to the 2004-2008 period. All other variables are defined in Table II. Coefficients are presented with z-statistics in parentheses. The symbols ***, **, and * denote statistical significance at the 1%, 5%, and 10%-levels, respectively.

As shown in Panel E and F in Table XII. The alternatively defined speculation is no longer significantly related to hedge ratio but still is still positively and significantly (at 10% level) related to duration. In this regard, duration as a measure of hedging has a more robust relationship with speculation than hedge ratio. Furthermore, it appears that the positive relationships between hedge ratio and capital expenditure, leverage along with the negative relationship between hedge ratio and quick ratio stand the robustness check, showing a valid connection between underinvestment concern, financial distress risk and incentive to hedge. On the other hand, with respect to duration, dividend yield, leverage, firm size and quick ratio also stand the robustness check, indicating valid correlations between dividends, financial distress risk, and economies of scale, capital constraints and the chosen maturity of derivative portfolios.

4.4.2 Test 2: speculation defined as distance to mean hedge ratio>1.7 or 2.0

The second test checks the robustness of the classification of speculation behavior by using different thresholds from the original models. Originally, a distance of 1.5 number of standard deviation from the mean hedge ratio is used as threshold and here stricter ones- 1.7 and 2 number of standard deviation from the mean hedge ratio are used.

Shown in Panel G, H, I and J in Table XII, the results of the second set of robustness tests are illuminating. With new thresholds that are stricter in defining speculation, the binary variable of speculation is positively and significantly (at 1% level) related to both hedge ratio and maturity, suggesting that the threshold chosen originally is a reasonable one and speculation behavior specified in this way is stable and robust. When a threshold of 2.0 standard deviation's distance is employed, all the variables that are significant in the original model specifications are robust. However, the tax loss carry-forwards dummy variable becomes positive and significant determinants of both hedge ratio and maturity and capital expenditure is no longer significantly related to hedge ratio when a threshold of 1.7 is adopted. To sum up, the relations between interest coverage, leverage, quick ratio, speculation and hedge ratio are shown to be valid and the relations between dividend yield, interest coverage, leverage, firm

size, preferred stocks, quick ratio, speculation and maturity are robust. Hence it can be concluded that when hedging is measured by maturity, the hypothesized influences on hedging policy from hedging substitutes, financial distress concern, economies of scale, financial constraints are seen while when the traditional measure of hedging is used, less influences are visible. Moreover, speculation is shown to be a significant determinant of hedging.

4.4.3 Test 3: split sample

The third test uses split samples as the time period of 2000-2003 is characterized by a stable oil price and is less tempting for firms to engage in selective hedging than in the time period of 2004-2008 thus it is highly relevant to examine if the relationship between hedging and suggested determinants is stable across sample periods.

With regard to hedge ratio, based on the Tobit regressions shown by Panel K and M in Table XII with split sample periods, it can be seen that only the relations between leverage, quick ratio, speculation and hedge ratio are stable across sample periods. Other factors, including convertible debt, interest coverage, firm size, management stock ownership and return on assets are shown to be significant during 2000-2003 but are no longer significant during 2004-2008; instead, dividend yield, market-to-book ratio and preferred stocks become significant post 2003. The great variations across sub-periods indicate instability in the performance of hedge ratio.

With regard to maturity as the dependent variables, as can be observed in Panel L and N, the relations between dependent variable and independent variables are more stable than with hedge ratio. Leverage, firm size, quick ratio and speculation are consistent determinants of hedging measured by maturity. And during 2000-2003, management stock ownership turns out to be positively associated with maturity as with hedge ratio during the same period. It implies that managerial risk aversion might indeed play a role in influencing firms policy of true hedging but not in firm’s speculative derivative usage hence this relationship is masked resulting in its insignificance during 2004-2008 under which the incentive to speculate is

stronger than hedging.

Throughout robustness tests, maturity as a measure of hedging is proved to outperform hedge ratio. The relations between maturity and independent variables show more consistency than the relations between them and hedge ratio. Although maturity does not distinguish pure hedging and selective hedging as predicted, it is a strong, stable and accurate measure of firm's hedging (including pure hedging and selective hedging) behavior as the positive relation between maturity and speculation is robust. Except having robust connections with firm size as well as speculation, maturity also has consistent relation with dividend yield, which indicates that dividend yield plays an important role in corporate hedging policy. The effects of economies of scale and dividend yield on hedging policy could not have been uncovered if only hedge ratio is employed as the proxy for hedging practice.

Speculation behaviour defined in the sample centres around year 2000/2001 and year 2007/2008. Although oil price was stable during the period of 2000-2003, oil price in 2000 was actually the peak of the past decade, which was in quite similar situation to year 2008. Behavioural finance theory (Shefrin, 2007, p.3&6) has shown that investors and managers are inclined to biases of overconfidence and optimism, therefore if a market view of long-term mean reverting but short-term positive price movement is held by managers, they are highly likely to engage in long-term derivatives positions in order to benefit from the near-term continuous increasing of oil price while at the same time lock in the peak price even when prices reverts to long-term mean. In this way, they accommodate their derivatives position (increase the amount, prolong the maturity) to speculate on market trend. This might be the explanation of the positive correlation between speculation and hedge ratio and the robust, consistent, positive correlation between speculation and maturity.

V. Conclusion

This study aims to investigate the performance of maturity as a proxy for corporate hedging

policy and more specifically, the study tests the relations between hedging determinants suggested by traditional and new theories, corporate selective hedging behaviour identified from firm's variability of hedge ratios and corporate derivative portfolios' maturity. The results are compared to the performance of traditional hedging proxy – hedge ratio with respect to those aspects.

Tobit models triangulated with robustness checks indicate valid positive relation between leverage and hedge ratio; negative relation between quick ratio and hedge ratio. This finding confirms the hedging incentive from financial distress concern and partially supports the effect of underinvestment concern (financial constraints) on hedging policy. Maturity, in addition to aspects mentioned above, is shown to be positively related to corporate selective hedging. Maturity is also positively related to firm size, confirming the influence of economies of scale on hedging policy. It can be thus concluded that maturity as a measure of hedging outperforms the traditional proxy with respect to hedging determinants in that it supplements the traditional measure by suggesting a linkage between firm size and hedging as well as a potential linkage between dividend yield and hedging. Furthermore, the performance of maturity regarding hedging determinants is more stable than hedge ratio across sample periods.

As for corporate speculative behaviour, contradictory to what the hypothesis predicts, maturity is not able to distinguish the pure hedging behaviour and speculation but is shown to be unilaterally positively influenced by speculation. This finding implies that similar to hedge ratio, maturity is contaminated by corporate speculation and is more of a measure of corporate derivatives usage instead of corporate hedging behaviour. This research suggests that the positive relation could be explained by managers' overconfidence and optimism so that when the oil price peaked, managers predicted a short-term continuous upward trend and long-term mean-reversion trend. Hence the management chose longer maturity for their derivative portfolio in order to benefit from the price increase in short term and secure the peak price in the long run.

In Heckman two-step estimation, the results are consistent when maturity and hedge ratio are used as proxies for hedging. The selection equations indicate that leverage, firm size, quick ratio and speculation are significant determinants of the decision to hedge (more precisely, the decision to use derivatives), and the response equations do not identify any significant determinants of the extent of hedging (the degree of derivatives usage). This finding supports the findings from Tobit models when maturity is used as proxy for hedging that the financial distress concern, underinvestment concern and economies of scale create incentives for hedging and is in line with the study of Allayannis and Ofek (2001) that determinants of the decision to hedge (to use derivatives) are not necessarily the determinants of the extent of hedging (derivatives usage). Speculation is shown to have significant impact on derivative usage in Heckman two-step estimation as also indicated in Tobit models when maturity is used as proxy.

In summary, this study has answered the research questions that 1) maturity is positively associated with certain hedging determinants – financial distress, underinvestment risk and economies of scale; 2) maturity is found to have a robust positive connection with corporate selective hedging behaviour and 3) the under-researched aspect of derivative usage − maturity outperforms hedge ratio in representing corporate hedging behaviour. Although it does not distinguish hedging and speculation behaviour as predicted in the hypothesis, the relations between hedging determinants, speculation and maturity are more stable, transparent and comprehensive than the relations between them and hedge ratio. However, this research also notifies that more precisely put, both maturity and hedge ratio are proxies for corporate derivative usage instead of corporate hedging.

The limitations of this study are that the results are industry-specific in that firms in oil and gas industry mainly hedge for commodity price risk and can hardly be generalized to the general practice of corporate hedging when there is an extensive presence of foreign debt and maturity matching has to be considered; and that the selective hedging indicator can be more precisely calculated if without data limitation. As this study shows, maturity is a highly relevant aspect of corporate derivatives usage but has been largely ignored in previous studies.

Future studies are encouraged to investigate the maturity aspect of corporate derivative portfolio with respect to financial distress, financial constraints and governance as the previous studies' investigation in debt maturity, and in maturity's own right instead of a proxy for hedging or derivative usage.

Appendix

A. Endogeneity test of leverage

The test for endogeneity between leverage and hedging is conducted following Graham and Rogers (2002), who state a two-way causality exists between the two variables. Tobit model is applied to investigate the relationship between hedging (measured by hedge ratio and duration respectively) and incentives to hedge as described in the hypotheses. Leverage, afterwards, trades places with hedging as the dependent variable while hedging becomes independent variable and is formulated in an ordinary least squares model as a function of hedging along with the same exogenous variables used in the Tobit models which are presented in Table X. The results turn out that leverage is not only a positive and statistically significant (close to 1% level) determinant of hedge ratio but also a positive and statistically significant (at 1% significance level) determinant of duration. To be more specific, one unit increase in leverage ratio is associated with 0.42 increase in the predicted value of hedge ratio and almost one unit increase in the predicted value of maturity.

On the other hand, it appears that hedge ratio is positively related to leverage at 10% significance level and duration is positively related to leverage at 1% significance level. Due to the panel data property, fixed cross-sectional effect and time effect are taken into consideration to rule out the noises resulted from the data nature. However, after taking cross-sectional effect and time variation of panel data into consideration, hedge ratio and duration are not significant determinants of leverage any more. Hence the relation found at first is highly likely to be caused by other factors rather than hedging policy and it is concluded that, in contrast with Graham and Rogers (2002), no endogeneity effect is found between hedging and leverage in this study.

A.1 Tobit models

As presented in Table X, the result from Panel A shows that the relationship between hedge ratio and leverage is positive and statistically significant and the result from Panel B shows that the relationship between duration and leverage is positive and statistically significant.

Those findings confirm the positive effect of leverage on hedging; however whether hedging has influence on leverage simultaneously is to be tested in the following sections.

A.2 Untreated OLS regressions

Table A.1. OLS regressions – endogeneity test of leverage

Independent variables	Panel O (DV: Leverage)	Panel P (DV: Leverage)
Binary: tax loss carry-forwards	-0.056620***	-0.058015***
	(-2.881717)	(-2.989483)
CAPEX	0.215336**	.1943660**
	(2.338243)	(2.127773)
Convertible debt	0.573111***	0.580049***
	(3.708170)	(3.800368)
Dividend yield	-0.038947	-0.044817
	(-1.314119)	(-1.525145)
Hedge ratio (O)/ Duration (P)	0.052911*	0.048241***
	(1.877193)	(3.121314)
Interest coverage	-0.000212	-0.000222
	(-1.339847)	(-1.418620)
Log firm size	0.029130*	0.016193
	(1.805275)	(0.974972)
Market-to-Book ratio	-0.097901***	-0.090518***
	(-6.161081)	(-5.734704)
No. outstanding options	0.002642	0.003265
	(1.188817)	(1.483278)
Percentage mgmt. ownership	-0.065121	-0.058323
	(-1.057338)	(-0.963320)
Preferred stock	0.058273	0.133539
	(0.220176)	(0.507399)
Quick ratio	-0.028265***	-0.025527***
	(-3.275765)	(-2.969859)
ROA	0.008851	0.005759
	(0.148140)	(0.097499)
Speculation (threshold: 1.5)	-0.034250	-0.043126
	(-1.127273)	(-1.437559)
Intercept	0.368611***	0.362089***
	(6.446295)	(6.399706)
No. total observations	278	278
Adjusted R^2	0.280771	0.297170
Log likelihood	140.4850	143.6910

Panel O represents OLS model using leverage as dependent variable while hedge ratio is included as an independent variable. Panel P represents OLS model using leverage as dependent variable while

duration is included as an independent variable. All variables are defined in Table II. Coefficients are presented with t-statistics in parentheses. The symbols ***, **, and * denote statistical significance at the 1%, 5%, and 10%-levels, respectively.

Panel O represents an OLS regression using leverage as the dependent variable and hedge ratio as one of the independent variables. It appears that leverage is positively related to hedge ratio at 10% significance level when cross-sectional effect and time effect are not yet considered. Similar to the result of Panel O, Panel P with duration as one of the independent variables and leverage as the dependent variable indicates that duration is positively related to leverage at 1% significant level. The results are obtained without considering cross-sectional effect and time variation.

A.3 Treated panel OLS regressions

So after the potential influence of cross-sectional and period specific effects is considered, the test result is shown as below:

Table A.2. Fixed-effect model – endogeneity test of leverage

Independent variables	Panel Q (DV: Leverage)	Panel R (DV: leverage)
Binary: tax loss carry-forwards	0.014432	0.013634
	(0.630643)	(0.604288)
CAPEX	0.365820***	0.346316***
	(3.177862)	(2.954249)
Convertible debt	0.410473**	0.426797**
	(2.281860)	(2.353935)
Dividend yield	-0.032520	-0.034413
	(-0.606971)	(-0.632436)
Hedge ratio (Q)/ Duration (R)	-0.008522	0.013400
	(-0.296468)	(0.938878)
Interest coverage	-4.07E-05	-3.60E-05
	(-0.331693)	(-0.294152)
Log firm size	0.184883***	0.177431***
	(3.839382)	(3.596105)
Market-to-Book ratio	-0.094021***	-0.092317***
	(-4.814689)	(-4.676632)
No. outstanding options	-0.001177	-0.000750
	(-0.398580)	(-0.249903)
Percentage mgmt. ownership	-0.150343*	-0.144828*
	(-1.803897)	(-1.737325)

Preferred stock	0.034996	0.014228
	(0.092456)	(0.037889)
Quick ratio	-0.019001**	-0.017899*
	(-2.091056)	(-1.947937)
ROA	0.037230	0.035400
	(0.418448)	(0.395247)
Speculation (threshold: 1.5)	-0.014056	-0.021504
	(-0.512524)	(-0.788902)
Intercept	-0.123204	-0.119367
	(-0.920690)	(-0.887219)
No. total observations	278	278
Adjusted R^2	0.578856	0.580166
Log likelihood	242.8892	243.3223

Panel Q represents fixed-effect model using leverage as dependent variable while hedge ratio is included as an independent variable. Panel R represents fixed-effect model using leverage as dependent variable while duration is included as an independent variable. All variables are defined in Table II. Coefficients are presented with t-statistics in parentheses. The symbols ***, **, and * denote statistical significance at the 1%, 5%, and 10%-levels, respectively.

As can be seen from Table A.2 Panel Q, after incorporating the panel data property, the relationship between leverage and hedge ratio is no longer statistically significant. And seen from Panel R, the relationship between leverage and maturity is no longer statistically significant either. To make sure that those effects are indeed present, the effect specifications are also examined. Results are summarized in Table A.3.

Table A.3. Redundant fixed-effect tests

	Panel S		Panel T	
Effect tests	Test statistics	Degree of freedom	Test statistics	Degree of freedom
Cross-section F	5.028985***	(40,215)	4.836218***	(40,215)
Cross-section Chi-square	183.599632***	40	178.400474***	40
Period F	5.703149***	(8,215)	5.930098***	(8,215)
Period Chi-square	53.499796***	8	55.429710***	8
Cross-Section/Period F	4.878145***	(48,215)	4.693327***	(48,215)
Cross-Section/Period Chi-square	204.808441***	48	199.262673***	48

Panel S represents fixed-effect redundant tests results regarding the fixed-effect model in Panel Q. Panel T represents fixed-effect redundant tests results regarding the fixed-effect model in Panel R. The symbols ***, **, and * denote statistical significance at the 1%, 5%, and 10%-levels, respectively.

The test results from Table A.3 Panel S and Panel T support that the property of panel data

has to be taken into consideration. Summing up the results above, the relationship between leverage and hedge ratio is not shown to be simultaneous. Similarly, the relationship between leverage and duration is not simultaneous either. Thus no evidence is found to support the hypothesis that hedging increases debt capacity.

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