Corporate Hedging, Firm Risk, Value, and Performance: Evidence from UK Firms

By

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ABSTRACT

This study investigates the corporate hedging decisions associated with firm value, performance, and risk. A number of theories in risk management literature suggest that, in market imperfections, the use of derivative instruments for hedging purposes increases firm value overall by mitigating agency costs and a firm's returns variability. Using a sample of UK nonfinancial listed firms during the period 2005-2012, we examine: (i) the effect of investment inefficiency on corporate hedging decisions; (ii) the impact of the use of foreign currency (FX), interest rate (IR), and commodity (CM) derivatives on firm value and performance; and (iii) the association between the corporate risk hedging and both stock returns volatility and the cost of equity capital implied in stock prices. We document new evidence regarding the effect of investment inefficiencies on hedging decisions. We find that hedging is strongly and positively associated with underinvestment or overinvestment, which confirms Morellec and Smith's (*Review of Finance, 2007, 11, 1-23*) theoretical analysis. We find strong evidence that derivative usage has differential firm valuation and performance effects depending on the financial risk type, contract type, and time of hedging strategies. Consistently, we find that FX risk hedging positively influences firm value and performance, while there is no significant result of IR risk hedging associated with the firm value creation which means that IR derivatives can be used for hedging or speculative purposes. Not surprisingly, the results show that forwards and swaps for FX risk hedge are positively and significantly associated with firm value over the time period, while firms associated with financial constraints are highly motivated to use options contracts. Finally, our results show that the stock returns volatility, on average, is lower when firms exercising hedging decisions overall, where a decline in the implied cost of equity is substantial. Our empirical results confirm these predictions and robust after employing various methods (e.g. special regressor, instrumental variables (IV-GMM), treatment effects, propensity score matching (PSM), and difference-in-differences (DiD)) to address potential endogeneity issues. However, our findings indicate that, consistent with the notion of the positive theory of financial risk management, the corporate hedging has economic values to derivative users.

Keywords: corporate hedging, derivative instruments, agency costs, information asymmetry, firm value, performance, stock returns volatility, implied cost of equity capital.

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DECLARATION

I hereby declare that the materials contained in this thesis have not been previously submitted for a degree in this or any other university. I further declare that this thesis is solely base on my own research study; and that all published or other sources of material consulted have been acknowledged in notes to the text or the bibliography.

Statement of copyright

Hany B. Ahmed

DEDICATION

This thesis is especially dedicated to the memory of my beloved Mother, who shares this dream with me; and my Father who passed away during my study.

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CHAPTER 1

Introduction

1.1. Research motivations

Existing studies empirically examine different theories of corporate risk hedging, but the firm's motives to use derivative financial instruments are still a puzzle. Hence, the impact of the use of derivative contracts on firm value and performance has become increasingly accepted by academics. Although the risk management theory suggests that the corporate risk hedging can increase firm value in the presence of market imperfections, different types of derivative instruments may lead to different effects on firm value. The paucity of studies investigating the relationship between the corporate risk hedging and the implied cost of equity capital is one of the main motivations for our investigation of this issue.

Although the classical Modigliani and Miller paradigm identifies that risk management is irrelevant, several recent studies explore inherent determinants of hedging risk. For example, Graham and Rogers (2002) argue that firms motives to hedge risk because of the likelihood of financial distress and firm size, but there is no evidence that firms hedge in response to tax convexity. The literature in corporate risk management proposes an impressive range of theories that can lead to better understanding and interpretations of the links between corporate hedging and agency costs. Nevertheless, market imperfections such as agency costs, asymmetric information, and costly financial distress provide a rationale for firms to manage their risk exposures with derivative instruments (Smith and Stulz, 1985; Froot *et al.*, 1993; Bartram *et al.*, 2009; Aretz and Bartram, 2010).

There are many past studies that have either relied on the implicit assumption that strong corporate governance plays a critical role in hedging determinants (Allayannis *et al.*, 2012) or provided evidence that can be interpreted through existing interactions of some explanatory variables on the firm level, i.e., leverage, as a link to hedge. Empirical research in financial risk management has largely ignored overinvestment problems factor. Recently, growing theoretical literature on the influence of both sides of investment inefficiency (under- or over-investment) on corporate hedging decisions emerged (Morellec and Smith, 2007). Hence, in this research, we analyse if agency costs helps in explaining corporate hedging, the likelihood of a financial decision to increase the use of derivative instruments often inconclusive empirical results in literature.

Although the financial theory suggests that in times when a firm faces the risk of financial distress, management may not invest in positive NPV projects (Myers, 1977). According to Froot *et al.* (1993), financial hedging activities facilitate firms to invest in projects when most needed. The agency costs are particularly relevant in light of several scenarios of direct influence of managers' self-interest in negative-NPV investments where managers support some private benefits regardless shareholders value (Tufano, 1998). Because external financing is costly, in the absence of corporate hedging strategies, managers can reduce the investment expenditures from the optimal level.

This underinvestment problem leads to a reduction of firm value, thus corporate hedging decisions are more likely to increase to mitigate agency costs (Bessembinder, 1991). Similarly, overinvestment problems, which has not yet been empirically analysed in the context of hedging decisions, can occur when managers accept projects, and not necessarily to be beneficial for shareholders, for entrenchment management power and managers' self-interest. Thus, the impact of overinvestment problems on firm value has become a critical driven factor in hedge motives and often corporate governance strength potentially leads to advantages to solve this problem.

Prior research attempts to reach conclusions on hedging incentives to cover a particular theory of risk management. Allayannis and Weston (2001) find evidence supporting the intuition of the positive relationship between corporate hedging and firm value creation. However, empirical evidence on corporate hedging determinants, and consequently effects of hedging on firm value and performance are mixed (Aretz and Bartram, 2010). Though recent empirical studies provide supporting evidence on the motives beyond the use of derivative instruments, additional incentives remain ambiguous. Broadly, Bartram *et al.* (2009) use an international sample to mainly examine theoretical incentives of corporate hedging including: financial distress and taxes, underinvestment problems, and management incentives. Consistently, Kumar and Rabinovitch (2013) collect a unique data set with detailed information on the derivative usage in oil and gas industry, and comprehensively provide evidence on hedging motives that are, in some circumstances, driven by the role of managerial entrenchment. These studies usually explore hedging incentives beyond firms' characteristics, and concentrate solely on their samples.

1.2. Brief overview

To fill in the gap in finance literature, in the current study we mainly investigate corporate hedging through streaming three dimensions as follows.

Chapter 2 – Hedging Decisions and investment inefficiency

In this chapter, we explore the association between the investment inefficiency and corporate hedging decisions. Thus, we extend the above into the question of what are the motivations of corporate hedging. In particular, we show that when firms in settings prone to underinvestment problems, where future projects are valuables to the shareholders, and those seem to be avoided because of managerial interests. This argument in literature is quite general and has relevance to any situation in the market imperfections, regardless of whether the firm currently faces financial distress for ongoing projects. Similarly, firms in setting prone to overinvestment problems, where projects financed are over their investment capacity, in which managers take actions to maximise their power and utility function over wider projects that may not lead to a value creation.

Despite the number the existing studies exploring whether corporate hedging reduces underinvestment problems, but lack of existing studies not yet investigate both sides of agency costs. Thus, we formalise our structure models in a simple framework, in which it starts exploring the link between corporate hedging and underinvestment problems. Broadly, the rule implies that appropriate financing policies should undertake projects with the best interests of value creation to the shareholders.

Chapter 3 – Which derivatives should firms use?

In this chapter, we investigate various derivative contracts and their effects on firm value and performance. Our models characterise the most common derivative contracts, in which firms report detailed information during the fiscal year. A practical implication of exploring financial risks (foreign currency, interest rate, and commodity price) and related the most common derivative contracts is that rather that looking at only the effects of corporate risk hedging solely on the basis of specific risk, influential effects of these contracts will also be valuable contribution. In addition to robustness tests for investigating the effects of corporate risk hedging with derivatives on firm value and performance, our analysis employ multiple approaches. Consistently, these approaches provide new insights into the following much-debated issues: 1) Which derivative contracts should a firm use? 2) When should a firm hedge? and 3) Whether hedging all financial risks yield more favourable outcome?

Chapter 4 – The impact of hedging on the cost of equity capital

In this chapter, we examine the association between corporate hedging decisions and the cost of equity capital. We also predict that corporate hedging can reduce the firm stock return variability. We suggest that firms in setting corporate risk hedging with derivatives should have a lower cost of equity implied in stock prices for several reasons. First, a good hedging policy to reduce a firm's return variability signals higher risk management quality and conveying managerial incentives to be consistent with shareholder best interests. Second, Bartram *et al.* (2011) find strong evidence that corporate risk hedging with derivative instruments reduce the total risk and systematic risk. On the theory side, several recent studies suggest that more risk hedging may lower the cost of equity capital. In Particular, Smith and Stulz (1985) suggest a fundamental basis that corporate risk hedging with forwards or futures contracts lead to a reduction of the firm return variability. Chen and King (2014) suggest that much of links between corporate hedging and the cost of equity is left unexplained in literature. The augmented arguments in literate on the market premium price implied in the cost of equity is mainly related to corporate risk (Modigliani and Miller, 1958). To our best knowledge, this study is among the first to look at the links between corporate risk hedging and the implied cost of equity capital.

These insights provide empirical evidence for drawing more conclusions in literature about the use of derivatives. Hence, the use of derivatives for hedging purposes plays a critical role as a financial policy in risk management activities. In this study, we employ data on UK nonfinancial firms over the sample period 2005-2012 to examine corporate hedging determinants, and the effect of the use of derivatives on firm value and performance. Further, on the one hand, corporate hedging decisions may contribute economic benefits to the firm, which could potentially reduce the firm's stock return volatility and the cost of equity capital (Bartram *et al.*, 2011; Gay *et al.*, 2011). In a world of capital market imperfection where information risk is costly, corporate hedging decisions are often associated with a reduction of information asymmetry (DeMarzo and Duffie, 1995; Géczy *et al.*, 1997; DaDalt *et al.*, 2002; Chen and King, 2014) and less financial distress costs (Smith and Stulz, 1985; Froot *et al.*, 1993; Nance *et al.*, 1993) that simultaneously increase the firm value. Several interesting results are obtained.

Chapter 5 – conclusion and remarks

This chapter concludes with a brief description of the theoretical background that supports this research.

- We find a positive association between investment inefficiency, which either under- or over-investment, and corporate hedging decisions. Consistent with theoretical research, Morellec and Schürhoff (2011) document that the costs of both under-or over-investment are important drivers of corporate hedging. Firms are more likely to hedge to control for investment inefficiency in both scenarios.
- While most of the existing studies focus on the average effects of the use of derivatives overall on firm value and performance, our empirical results show the effects of risk hedging with different types of derivatives. Theoretically, Bessembinder (1991) shows that corporate risk hedging with linear contracts, such as forwards, constitutes an important instrument in the risk management portfolios of many firms because It leads to a greater value by reducing incentives to underinvest. That means corporate hedging with forward contracts allows that firm to capture economic benefits from new investment when growth opportunities exist in the presence of financial distress.
- Our models predict a lower stock return volatility and cost of equity capital when firms hedge their financial risk exposures. Our findings show that corporate risk hedging may reduce information asymmetry costs implied in the cost of equity capital. The above discussion leads us to the following section that illustrates the research background.

1.3. Research background

This section illustrates the research background, which is motivated by the positive theory of corporate risk hedging and hedging determinants. The positive theories of risk management at the firm level in the presence of capital market imperfections (Jensen and Meckling, 1976; Smith and Stulz, 1985; Nance *et al.*, 1993) argue that maximising the market value of the firm can be achieved through an overall reduction of asymmetric financial risks. Thus, the use of derivative financial instruments in corporate risk hedging has increasingly become standard practice for nonfinancial and financial firms mainly with foreign operations.

With managerial incentives (Kumar and Rabinovitch, 2013), agency costs (Leland, 1998), and the presence of information asymmetry (DeMarzo and Duffie, 1995; Géczy *et al.*, 1997; DaDalt *et al.*, 2002), the principle can ensure that corporate hedging creates value to the firm. Corporate hedging decisions mitigate agency costs by reducing under-or over-investment (Morellec and Schürhoff, 2011) and a lower information asymmetry (Chen and King, 2014). This implies that the investment is associated with managerial incentives to shift their own benefits (Aggarwal and Samwick, 2003), indicating that under-or over-investment is indeed related to agency problems, but the corporate hedging theory in an influential perspective shows strong responses of managers (Morellec and Smith, 2007). A plausible literature suggests that corporate hedging is a leading financial policy to alleviate investment inefficiency.

The most prominent of these studies in risk management theory is the economic values of corporate hedging for the firm. From the theory of agency conflicts, for example, (Jensen and Meckling, 1976) argue that the conflict of interests between managers and shareholders is due to management incentives when managers increase their power for their own interests and show their utility function. Clearly, the research background is solid on the basis of the theoretical paradigm. Hence, we argue in this study that corporate hedging is consistently associated with strong governance mechanisms. Our models further incorporate a positive association between investment inefficiency and corporate hedging decisions, in the intervention of strong corporate governance.

The literature remains underdeveloped which extracts existing theories of risk management. However, existing research streams hedging incentives on the fundamental theory of risk management, on those findings with selective sample or specific industry. The remarks of a substantial literature (e.g., Smith and Stulz (1985); Nance *et al.* (1993)) has focused on exploring the hedging determinants and the optimal hedging level. For example, (Bartram *et al.*, 2009) finds that the increasing likelihood of corporate risk hedging is statistically positive and significant for firms that have increasingly underinvestment problems and higher financial distress.

The empirical evidence on whether the corporate risk hedging with derivative instruments does add to firm value and contributes to firm performance is mixed and depends on the type of risk hedging and type of derivative instruments. In spite of the substantial impact of hedging on the firm outcome, the existing argument in risk management expands upon how different derivative instruments in the derivative may vary in its effects. Belghitar *et al.* (2013) document that hedging instrument choices may be in favour of some firms which are associated with symmetric payoffs (i.e., futures, forwards, and swaps), and those with asymmetric payoffs (e.g., options). Consistently, prior theoretical research shows that corporate risk hedging with a particular derivative contract reduces underinvestment problems. For example, (Bessembinder, 1991) documents the entire shifting of risk when a firm uses forward contracts, which are a common use for hedging currency risk, those are more likely to increase its value by reducing incentives to underinvestment.

In spite of the existing argument of the role of various derivative instruments, corporate hedging as a financial policy plays a vital ground to alleviate agency costs in the presence of strong corporate governance levels (Aretz *et al.*, 2007; Aretz and Bartram, 2010; Allayannis *et al.*, 2012; Lel, 2012). However, the effect of corporate hedging on firm value and performance in firm ex-ante risk vary across time. This study explores the most common derivative contracts which require better understand of their effects over time-varying on firm value and performance. A significant literature exists (e.g., Block and Gallagher (1986); Chang and Wong (2003); Adam (2009); Chernenko and Faulkender (2012) on the impact of specific derivative instruments, in particular, such as currency options and swaps as well as interest rate, for those with geographical diversification and multinational firms face substantial currency fluctuations, on the firm outcome (value and performance). Despite the widespread use of derivatives, the optimal weight of positions is still uncovered in the existing studies.

The key to this study is that we treat corporate hedging decisions as an endogenous variable when estimating the impact of corporate hedging, in equilibrium, on firm value and performance. We also allow robustness tests in the empirical analysis to examine the level of endogeneity and self-selection bias. Understanding the interrelations between corporate hedging and related factors is critical to address potential endogeneity issues.

Literature provides support for the positive effects of corporate risk hedging on shareholders' values, (Bartram *et al.*, 2009) and (Bartram *et al.*, 2011) document well-known benefits of risk hedging that resulting in lower stock returns volatility. Empirical studies suggest several motivations for hedging: a reduction in the cost of equity (Gay *et al.*, 2011) and less information asymmetry (DeMarzo and Duffie, 1991). For example, (Nelson *et al.*, 2005; Gay *et al.*, 2011) provide further evidence that corporate risk hedging affects the level and fluctuations of shareholder returns.

Based on sample data from nonfinancial firms listed in the FTSE-All share index from 2005 to 2012, we examine the hedging determinants and the effects of corporate risk hedging on firm value and performance. In the seminal study, we explore the impact of corporate hedging on the stock return volatility and the implied cost of equity capital. Our hand-collected data for hedging activities in UK firms show empirical evidence and suggests that corporate hedging has, as a financial tool, economic benefits, indicating that, in equilibrium, the relationship between hedging risk, and firm value and performance will be positive. Interestingly, our models show that such a conclusion is not warranted when the firm uses various derivative contracts without cautiously consider the optimal level of hedging positions, and the magnitude of derivative instruments. Despite these unique features of empirical studies, we are able to identify the gap in literature and extracting our empirical findings. This discussion leads us to the research question section.

1.4. Research problem

There is a large set of literature in corporate risk hedging and value relevance of derivatives. Indeed, the major objective of this study is to provide new insights into the question why some firms hedge, whereas other do not. While the motivations for, and the determinants of, the use of derivative financial instruments have been relatively investigated, our research addresses agency costs as a substantial factor. The relationship between corporate hedging, and firm value and performance has been explored to a significant extent in the literature, showing that the use of derivatives leads to a value creation for the firm (Stulz, 1984; Smith and Stulz, 1985; Lang and Stulz, 1994; Froot and Stein, 1998). Therefore, several existing studies explore the potential implications on the use of derivative and provide empirical conclusions on the economic benefits of hedging.

The purpose of this study is to shed light on the strongest motivation to use derivatives, and what is the impact of derivatives on firm value and performance. Further, we investigate whether derivative users are associated with a potential risk reduction. This discussion leads us to the research questions, which is the main concern of this study.

1) What is the association between under- or over-investment problems and corporate hedging decisions?
2) Does the use of different types of derivative instruments significantly lead to positive effects on firm value?
3) Do different types of risk hedging tend significantly to increase firm value in risk time-varying?
4) Does corporate risk hedging reduce to the firms' cost of equity implied in stock prices and return volatility?

In contrast to existing studies, this study complements the literate that directly tests the use of derivatives and streaming its impact on the agency costs, firm value, and stock returns variability. We also expand the evidence on the role of corporate hedging decisions in mitigating the implied cost of equity capital. We contribute to the stream literature on the links between the use of derivatives and investment inefficiency (under- or over-investment). Prior studies (e.g., Bartram *et al.* (2009)) focus on underinvestment problems and financial distress, while others (e.g., Kumar and Rabinovitch (2013)) explore managerial incentives in hedging risk, or the impact of the hedging risk on firm value (e.g., Allayannis *et al.* (2012)). We also add to their findings by showing the effects of different types of derivative contacts on the firm value and performance.

To investigate the research problems, this study explores the research questions using UK nonfinancial firms listed in the FTSE-All share index. There is a plausible reason to employ nonfinancial firms for investigating the inherent incentives of corporate hedging. First, we exclude financial firms because the use of derivatives might be associated with hedging risk or speculation. Thus, we purely focus on the use of derivatives to hedge financial price variability. This is consistent with nonfinancial firms that explicitly report derivative contracts in hedge accounting notes and detailed financial disclosures. Interestingly, the hedge accounting under International Financial Reporting Standards (IFRS) has successfully developed, which introduces more financial standards by mid of 2004 for the derivative positions held by listed firms, since the UK GAAP required firms to report financial derivatives from 1999. We use UK nonfinancial firms in our analysis to address this research question over the period 2005-2012 because hedge accounting was inconsistent prior 2005.

However, there is the somewhat puzzling evidence about the links between corporate risk hedging with the most common derivative contracts and the firm value and performance. In particular, what are the motives beyond using derivative instruments? However, these are open questions in our research to predict the economic benefits of hedging risk exposures.

1.5. Aims and objectives

This section briefly summarises the aims and objectives of this study. The motivations for this study rely on risk management theories and the existing empirical research. This study aims to achieve new insight into the existing research and adds to the literature that corporate hedging decisions have economic benefits to the firm outcomes. The main objectives in this research study are as follows:

- To investigate the hedging determinants in the presence of agency costs (i.e., investment inefficiency), financial distress, and information asymmetry.
- To explore the effects of the most common derivative instruments (futures, forwards, options, and swaps) on firm value and performance, which are favourable in instrument choices.

- To document the relation between corporate hedging and both stock return volatility and the cost of equity capital.
- To provide a new synthesis of recent methods in econometrics techniques that efficiently addresses potential endogeneity problems in linear and nonlinear models, in which the coefficients estimation are consistent.

Furthermore, this study aims to advance our understanding of corporate hedging and existing theories as follows.

First, we examine how corporate hedging decisions influence firm value and performance. Existing studies attempt to limit potential results bias because of endogeneity issues or problems in risk management models. We aim to provide robustness tests in our structural models and to deal with potential endogeneity concerns. In particular, the changes of firm value and performance may not be driven by financial derivatives use alone, but also by other observable or omitted explanatory variables. In each chapter of this study, we employ appropriate methods to deal with potential endogeneity issues.

We aim to predict that nonfinancial firms might use the financial derivatives to mitigate agency problems in the presence of strong corporate governance. The current literature suggests that hedging decisions can be mainly driven by financial distress, which can come in the form of under- or over-investment problems, agency conflicts of equity and debt (Smith and Stulz, 1985; Jensen, 1986; Nance *et al.*, 1993; Morellec and Smith, 2007). Further, Bartram *et al.* (2011) conduct an international study using a large sample of nonfinancial firms in which the use of derivative financial instruments reduces total risk exposures and systematic risk. Thus, we aim to fill this gap in the literature.

Second, whether derivative contracts induced by derivative markets have similar impact on the firm value and performance. The recent financial crisis 2007-2009 and downside risk are examples of the importance of derivative instruments which brought new scrutiny to the use of derivative contracts. There has been some evidence from US and UK firms that derivative instruments receive substantial increases in the last decade during the pre- and post-financial crisis, while the shareholders' value can experience a decline in their wealth because of financial risk.

Third, this study documents that derivative users have a reduction in stock returns volatility and a lower cost of equity capital. For example, Bartram *et al.* (2011) conduct an international study using a large sample of nonfinancial firms in which the use of derivative financial instruments reduces total risk exposures and systematic risk.

1.6. Research methodology

In this section, we provide a brief discussion of the research methodology in which the methods we use are applied and then our results are robust. Our robustness tests should be viewed as suggestive. We note that the causality effects between the use of derivatives and firm value or performance are endogenously determined by similar variables. Therefore, we consider related instrumental variables that are variables in the first stage of simultaneous estimation and not correlated with the dependent variable in the second stage estimation. The research methodology, in this study, critically uses recent various methods to eliminate the problem of endogeneity or omitted variables bias estimations. We summarise the methods used in each chapter as follows.

- **Chapter Two:**

The probit regression is used to model a firm's binary decision of whether or not to use derivative instruments for hedging overall (H), foreign currency (FX), interest rate (IR), or commodity price (CM) risk. The dependent variable (hedging) in the probit model estimation takes the value of one if a firm uses FX derivatives, IR derivatives, or CM derivatives, respectively, and zero otherwise.

While existing models in corporate hedging determinants provide a rich intuition as to why firms hedge in line with market imperfections, this chapter addresses the fundamental question whether investment inefficiency (under- or over-investment) increases the likelihood of corporate risks hedging. Thus, firms may be more likely to hedge risks not only to control for underinvestment problems, but also to control for overinvestment incentives driven by managerial entrenchment power and self-interest.

Our methodology in this chapter starts with base line probit regressions to shed light on the relationship between agency costs and corporate hedging decisions. It also provides a number of new predictions relating the benefits associated with strong corporate governance. Therefore, corporate governance can lead to an increase of the likelihood of hedging decisions to mitigate the overinvestment incentives. Agency costs are found to be endogenous and significant for our models, especially when estimating a binary decision (corporate hedging) model with binary endogenous regressors. We present in turn the special regressor approach, which supports consistent coefficient estimations (Dong and Lewbel, 2015), that relies on a different set of assumptions.

- **Chapter Three:**

To assess the effect of the use of derivative instruments on firm value and performance, we use recent developed methods in econometrics to control for potential endogeneity issues, self-selection bias, omitted variables bias, and time-varying. Before estimating our models with instrumental variables approach, we perform OLS baseline regression estimations to determine whether the effects of derivative contracts on firm value and performance vary with respect to whether some favourable contracts can be potentially positive because of their costs in derivative markets (i.e, forward contracts). There are two types of endogeneity that apply in this case. First, it is possible that more nonfinancial firms tend to be involved in foreign operations and their strategy mainly based on geographical diversification. Since our underlying argument is that it may be difficult to identify the cause and effect between foreign sales and foreign expenditures, the baseline of OLS regression estimations could be biased. Second, there may be some other important characteristics, which could affect the firm performance such as firm size, the level of financial distress, or related industries.

First, we control for endogeneity of risk hedging foreign currency (FX), interest rate (IR), and commodity price (CM) risk using instrumental variables approach with GMM system (IV-GMM). The difference between OLS and IV-GMM estimator is that the instrumental variables approach provides consistent and efficient estimations.

Second, we address potential self-selection bias by employing treatment effects methods (i.e, treatment effects, propensity score-matching and difference-in-differences). It is more likely that firms may use derivative financial instruments (i.e, future, forward, option, and swap) for hedging or speculative purposes (Allayannis *et al.*, 2012).

Third, choosing difference-in-differences method is more challenging, in which hedging risk is time-variant. The method enables us to explore two different categories in time-varying: 1) post-crisis vs. pre-crisis and 2) during crisis vs. non-crisis.

- **Chapter Four:**

In this chapter, we estimate the cost of equity capital that is implied in stock prices and based on two models introduced by Easton (2004) and (Ohlson and Juettner-Nauroth, 2005) as implemented by (Gode and Mohanram, 2003). Detailed descriptions of the cost of equity capital estimations are summarised in Appendix A. Since there is a little consensus in the literature on which models precisely estimate the implied cost of equity, we follow (Dhaliwal *et al.*, 2016) in using the mean of estimates from these models to mitigate of the effect of measurement errors, which may be associated with one particular model. We perform various robustness tests on the effects of corporate hedging decisions in the cost of equity estimates and potential endogeneity issues arise.

1.7. Research contributions

Although investment efficiency and volatility risk are more common in risk management theory, relatively little attention is paid to the phenomenon of agency costs, different types of derivative instruments, and the implied cost of equity. Specifically, this study contributes to the empirical literature in several ways.

First, it adds to the long debate on the most driven factors of hedging incentives and the consequences of investment inefficiency. Most of the debate in the large literature focuses on underinvestment problems as a result of managerial risk-aversion. One popular way of testing both sides of investment inefficiency when it is beyond the optimal levels is based on accountancy-basis. Following Richardson (2006)'s model, we predict under-or over-investment to test the effects of investment inefficiency on corporate hedging decisions. Different from earlier studies, we provide empirical evidence that corporate risk hedge is more likely to increase to mitigate the agency costs, indicating that firms in settings prone to either under- or over-investment, in the presence of strong corporate governance intervention, are positively associated with more hedging decisions.

Second, consistent with the existing theoretical research (e.g., Bessembinder (1991); Chang and Wong (2003), that focused on most popular derivative contracts in risk management strategy, we examine the impact of the risk hedging of foreign currency (FX), interest rate (IR), and commodity price (CM) on firm value and performance, where we control for time-varying. The results reply on propensity score matching indicate that for hedging FX risk with various derivative contracts are associated with positive impact on the firm value except options, while forward contracts in hedging IR risk are consistently associated with positive incremental value. We contribute to the literature that the association between corporate risk hedging and firm value replies on the type of contracts and time-varying effects. To our best knowledge, this study contributes to the literature as whether the most common derivative contracts lead to a value creation.

Third, this study contributes to currently existing research on investigating the effects of corporate hedging decisions on the stock return volatility and the implied cost of equity capital. We find derivatives users have a significantly lower cost of equity capital implied in stock prices, and corporate hedging decisions attribute a reduction on stock return volatility to users.

However, our analysis presents a comprehensive perspective on determinates of hedging decisions where the derivative instruments have various effects on firm value and performance. Though theoretical literature on corporate risk management and agency costs provide strong evidence on the hedging benefits on firm value and performance in the presence of market imperfections, the optimal level of derivative contracts and magnitude are an important area for future research. This study provides new features and a fruitful area of research.

1.8. Structure of the thesis

This chapter has discussed the research motivations and background of this study, outlined the research problem, and specified aims and objectives in conducting this research. We shed light on the main contributions of this study. We illustrate a brief description of each chapter. The remainder of this thesis is structured as follows.

Chapter two explores the relationship between corporate risk hedging and agency costs presented in investment inefficiency. In particular, this chapter addresses the question of whether under- or over-investment is an important factor in hedging determinants by examining nonfinancial firms listed in the FTSE-All share index on the London Stock Exchange over the period 2005-2012. Specifically, based on theoretical predictions, we argue that the hedging decisions would relatively be more likely to increase with under- or overinvestment problem scenarios, in the intervention of corporate governance mechanisms, to help in alleviating agency costs. Our findings are robust to alternative specifications of binary models and recent developed econometrics methods.

Chapter three examines the effect of hedging foreign currency (FX), interest rate (IR), and commodity price (CM) risk on firm value and performance. We argue that the effectiveness of hedging strategies varies significantly across both the financial risk that is hedged and the derivatives used in the hedging. We predict that when the analyses are conduced across different time periods, our findings based on the difference-in-differences method combined with matching strategy shows that the impact of hedging is time-specific.

Chapter four investigates the relation between corporate hedging decisions and the firm's implied cost of equity capital. We hypothesise that more hedging decisions reduce the stock returns volatility and can lead to a lower cost of equity capital.

Chapter five finally provides the research conclusions. In this chapter, we summarise our findings and critically note how our results are robust to alternative methods employed in this study. We highlight the key contributions in this research and provide new insights into implications for future research.

CHAPTER 2

Financial Hedging Decisions and Investment Inefficiency

2.1. Introduction

It is a rendered fact that the theory of corporate risk management is concentrated. In particular, the determinants and consequences of corporate hedging decisions have received extensive attention in finance literature. Recent studies provide evidence that mitigation of agency costs associated with underinvestment problems undoubtedly plays a crucial role in shaping corporate hedging policies (Bessembinder, 1991; Froot *et al.*, 1993; Bartram *et al.*, 2009). However, it is difficult to fully quantify the relative importance of different agency concerns in risk management theory. It is challenging to uncover corporate hedging policies and motives, with specific incentives that link agency costs and the likelihood of increased hedging decisions, due to endogeneity concern. Many prior theoretical (e.g., Smith and Stulz (1985); Nance *et al.* (1993); Aretz *et al.* (2007)) and empirical studies (e.g., Clark and Judge (2008)) acknowledged market imperfections and provided rich intuition about incentives for corporate hedging.

The literature suggests that firms potentially suffering from underinvestment or asset substitution problems tend to hedge more (see e.g., Fok *et al.* (1997); Géczy *et al.* (1997), while the relevance of the overinvestment problem as theorised by Morellec and Smith (2007) also tends to induce firms to increase risk hedging. The existing argument of overinvestment problem is due to managerial incentives and self-interest of more investment expenditures, in which firms increasingly have free cash flow and less growth options (Jensen, 1986). On the other hand, Kumar and Rabinovitch (2013) argue that overinvestment problem driven in part by abundant free cash flow should lead firms to hedge because of precautionary reasons. Thus, managers might have incentives to overinvest even in risky asset (Jensen and Meckling, 1976; Jensen, 1986) because managers derive benefits in such a setting scenario problem. Almeida *et al.* (2011) argue that higher cash balances may also intensify overinvestment problem by entrenched managers. While finance literature provides several hedging theories, evidence on the influence of the investment inefficiency to hedge remains ambiguous. A growing empirical literature links the investment inefficiency of the firms to hedging decisions as an important determinant (Gay and Nam, 1998).

The classical theory of the agency costs starts from the conflicts between managers and shareholders, and suggests that firms' growth options in their investment opportunities must be contingent with underinvestment problems (Froot *et al.*, 1993; Nance *et al.*, 1993; Bartram *et al.*, 2009). Thus, agency costs can induce a firm's hedging decisions, if corporate governance mechanisms reside strongly. Motivated by the classical agency theory of the firm, this chapter studies how investment inefficiency concerns influence the hedging activities in response. In relation to the role of corporate governance mechanisms' intervention between agency costs and hedging decisions, to the best of our knowledge this is the first study that empirically examines the effects of both underinvestment and overinvestment on corporate hedging decisions.

We enter this picture with alternative methodology, which helps us to explore the links between agency costs, namely, under- or over-investment problems, and corporate hedging decisions. We identify these effects by estimating a *probit* regression model of the likelihood of corporate hedging decisions and investment inefficiency (Underinvest) that embeds agency costs frictions. We use a *probit* regression model as an essential milestone for our empirical investigation. Understanding the effects of underinvestment problems requires distinguishing it from the overinvestment problems, which only makes sense in binary outcome models. Many of the prior studies in corporate risk management, theoretically and empirically, are based on structural models, in market imperfections, that provide rich intuition beyond incentives to hedge and why firms do (not) hedge?.[1]

Existing arguments imply that the relationship between investment inefficiency as an important factor in hedging determinants is expected to be positively associated with the propensity of corporate risk hedging decisions. Indeed, we argue that a number of existing hedging theories can be explained through this intuition, in which firms take actions with corporate risk hedging to alleviate agency costs. To provide answers to this argument, we formalise a simple framework of hypotheses: 1) firms in settings prone to underinvestment problems are positively associated with more corporate risk hedging 2) the interaction of overinvestment problem with corporate governance mechanism leads to more hedging decisions to mitigate agency costs 3) firms with higher information asymmetry are more likely to hedge.

Our main contribution in this study is to present and test under- or over-investment in risk management theory, concerning the investment expenditure scenarios. Therefore, this line of research is extended to hypothesise and find a conditional positive association between investment inefficiency and the likelihood of hedging financial risk exposures. We analyse issues, which are difficult to address, mainly with endogeneity problems to consider the impact of under- or over-investment on the hedging decisions. Strong predictions are provided on how investment inefficiency translates incentives to manage financial risk exposures into actual decisions with the usage of financial derivatives. Degryse and De Jong (2006) identify that underinvestment is due to information asymmetry costs, while overinvestment reflects conflicts in managerial discretion.

[1] See, among others, Aretz *et al.* (2007), Clark and Judge (2008), Smith and Stulz (1985), Géczy *et al.* (1997), and Nance *et al.* (1993) for some recent empirical issues with regards to the determinants of hedging financial risks.

Recently, a debated argument in the literature is the determinants of hedging with regards to the financial risks.[2] Previous studies empirically examine different theories of corporate hedging by univariate and multivariate analysis. However, no clear common conclusions are identified on what really induces firms to hedge using derivative instruments. In the neoclassical model of (Modigliani and Miller, 1958), the investment opportunities of the firm are not affected by their various financing policies in perfect capital markets (Myers, 1977).

Recently, various firms have increasingly mitigated the investment inefficiency that has been regarded as a phenomenon for agency costs.[3] However, the consequence of investment efficiency, which links with hedging decisions, is not yet understood. As prior studies in finance literature generally focused on tax incentives and financial distress in association with hedging decisions (Smith and Stulz, 1985; Mian, 1996), therefore in this study we consider several motivations for hedging financial risks: under- or over-investment, the influence of strong corporate governance, and asymmetric information. However, differences in erroneous conclusions in risk management literature to capture the determinants of hedging from different dimensions are incomplete. In market imperfections, informational asymmetries may lead to some investment inefficiency on whether investment opportunities are being taken or not (Morgado and Pindado, 2003). Therefore, the debate is centred on understanding the investment inefficiency as an important factor in hedging decisions, and whether interactions between investment inefficiency and corporate governance role may result in alleviating agency costs. However, empirical tests offer explanations for hedging financial risks with regards to foreign exchange price exposures, interest rate volatility price and

[2] Graham and Rogers (2002) document that firms frequently use financial derivatives to increase debt capacity, but provide no evidence that firms hedge in response to tax convexity. Incentives to hedge are conditional with other important implications.

[3] From 1st January 2005, IAS 39 requires firms to report derivative instruments with regards to net investment in foreign operations. For instance, Vodafone PLC, the Group uses derivative financial instruments to hedge its exposure to foreign currency and interest rate risks in foreign operations. To the extent that such instruments are matched against an underlying asset or liability, they are accounted for net investment hedges.

commodity price risks using various samples and methodologies. This suggests that many questions remain unanswered when trying to understand beyond the determinants of corporate hedging strategies in nonfinancial firms.

This study helps to fill this gap by providing the first interactions of empirical investigation of how underinvestment affects firms' hedging decisions. For example, *Do the probability of hedging decisions increasingly being induced by the existence of underinvestment problems? Could both underinvestment and overinvestment problems increase the likelihood of hedging decisions by strong governance mechanisms? Could greater information asymmetry affect the likelihood of hedging decisions in market imperfections?*. In this chapter, we extend the above insights into what the effects of agency costs on corporate hedging decisions. In particular, we show that well-known determinates of hedging decisions for foreign currency, interest rate or commodity price risks, as predicted in the previous studies: , mitigation of agency costs associated with underinvestment problems (Bessembinder, 1991; Froot *et al.,* 1993), reduction in information asymmetry costs (DeMarzo and Duffie, 1995; Dionne and Triki, 2013), and lower likelihood of financial distress (Smith and Stulz, 1985).

This argument is relevant in this study to expect that the relationship between underinvestment and hedging decisions is positive. Indeed, we argue that a number of existing hedging theories can be explained through this notion, in which firms take actions with hedging decisions to minimize the impact of future underinvestment problems. These arguments are formalised in a simple framework of hypotheses, reflecting the interactions of underinvestment problems with corporate governance mechanisms. In this sense, this study is conducted using a panel data of the listed nonfinancial firms on the London Stock Exchange over the period of 2005-2012, as the comprehensive data information on hedging financial risks in risk management disclosures in firms' annual reports is complementary.

To test our hypotheses, given the significance of the capital market imperfections and strong corporate governance mechanisms in the UK market, it is a unique dataset of this study that sheds light on the investment inefficiency in association with hedging incentives.[4] However, several empirical studies in literature randomly select data based on US firms or an international sample for exploring the hedging determinants, while other studies document evidence for hedging firms based on a particular risk exposure or a specific industry.

Given the strong effect of investment inefficiency problems on the likelihood of hedging decisions, we employ Richardson's model to predict firms with under- or over-investment. Prior studies (e.g., Bartram *et al.* (2009)) suggest various measures, such as Tobin's Q, R&D to assets and capital expenditure to assets, as proxies for underinvestment models. However, these studies are quite convinced with firm-level characteristics, financial constrains or cash flow sensitivity. The Richardson (2006) model is utilised to predict abnormal investment proxy, which defines under- (over-) investment as the investment opportunities that are less (greater) optimum levels of investment with a dummy variable 1, and 0 otherwise. Comparing this framework with other prior studies, we find that predicting the sensitivity of investment efficiency in line with accountancy methods is more robust. Investment inefficiency can be predicted as a continuous variable instead. For example, Gomariz and Ballesta (2014), following Biddle *et al.* (2009), estimate that the expected level of investment based on growth opportunities and all deviations from the actual investment expenditure in the error term represent investment inefficiency. In contrast, we adopt Richardson's accounting-base framework to predict the residuals from regression dynamic model estimation, and these residuals (negative or positive) are converted into a dummy variable of

[4] We use a hand-collected data set of UK nonfinancial firms listed in the FTSE All-Share Index. Prior to 1st January 2005, the accounting policies for derivatives were in accordance with UK GAAP, and any gain or loss on the hedging instruments was recognised directly in the income statement. The lack of details and comparability of hedge accounting in financial disclosures kept the information provided by firms on the use of derivative instruments is going to be of limited value.

1 as a proxy for underinvestment and 0 for overinvestment. Therefore, our approach provides a powerful method to precisely estimate investment inefficiency that relies on the basis of accounting framework. In the test method, it is recognised that the relationship between investment inefficiency and hedging decisions could be endogenous.

To fully account for the potential problems arising from endogeneity, our empirical tests utilise the modest recent method in *probit* models – with instrumental variables – to address an endogenous explanatory binary variable using a binary choice model with the special regressor model (Chen *et al.*, 2016).[5] Our empirical results show that hedging incentives increase in the presence of underinvestment problems. The positive correlation between underinvestment and hedging decisions is also associated with prior studies. In contrast, our findings are consistent with Bartram *et al.* (2009), who document that since the underinvestment costs might be more severe for firms with investment opportunities, and external capital is costly, hedging decisions could consequently increase beyond corporate incentives.

The results of this study, which show that underinvestment problems are positively correlated with hedging decisions, are also in line with the agency costs hypothesis (Stulz, 1990): mitigating the costs of under- or over- investment can influence related corporate financing policies, such as corporate hedging activities, to induce managers inversely to the volatility of cash flows above the optimum.

Our results contribute to the literature in several ways. First, we extend the growing literature on the links between investment inefficiency and corporate hedging decisions. We show that, firms prone to under- or over-investment, those with more corporate governance mechanisms are more likely to hedge more to alleviate agency costs. Second, we show that,

[5] In heteroskedastic binary response models with one or more discrete explanatory variable that is supposed to be endogenous, special regressor based estimator consistently estimates coefficients in contrast with iv-probit or 2sls-probit models.

firms associated with greater information asymmetry should have stronger influence on the likelihood of hedging decisions to increase. The corporate hedging has economic benefits to firms, for those with greater asymmetric information costs are more likely to hedge more (DeMarzo and Duffie, 1995). Third, we perform robustness tests using the special regressor (V) method estimator (Lewbel, 1998; Dong and Lewbel, 2015) – with instrumental variables (IVs) – that consistently estimate the likelihood of hedging decisions in the presence of endogeneity concerns. Unlike commonly used methods in econometrics literature, the special regressor-based estimator in binary regression models has several advantages: provides consistent estimates of the model coefficients, allows for general and unknown forms of heteroscedasticity, and does not require endogenous regressors of interests to be continuously distributed.

The remainder of the chapter is as follows. Section 2 reviews the risk management theory, related empirical evidence about the correlation between hedging decisions and investment inefficiency, and exploring the role of strong corporate governance mechanisms influence on agency costs. Section 3 describes how we construct our sample of firms that use derivative instruments to hedge financial risks (foreign currency, interest rate, and commodity price). Section 4 performs tests and reports the empirical results and Section 5 concludes.

2.2. Literature review and hypotheses development

Theoretical review of corporate hedging has been studied as a solution for agency conflicts that appear when investment expenditures diversify from the optimum levels. In the centre of agency theory, Myers (1977) argues that managers acting as agents of the stockholders and information asymmetry drives linkage between investment opportunities and financial risks such as the cost of bankruptcy and financial distress. Prior research (e.g., Morgado and

Pindado (2003); Pindado and De La Torre (2009)) hypothesises and finds that under- or over-investment is in accordance with divergence of interests between shareholders and managers. Therefore, DeMarzo and Duffie (1991), among others, explore incentives of hedging and link between corporate hedging and information asymmetry using models in which hedging strategies by managers increase their usefulness and indicators of managerial quality. Thus, in an attempt to mitigate the adverse effects of agency costs on the consequences of firm value and performance, corporate hedging decisions are positively driven by the desire to finance new investment in both under- or over-investment problems (Morellec and Smith, 2007).

Under the neo-classical theory of risk management, firms with greater growth opportunities and tighter financial constraints are more likely to hedge financial risks (Géczy *et al.*, 1997; Bartram *et al.*, 2009). The choice of investment opportunities, and its link with hedging decisions, is central to the investment financing of corporations. Nance *et al.* (1993) suggest that firms are more likely to adapt to corporate hedging decisions in uncertainty or volatility of financial risks to control agency problems with potential growth opportunities. Financial economic has a rich literature analysing corporate hedging decisions in empirical studies, as a component of corporate financial policy. However, it has provided little guidance with regards to investment efficiency. Under- or over-investment problems can be seen as the two sides of investment inefficiency. Firms may engage in projects with positive (negative) net present value due to managers' incentives. It is also consistent with Almeida *et al.* (2011)'s model and its extensions, who show that information problems often force the firms to pass up profitable opportunities and can increase underinvestment problems. In this chapter, we examine the role of investment inefficiency and information asymmetry in hedging decisions. By lowering either under- or over-investment problems, the optimum level is more likely to exhibit an effect on hedging decisions.

It is not surprising that most of the previous studies have focused primarily on underinvestment problems (i.e., Bartram *et al.* (2009)) or firms' characteristics on corporate hedging strategies (Allayannis *et al.*, 2012). However, the motives beyond the firms' characteristics could be the main driving factors. In this section we provide a brief summary on the determinants of the use of derivative financial instruments that mostly examine nonfinancial firms in finance literature. In the literature, Smith and Stulz (1985), for instance, provide a developed theory that shows incentives on why certain corporations should hedge and others do not. This puts forward considerations on tax reductions (Graham and Smith, 1999), transaction costs of financial distress, information asymmetry, managerial compensations and risk aversion (see, i.e., Smith and Stulz (1985)).

In this context, several empirical studies extend the hedging theory by identifying the determinants of hedging that influence corporations' decisions to use type and level of derivatives in financial risk exposures. For example, Aretz *et al.* (2007) , Afza and Alam (2011) and Purnanandam (2008) document that financial decisions behind hedging motives exist in market imperfections that corporate hedging policies can help firms to reduce agency costs, costly external financing, costs of bankruptcy, tax convexity, volatility cash flows, and unsystematic risks. As a result of this theory, the motives of using derivatives financial instruments in corporate hedging practices are still in debate for providing diverse explanations. Conceptually, several empirical studies (e.g., Nance *et al.* (1993)) have examined why and how corporations implement corporate hedging policies for risk management.

Furthermore, it is challenging to assess the extent by which existing empirical studies conclude evidence of the motives beyond the use of derivatives, particularly from the view of the underlying structural models or specific explanatory variables. Testing these theories on the determinants of hedging strategies entails critical challenges. Also, it highlights the importance of endogeneity concerns, with regards to corporate hedging motives (Aretz and Bartram, 2010). Lievenbrück and Schmid (2014) state that firm size has an important economic impact on any financial policy and, in particular, hedging decisions. For example, Graham and Rogers (2002) document that firms hedge because of expected financial distress costs and firm size. Similarly, Géczy *et al.* (1997) show that firm size is a proxy for economies of scale in the costs of hedging, indicating that if smaller firms have greater asymmetric information, thus the corporate hedging is more likely to increase because hedging will reduce their variability. However, this influence simultaneously affects the factors in the probability of hedging decision choices over time. Likewise, the level of firm profitability is more likely to affect hedging decision choices. However, in situations where external financing is costly, firms hedge to alleviate underinvestment problems and achieve a lower level of information asymmetry costs that the firm will obtain these funds at a lower cost.

Bonaimé *et al.* (2014a) provide evidence of an association between hedging and payout decisions over dividends, showing in the cross-section and within firms that hedging firms have significantly less flexibility in their payout policy structure, which is jointly determined by other firm characteristics. Therefore firms accordingly hedge in connection with the level of financial flexibility to avoid financial distress and underinvestment. Empirically, several studies have focused on the tax incentives that could lead to progressive hedging decisions (Smith and Stulz, 1985; Tufano, 1996; Allayannis and Weston, 2001; Bartram *et al.*, 2009). Recently, Amaya *et al.* (2015) and Fehle and Tsyplakov (2005) develop a dynamic risk management model to investigate the determinants of a firm's optimal hedging decisions. The different incentives of hedging financial risks through different structural dynamic models provide additional insights and implications to be considered in this study. This empirical evidence focuses only on the relation between capital structure, financial distress and hedging policy and show mixed results. Using leverage variables as proxies for financial distress are significantly related to derivatives use in non-financial firms (Clark and Judge, 2008).

In this study, financial flexibility factors are considered as important in hedging decisions and are difficult to exclude or empirically test its relation. Thus, our robustness analysis employs the special regressor (V) method that extends to controlling for endogeneity concerns when financial distress critically drives corporate hedging decisions. However, joint interactions could exist beyond the main determinates of hedging decisions. Therefore, the choice of investment inefficiency, in addition to an endogenous choice of the level of investment inefficiency (under- or over-investment), can be incorporated in our present model. Although not explored explicitly in the prior risk management literature, our model links the investment inefficiency with the considerable corporate governance mechanisms, beyond the current obvious concerns of analysis.

2.2.1. Underinvestment and hedging decisions

Prior studies in the literature show that investment efficiency is potentially an important rational for hedging decisions of the firm. For those prone to underinvestment, the nature of agency costs is generally generated by financial distress and information asymmetry. This is the costs associated with the existence of debt and outside equity problems described by (Jensen and Meckling, 1976). Thus, corporate hedging has shown that agency costs are strongly supportive of the hypothesis that the probability of hedging decisions is associated with reductions in the level of under- or over-investment problems. Géczy *et al.* (1997) examine determinants of corporate hedging decisions with regards to currency derivatives between two differential groups of users and nonusers with the hypothesis that hedging can reduce underinvestment costs associated with investment opportunities.

Expected agency costs mitigations and indirect bankruptcy costs are linked to the probability of hedging decisions if derivative contracts help reduce the level of underinvestment or overinvestment problems. For instance, Froot et al. (1993) document that corporations are more likely to hedge as hedging potentially increases the availability of free cash flows for future attractive investment opportunities, which leads to a reduction in underinvestment problems. Firms with underinvestment problems may have more incentives to hedge in times of financial distress (Myers, 1977); this theoretical explanation is in line with the empirical findings of Géczy et al. (1997). Therefore, at the optimum level of growth opportunities, firms are more likely to lower hedging activities in order to reduce the availability of free cash flows that can be used in investing in negative net present value (NPV) projects (i.e., overinvestment problem) (Bessembinder, 1991).

With capital market imperfections, hedging decisions can alleviate underinvestment or overinvestment problems by increasing the effectiveness of managerial efforts. In line with the theoretical setting of Morellec and Smith (2007), our analysis empirically points to an important hedging motive behind corporate investment policies that both underinvestment and overinvestment are strong drivers of hedging decisions. Surprisingly, theoretical research has not yet focused on how the investment efficiency affects corporate hedging decisions. The arguments, in a number of recent studies, show that corporate investment is empirically associated with firms financial constrains for growth opportunities.

As pointed out by Almeida and Campello (2007), firms' financing frictions affect investment decisions, which supports managers' incentives for hedging. Surprisingly, empirical research has not yet focused on how the investment efficiency affects corporate hedging decisions. Furthermore, some studies showed a positive association between propensity to hedge and investment inefficiency (Gay and Nam, 1998; Morgado and Pindado, 2003; Morellec and Smith, 2007; Bartram *et al.*, 2009) If firms face underinvestment problems, such problems can be reduced in the future by increasing the likelihood of hedging decisions. The above discussion leads to the following hypothesis.

H1. *Underinvestment Hypothesis*: Firms hedge more in settings prone to underinvestment problems.

Thus, if a firm faces underinvestment problems due to increasing agency costs, the expected underinvestment problems can be reduced by increasing the likelihood of hedging decisions.

2.2.2. Do corporate governance roles mitigate investment inefficiency?

Prior research (Leland, 1998; Allayannis *et al.*, 2012; Lel, 2012) focuses on the effects of corporate governance mechanisms on hedging activities, and generates implications that strong corporate governance is an important factor in hedging policies. These studies take an international perspective in cross-country analysis and compare the strength of corporate governance effects on hedging decisions using alternative proxies and various subsamples.[6] The strength of corporate governance can also lead to better corporate hedging decisions or optimal hedging activities (Lel, 2012). Allayannis *et al.* (2012) suggest that the use of derivatives should be positively associated with firm value for well-governed firms.

In this chapter, we extend this literature by examining corporate governance intervention and agency costs, in which corporate hedging activities can alleviate investment inefficiency (under- or over-investment). This alters the association between firms in settings prone to under- or over-investment scenario as documented by García Lara *et al.* (2016). However, we present a comprehensive perspective on corporate hedging decisions, and the results are more robust to interactions between under- or over-investment and corporate governance. Understanding the association is important, especially, when the agency costs is one of the

[6] A large literature examines theoretically and empirically various rationales for risk management, and links it with corporate governance roles (see, e.g., Aretz and Bartram (2010); Aebi *et al.* (2012)).

key considerations for corporations and institutional investors. In fact, under- or over-investment problems are more direct yardstick of investment efficiency that may affect the likelihood of hedging decisions in the presence of corporate governance mechanisms. Stronger corporate governance means limiting agency problems that might lead to alleviate agency costs. Therefore, this perspective predicts a positive association between under- or over-investment and the likelihood of corporate hedging decisions. In particular, in this section, we focus on the role of corporate governance effects on increasing the likelihood of hedging financial risks.

Prior studies on corporate risk management emphasise the effects of corporate governance on the economic consequences of firm value and performance. Consistent with a number of theories, we examine these governance mechanisms on corporate hedging as viewed from the dilemma of different proxies, with typical intervention of both under- or over-investment problems. Yet, few direct results are available on how most governance mechanisms (e.g., governance-score) affect hedging decisions, as many these interactions occur beyond the investment inefficiency costs. In this study, we support the existing literature with the role of strong corporate governance in mitigating agency costs.

However, few related studies also use direct evidence to examine the effect of sub-samples of strong (weak) governance roles on corporate hedging activities. Although this supportive evidence in literature is a considerable issue, but it is not essential in this study as this research design mainly focuses on the intervention effects. Inherent challenges in this study occur because different corporate governance mechanisms have different levels of influences on hedging decisions. The above discussion leads to the following predictions:

H2a. *Underinvestment hypothesis*: Stronger corporate governance is likely to induce firms to hedge more in settings prone to underinvestment problems.

H2b. *Overinvestment hypothesis*: Stronger corporate governance is likely to induce firms to hedge more in settings prone to overinvestment problems**.**

Overall, corporate governance hypothesis is crucial to prove that hedging activities in line with agency costs are more likely to increase to mitigate under- or over-investment problems. Firms with strong corporate governance are more likely to use corporate hedging policies; when positive NPV investment opportunities are ignorable, underinvestment problems are more likely to be reduced. To test our hypothesis of corporate governance intervention, we use governance-score as a proxy for the strength of corporate governance mechanisms. We use this proxy because it is comprised of several widely used governance measures ranked from Bloomberg dataset.[7] The advantage of using governance-score (ln) measure is a powerful proxy and an alternative measure of how a firm is strictly complied and monitored by different dimensions of corporate governance mechanisms (see i.e., Allayannis *et al.* (2012); Lel (2012); Kumar and Rabinovitch (2013)).

2.2.3. Do hedging decisions reduce the information asymmetry costs?

A useful intuition regarding Hypothesis H3 is that in the presence of agency costs, there is information asymmetry motive for hedging (DaDalt *et al.*, 2002); that is additional to other motivations such reducing the expected costs of financial distress (Campello *et al.*, 2011), lower taxes (Smith and Stulz, 1985; Graham and Smith, 1999), and risk-shifting problems (Campbell and Kracaw, 1990; Chen and King, 2014). Prior studies, for example, DeMarzo and Duffie (1995) develop a model showing that the probability of corporate hedging risk may increase to induce the managers' incentive to make optimal investment decisions and eliminate extraneous noise in information sets associated with the firm's earnings fluctuations

[7] We use the natural log of corporate governance score index because the data distribution of the index is skewed. This score index used a measure of corporate governance mechanisms as combined factors (e.g., board size, board independence, gender on board, ownership, etc) which represents a unified rank.

because hedging reduces their variance. Thus, financial hedging decisions reduce the asymmetric information costs regarding the management ability to risk-shifting and value-maximizing shareholders. Kumar and Rabinovitch (2013) document various aspects associated with asymmetric information, using board independence as a proxy, and hypothesise that when board characteristics associated with greater monitoring of CEO power have a significantly negative impact on hedging decisions.

Aretz and Bartram (2010), among others, summarise the most supportive proxies of rationales for hedging decisions. Their study comprehensively documents theoretical models in literature and expected signs of the correlation between hedging decisions and its most related motives. However, given the probability of hedging decisions to reduce agency costs, consistently with these prior studies, the board independence proxy is widely used in literature for information asymmetry (e.g., Borokhovich *et al.* (2004); Dionne and Triki (2013); Kumar and Rabinovitch (2013). Since information asymmetry generally is not directly observable, several studies recently have provided evidence of a strong relationship between board independence and firms' hedging decisions and the empirical evidence is mixed. Géczy et al. (1997) argue that firms hedge foreign currency risk to eliminate extraneous noise, indicating that the corporate hedging is a signal of management ability to mitigate the probability of bankruptcy costs. Theoretically, DeMarzo and Duffie (1995) argue that firms with greater asymmetric information costs are more likely to hedge because corporate hedging decisions will reduce noise in their performance and earnings variability. Consistently, DaDalt *et al.* (2002) find strong evidence that the use of derivative instruments is associated with lower asymmetric information. Prior empirical research investigates the relationship between corporate hedging and asymmetric information based on alternative measures as proxies for asymmetric information with limitation related to exogenous factors. This discussion leads to the following prediction.

H3. *Asymmetric information hypothesis*: Firms with greater asymmetric information leads to an increase in the likelihood of hedging decisions.

Following DeMarzo and Duffie (1995), we hypothesise that greater asymmetric information leads to more risk hedging with derivatives because corporate hedging decisions reduce the noise contained in a firm's earnings variability. An examination of this issue is important in the presence of existing agency costs, as the mitigation of information asymmetry costs through hedging can also contribute to economic benefits of hedge risk overall. In line with prior research, we use two proxy variables to measure asymmetric information: the percentage of unrelated directors on board ("board independence") (e.g., Borokhovich *et al.* (2004); Kumar and Rabinovitch (2013), and the number of analysts following the firm (e.g, Géczy *et al.* (1997)).

2.3. Methodology

This section discusses the methodology implemented in this study to investigate the relationship between agency costs and the probability of hedging decisions. Prior research (e.g., Nance *et al.* (1993); Mian (1996); Bartram *et al.* (2009)) hypothesises and empirically tests corporate hedging decisions using binary variables that identify if a firm uses financial derivatives for hedging financial risk exposures; foreign currency (FX), interest rate (IR), and commodity price (CM) risk. We extend this line of research, similarly hypothesising and finding a plausible positive association between the likelihood of hedging financial risks and investment for firms predicted in settings prone to under- or over-investment.

We introduce a dynamic model to predict abnormal investment expenditures (under- or over-investment) by adopting Richardson (2006)'s model of investment expenditure. The study then discusses an empirical specification of corporate governance mechanism in an interaction term and predicts its influence on the likelihood of hedging decisions to alleviate investment inefficiency. Thus, we expand the evidence on the role of corporate governance mechanism in mitigating both under- and over-investment problems. We introduce a discrete model with the special regressor method as a new suitable estimator in econometrics (Dong and Lewbel, 2015; Chen *et al.*, 2016), that allows us to take into account a potential source of endogeneity between agency costs and hedging decisions.

This methodology has advantages to treat potential endogenous explanatory variables, which are not necessary to be continuously distributed. The initial goal of our robustness test is to estimate consistent coefficients in binary models outcome, but ultimately we are also interested in predicting the marginal effects of investment inefficiency, looking at how the probability of hedging risk decision that equals one changes when investment inefficiency changes.

2.3.1. Model Specification

To accurately investigate the underinvestment or overinvestment problems as an important determinant on hedging decisions, we require an empirical nonlinear panel model that employs specified function of binary outcome. Hedging decisions is a choice outcome in a panel *probit* regression estimation, which considers the influence of determinants of hedging activities. The potential endogeneity between agency costs and hedging decisions is noted above. Bartram *et al.* (2009) highlight that the relationship between corporate hedging, agency costs and financial distress is intuitive.

Therefore, this section begins by estimating a *probit* regression model in a panel data of under- or over-investment problems, as important determinants in hedging decisions. The *probit* regression has the following specification:

$$\text{Prob}\ (\text{Hedging}_{i,t} = 1) = \Phi\ (\alpha_0 + \alpha_1\ \text{Underinvest}_{i,t} + \theta\ \mathbf{X}'_{i,t} + \text{Industry FE} + \text{Year FE} + \varepsilon_{i,t}) \qquad (1)$$

where the dependent variable, $Hedging_{i,t}$, is 1 if the firm *i* makes hedging decisions for any type of risks (FX, IR, or CM) respectively and 0 if no hedging decisions are taken in year *t*. Φ is the cumulative standard normal function. In Eq. (1), the independent variables include hedging determinants: investment inefficiency; and several firm characteristics, such as firm size, value (book-to-market), profitability, and financial distress measures. Finally, we add industry- and year-fixed effects to deal with omitted variables that are industry and time specific. In our model, we focus on investment inefficiency, $Underinvest_{i,t}$, which is a proxy used to detect the likelihood of under- or over-investment problems, that takes dummy with value 1 if the firm has an abnormal investment expenditure less than the optimum level, and 0 otherwise.

The abnormal investment expenditure (residuals) is predicted in each firm-year observation, where it may take negative (positive) residuals for underinvestment (overinvestment) problems. We estimate the above equations in a panel data with a *probit* regression model that includes industry dummy and year dummy to control for industry-year fixed effects at the firm level. We use Eq. (1) to examine the hypothesis H1, which is, whether the association between underinvestment problems and the likelihood of hedging decisions to be positive, indicating that hedging activities are more likely to increase to mitigate agency costs. In Eq. (1), the coefficients of interest is likely predicted (i.e., Underinvest = 1), we expect the α_1 coefficients to be positive, indicating that corporate hedging decisions to increase with underinvestment problems to mitigate agency costs. All details of independent variables of our models are described in Table 1.

2.3.2. Corporate governance intervention

In the presence of corporate governance influence on hedging decisions, we test hypothesis H2a and H2b, throughout the interaction term with underinvestment problems as follows in Eq. (2). We estimate the following model:

$$\text{Prob}\ (\text{Hedging}_{i,t} = 1) = \Phi\ (\alpha_0 + \alpha_1\ \text{Underinvest}_{i,t} * \text{GOVERNANCE}_{\ i,t} + \alpha_2\ \text{GOVERNANCE}_{\ i,t} + \alpha_3\ \text{Underinvest}_{i,t} + \theta\ \mathbf{X}'_{\ i,t} + \text{Industry FE} + \text{Year FE} + \varepsilon_{\ i,t}) \quad (2)$$

where the dependent variable is defined in Eq.(1), except for governance control (GOVERNANCE). We choose governance-score as a proxy for corporate governance mechanism in the interaction term in Eq. (2). Governance-score is measured by the natural logarithm of a given score of combined factors that indicates the strength of a firm's corporate governance. Likewise, Aretz and Bartram (2010) note alternative measures (e.g., governance index), in a unified framework, that describing different dimensions of corporate governance structures. While, the empirical literature typically uses various proxies for corporate governance mechanisms (e.g., Allayannis *et al.* (2012); Kumar and Rabinovitch (2013) that often viewed as the most important driver for hedging decisions, we use governance-score, which measures multiple factors such as independence, board size, analysts' recommendations, gender on board, and ownership, as an aggregate rank of corporate governance strength. A higher rank of governance-score for a firm indicates a higher level of strong corporate governance, while a lower rank indicates weak corporate governance mechanisms. In general, corporate governance mechanisms are designed to align the interests of managers and shareholders, and hence mitigate agency conflicts (Lu and Wang, 2015).

We do expect the sum of α_1 and α_2 to be positive and significant confirming that more governance control (GOVERNANCE) firms hedge more in settings prone to underinvestment problems (i.e., Underinvest = 1). Also, α_2 coefficient for governance control (GOVERNANCE) is expected to be positive and significant, confirming that hedging decisions is more likely to increase with settings prone to overinvestment problems (i.e., Underinvest = 0). This occurs for two considerable reasons. First, corporate governance strength may affect a firm's hedging decisions, among other financing policies, so to ensure that we isolate separately the proxy of corporate governance, we estimate the following model. The dependent variable, $\text{Hedging}_{i,t}$, is defined in previous models, while the details of variables in Eq. (2) can be found in Table 1. Particularly, we follow previous research in corporate hedging theories and conduct our models in line with the determinants of hedging decisions. We control for the basic fundamentals of firms' characteristics in corporate hedging. More precisely, we control for firm size, value (book-to-market), profitability, and financial distress.

2.3.3. Information asymmetry effects

$$\text{Prob}\,(\text{Hedging}_{i,t} = 1) = \Phi\,(\alpha_0 + \alpha_1\,\text{Underinvest}_{i,t} + \alpha_2\,\text{InfoAsym}_{i,t} + \theta\,\mathbf{X}'_{i,t} + \text{Industry FE} + \text{Year FE} + \varepsilon_{i,t}) \quad (3)$$

where the dependent variable and other variables are previously defined in Eq. (1), except for InfoAsym. We use two proxies for information asymmetry (InfoAsym): the board independence and analysts following the firm. We expect the coefficient of α_1 to be consistently positive and significant; indicating that underinvestment problems increase the likelihood of hedging decisions (FX, IR, and CM). Given our prior theoretical argument related to information asymmetry influence on the likelihood of hedging decisions, we are particularly interested in testing the relationship between information asymmetry and corporate hedging through various aspects of variables.[8] First, we predict that higher board independence is expected to indicate lower asymmetric information. We measure the board independence as the percentage of independent members on the board. We expect α_2 to be negative and significant, which implies that hedging decisions are more likely to be adopted with a higher degree of asymmetric information (hypothesis 3). The board independence in our model presents the percentage of independent directors of total board membership during the year. Likewise, Kumar and Rabinovitch (2013) finds a strong negative role of board independence on corporate hedging intensity. However, in our frame model any factor that raises the noise of asymmetric information appears to confirm our prediction that corporate hedging decisions help to alleviate information asymmetry costs. Because hedging pricing fluctuations can alter the risk of a firm' earnings variance, thus this asymmetry naturally encourages managers to hedge these risks as they probably have private information about risk exposures (DeMarzo and Duffie, 1995).

2.3.4. Endogeneity concerns

There is a general consensus in the literature that the relationship between agency costs and hedging decisions is not exogenous. However, prior research demonstrates that, in line with our view, investment inefficiency potentially may be drawn through other financial policies. Few prior studies try to illustrate that most determinants of investment inefficiency are also important for corporate hedging decisions. For example, Gay and Nam (1998) find that the probability of corporate hedging is driven partially to avoid underinvestment problems, when the firm has relatively great growth opportunities and also as a strategy to increase firm value. Aretz and Bartram (2010) confirm that most prior studies in corporate risk management fail

[8] We note, however, that the literature finds ambiguous relationship between board independence and corporate hedging. Theoretically, the board independence is supposed to be part of enhanced roles of corporate governance.

to account for the endogeneity of variables that are proxies for corporate financial policies, such as investment growth. But it is subject to using appropriate methodologies to solve such problems in corporate hedging theories (Arnold *et al.*, 2014).

In this line, it is argued that the common use of maximum likelihood, control function, and two stage least squares linear probability models estimation cannot produce reliable inferences for binary choice models with one or more endogenous discrete explanatory variables or simple fixed effects panels. Briefly, we compare the features of four binary choice models with endogenous variables: 1) maximum likelihood estimator which requires a complete set of parametric specification of the endogenous variable with the error term; 2) control function estimator can only be valid and provides consistent estimation when the endogenous regressor in our model (Underinvest) is continuously distributed; 3) 2SLS linear probability model is inconsistent estimator for signs and magnitude of coefficients accordingly. However, maximum likelihood and control function, can also suffer by not allowing various types of heteroscedasticity; and 4) the special regressor estimator provides coefficients estimation in *probit* models as special cases when the endogenous variable of interest is binary, and can efficiently generate the signs of results consistently with the predicted theory in literature. Therefore, we introduce the advantage of especial regressor estimator in nonlinear panel *probit* model with discrete endogenous variables.

The special regressor estimator in panel *probit* model has the most significant advantages of leading methods - maximum likelihood, control function and instrumental variable 2SLS linear probability models - that allow us to control for discrete endogenous variables or many types of heteroscedasticity (Dong and Lewbel, 2015; Chen *et al.*, 2016). The first explanation is that omitted unobservable firm characteristics, interactions between factors or other determinants of hedging activities may affect the probability of hedging. There is strong evidence consistent with underinvestment problems on increasing the likelihood of corporate hedging. This explanation suggests that corporate hedging activities induce mitigating agency costs associated with underinvestment problems.

Obviously, based on the specification and complicity of the techniques illustrated for the special regressor model, which has been written by Baum (2012), the model requires to perform postestimation test statistics (e.g., endogeneity, underidentification, and overidentification tests) in the presence of conditional structural functions. The special regressor (V) model powerfully identifies the validation of estimation results; otherwise the model specification with the instruments variables employed will be volatile. This estimator has advantages of being consistent on the estimation and the validation of the model in comparison with maximum likelihood, control function and nonlinear 2SLS methods. Valid ordinary instruments for investment inefficiency (Underinvest) need to satisfy two conditions: it should be correlated with agency costs (Underinvest), but it should not be correlated with the residual in the regressions of the special regressor estimator.

Given that corporate hedging decisions appear in response to higher leverage as a proxy for financial distress, we expect the effects of financial distress would be particularly affected when the profitability is low. In our model estimates, using firm leverage as a special regressor to identify coefficients in the binary response model of hedging decisions typically with heteroskedastic errors. A special regressor corrects additional conditions on the support of the model (Chen *et al.*, 2016) as financial distress plays a critical role in corporate hedging decisions (Bartram *et al.*, 2009; Aretz and Bartram, 2010).

2.4. Data and variable definitions

2.4.1. Sample selection

In this section, we describe the construction of the sample and the process of data collection. We use firms' annuals reports from their official websites for collecting hedging decisions and activities. Our data is extracted from Bloomberg dataset and Thomson Reuters DataStream. To enhance the power of hand-collected data for hedging decisions, we gather as many notes as possible on the details of risk management policies plus notional amounts available of derivative instruments reported in financial statements and hedge accounting disclosures.

Our sample covers 8 years – from 2005 to 2012 for nonfinancial corporations listed in the FTSE All-Share Index. Prior to 2005, derivative contracts and their notional amounts were inconsistent in details. Financial firms are excluded because their purpose for hedging financial risks may differ from non-financial firms in terms of derivatives for speculations or trading. To mitigate the influence of outliers in the sample period, all continuous variables have been checked at the mean and median from available data sources. As a result, 92% of the sample matched with firms' annual reports. We eliminate the remaining (8%) from our sample because of the profitability is prone to abnormal losses in one or more years. Therefore, our sample consists of 252 nonfinancial firms listed in the FTSE All-Share Index. These selection procedures result in a maximum of 2,016 firm-year observations, although the number of observations seems reasonable in hand-collected data for hedging decisions.[9] Yet such comparisons are not made routinely, but rely on a plausible consideration of special interest and data availability.

However, in our sample selection, all corporations are required by International Financial Reporting Standards (IFRS) on the hedge accounting to report compulsory details of the use of derivatives in their annual reports from late 2004. Increased financial notes regarding

[9] See for example, Kumar and Rabinovitch (2013) explore the determinants of hedging and use a hand-collected data set from the oil and gas E&P industry for an empirical analysis that comprises 41 firms that yields a total dynamic panel data of 2087 firm-quarters observations only. With the exception of Bartram *et al.* (2011) data to explore hedging incentives in an international sample, prior studies are more broadly document various empirical evidence using specific industry or risk exposure to conclude the extent to which the likelihood of derivative instruments use for hedging purposes that all of them in a manner consistent with the theory.

corporate risk management policies and financial derivative instruments use for hedging financial risks - including foreign currency (FX), interest rate (IR) and commodity price (CM) risks – support more transparent. Furthermore, the new rules of IFRS with regards to hedge accounting encourage institutional investors and the mechanism of corporate governance to better assess corporate hedging decisions with investment decisions (Chen and King, 2014). UK nonfinancial firms in our sample selection provide a unique dataset for this study for a number of reasons. Corporations listed on the London Stock Exchange were required to report derivative financial instruments and details of risk management policies, but information asymmetry on corporate hedging decisions and volumes were inconsistent. Accordingly, substantial changes to hedge the accounting framework under the introduction of The International Accounting Standards (IAS) 32 and IAS 39 have been criticised and provide the most transparent and relevant information for investors (Chen *et al.*, 2013a).

To the extent that the fair value hedge of derivatives provides more information about their notional amounts, it is expected to add more detailed information on risk management policies. The complicity of changes of hedge accounting may be significant to lead to a better understanding of firms' hedge decisions and corporate risk management policies since 2005. This issue is important in our data collection since we have collected the data observations carefully and linked to derivative contracts and hedging activities in UK nonfinancial firms in order to address our hypotheses. The variables and data sources are summarised in Table 1.

Table 1
Definitions of Variables

This table summarises and defines the variables used in our analysis. The principle data sources are firms' annual reports for the derivative use, Bloomberg, and DataStream. Market data for firms' ownership structure are obtained from Thomson One Banker.

Variable	Definition	Data Source
Derivatives use:		
Foreign currency hedge	Dummy variable with value 1 if firms use derivative securities for hedging foreign currency (FX) risk, and 0 otherwise.	Annual report
Interest rate hedge	Dummy variable with value 1 if firms use derivative securities for hedging interest rate (IR) risk, and 0 otherwise.	Annual report
Commodity price hedge	Dummy variable with value 1 if firms use derivative securities for hedging commodity price (CM) risk, and 0 otherwise.	Annual report
Firm characteristics:		
Underinvestment	Dummy variable with value 1 if the difference between real investment and optimal investment, which interpreted as unexpected investment, is negative and 0 otherwise.	
Institutional ownership%	The percentage of a firm's shares held by institutional investors.	Thomson One
Independence%	The percentage of independent directors of total board membership.	Bloomberg
Analysts (ln)	Natural logarithm of number of analysts following the firm and making recommendations.	Bloomberg
Governance score	The rank of corporate governance mechanisms that characterize the firm's strength overall. It includes the rank of multiple factors such as: independence, board size, analysts' recommendations, gender on board, ownership etc.	Bloomberg
Tobins' Q (ln)	Ln [total assets – book value of equity + market value of equity) /total assets. This measure is used as a proxy for firm growth opportunities.	DataStream
Firm size	Natural logarithm of the book value of total assets.	Datastream
Firm age (ln)	Natural logarithm of the number of years since the stock of the firm first listed on the London Stock Exchange.	Datastream
Book-to-market	Book value of equity from the most recent available financial statements divided by market value of equity at time *t*.	
Leverage	Book value of total debt, including short and long debt / book value of total assets.	Datastream
Z-score	is a ranked variable that indicates the probability of a firm to enter a bankruptcy within the next two years. It is calculated as follows based on the model of Altman (1968). Z-score = 1.2 × (working capital / total assets) + 1.4 × (retained earnings / total assets) + 3.3 × (earnings before interest and taxes/total assets) + 0.6 × (market value of equity/book value of total liabilities) + 0.999 × (sales/total assets).	Bloomberg
Revenue	Total of operating sales less various adjustments to gross sales.	Datastream
Return on assets (ROA)	The ratio of earnings before finance costs and tax to the book value of total assets.	Datastream
Current ratio	The ratio of current assets to current liabilities. It is the ratio of the firm's liquidity that measures its ability to pay its short-term and long-term obligations.	Bloomberg
Earnings-price share (E/P)	The ratio of earnings per share to the market share price at the end of the firm's fiscal year.	Bloomberg
Cash ratio	The ratio of the sum cash and cash equivalents to total assets.	Bloomberg
Stock return%	The ratio of difference in stock prices at the end of firm's fiscal year between time *t* and *t-1* scaled by stock price at the end of previous fiscal year (*t-1*).	Bloomberg
Investment expenditures		
I_total (£bn)	The total investment expenditure and it is calculated as the sum of *CAPEX* plus new acquisitions and *R&D* expenditure less *SalePPE*.	Bloomberg
CAPEX (£bn)	The capital expenditures, e.g., cash paid to acquire long-term assets for construction and production.	Bloomberg
Acquisitions (£bn)	The total acquisitions expenditure of new acquired projected.	Bloomberg
R&D (£bn)	The total research and development (R&D) expenditure	Bloomberg
SalePPE (£bn)	The total sale of property, plant and equipment, e.g., net cash received from disposals of fixed assets and other long-term assets.	Bloomberg
I_main (£bn)	The depreciation and amortisation of existing assets in place.	Bloomberg
I_*new* (£bn)	The total investment less investment to maintain existing assets in place (I_*total* – I_*main*).	
I^e_*new*	The expected investment expenditure in new positive NPV projects.	
I^u_*new*	The abnormal of investment expenditures (unexpected) predicted in time *t*. It is calculated as the residuals predicted from Richardson's model adopted by dynamic GMM system.	

Panel A of Table 2 presents summary statistics of hedging financial risks (FX, IR, and CM) during the sample period. Statistics show that the trend of hedging activities relating to overall hedge financial risks (FX, IR or CH) has been increasing from 79.4% to 85.3% over the time period of 2005-2012. The majority of corporate hedging decisions have the highest activities percentage with regard to foreign currency (72.6%) risk and interest rate (66.7%) risk in comparison with commodity price (15.5%) hedge risk, respectively. In terms of sample frequency, a small percentage of sample observations relating to hedging the commodity price risk comes from firms in oil & gas industry or purchase commodity raw materials for intra operational activities (e.g., transportation).

Panel B of Table 2 provides the descriptive statistics for the main variables, including the mean, median, standard deviation, 25th percentile, 75th percentile, 90th percentile, minimum, and maximum. The reported mean and median values for firm characteristics and other control variables are in line with prior research (Panaretou, 2014). Since this study investigates the effects of investment inefficiency on corporate hedging decisions, detailed information on the investment expenditures are reported. The means (medians) of the expected investment expenditure in new positive NPV projects (I^e_*new*) and the abnormal of investment expenditures (unexpected) predicted in time *t* (I^u_*new*) are 0.056 (0.022) and 0.000 (-0.007), respectively. We observe that on average, 55% of sample firms can be classified as underinvesting. This is consistent with Gomariz and Ballesta (2014) study, which showed that approximately 52% of Spanish listed companies during the period 1998-2008 are in settings prone to underinvestment problems.

Table 2

Summary Statistics

This table presents a summary statistics of hedging decisions sample by year in Panel A. with related to foreign currency (FX), interest rate (IR) and commodity price (CM) risks. Panel A. shows the trend of corporate hedging behaviours for hedging risks (overall) and uses of three types of hedging derivatives of the sample 252 firms over time. Panel B. reports firms' characteristics and other control variables for the full sample. Full sample uses Thomson Reuters DataStream and Bloomberg data sets for all firms' characteristics, while dummy variables of hedging decisions are hand-collected precisely from firms' annual reports for the period 2005-2012. The variable definitions are in Table 1.

Panel A: firms' hedging financial risks by year

Time periods	Total	Hedging (any)		Foreign currency hedging		Interest rate hedging		Commodity hedging	
		N	%	N	%	N	%	N	%
2005	252	200	79.4%	156	61.9%	154	61.1%	32	12.7%
2006	252	204	81.0%	163	64.7%	155	61.5%	35	13.9%
2007	252	213	84.5%	171	67.9%	161	63.9%	33	13.1%
2008	252	216	85.7%	173	68.7%	164	65.1%	38	15.1%
2009	252	218	86.5%	176	69.8%	168	66.7%	36	14.3%
2010	252	219	86.9%	178	70.6%	168	66.7%	37	14.7%
2011	252	217	86.1%	183	72.6%	167	66.3%	39	15.5%
2012	252	215	85.3%	183	72.6%	160	63.5%	38	15.1%
Total	2016	1702	84.4%	1383	68.6%	1297	64.3%	288	14.3%

Panel B. summary statistics of firm level variables

variable	N	Mean	Median	Std.	25th pctl	75th pctl	90th pctl	Min.	Max.
Hedging decisions	2016	0.844	1.000	0.363	1.000	1.000	1.000	0.000	1.000
Foreign currency hedge	2016	0.686	1.000	0.464	0.000	1.000	1.000	0.000	1.000
Interest rate hedge	2016	0.643	1.000	0.479	0.000	1.000	1.000	0.000	1.000
Commodity hedge	2016	0.143	0.000	0.350	0.000	0.000	1.000	0.000	1.000
Underinvestment (dummy)	1512	0.550	1.000	0.498	0.000	1.000	1.000	0.000	1.000
Institutional ownership	2016	0.812	0.843	0.131	0.748	0.908	0.950	0.220	1.000
Independence	2016	0.502	0.500	0.141	0.429	0.600	0.667	0.000	0.786
Analysts (ln)	2016	0.880	0.954	0.434	0.602	1.230	1.380	0.000	1.710
Governance score (ln)	2016	3.910	3.950	0.225	3.840	4.050	4.140	1.690	4.370
Firms' characteristics									
Total assets (£bn)	2016	4.706	0.854	14.983	0.279	2.730	9.170	0.005	188.000
Market value (£bn)	2016	3.892	0.675	11.470	0.213	2.171	7.160	0.003	128.000
Firm size	2016	13.700	13.700	1.740	12.500	14.800	16.000	8.590	19.100
Book-to-market	2016	0.626	0.453	0.600	0.258	0.801	1.260	0.003	5.560
Leverage	2016	0.221	0.203	0.178	0.072	0.323	0.460	0.000	0.990
Z score	2016	4.170	3.340	4.180	2.280	4.870	7.140	-5.040	66.700
Return on assets (ROA)	2016	0.056	0.055	0.094	0.027	0.094	0.141	-0.786	0.697
Current ratio	2016	1.520	1.240	1.360	0.839	1.700	2.630	0.000	21.600
Earnings-price ratio (E/P)	2016	0.084	0.067	0.115	0.043	0.098	0.148	0.000	2.970
Cash ratio	2016	0.124	0.075	0.148	0.034	0.157	0.280	0.000	1.530
Stock return	2016	0.198	0.133	0.612	-0.134	0.393	0.767	-1.000	5.660
Investment expenditures									
I_total (£bn)	2016	0.373	0.031	1.680	0.007	0.148	0.615	-3.125	40.051
CAPEX (£bn)	2016	0.263	0.024	1.027	0.006	0.109	0.414	0.000	14.490
Acquisitions (£bn)	2016	0.144	0.002	1.113	0.000	0.031	0.176	-2.563	37.526
R&D (£bn)	2016	0.046	0.000	0.287	0.000	0.004	0.036	0.000	3.810
SalePPE (£bn)	2016	0.079	0.003	0.430	0.000	0.022	0.114	-0.105	10.989
I_main (£bn)	2016	0.209	0.017	0.909	0.004	0.070	0.273	0.000	12.481
I_*new* (£bn)	2016	0.164	0.010	1.303	-0.002	0.065	0.336	-7.909	37.936
I^{e}_*new*	1764	0.056	0.022	0.157	-0.003	0.074	0.166	-0.793	2.170
I^{u}_*new*	1512	0.000	-0.007	0.142	-0.059	0.037	0.097	-0.897	2.070
Tobins' Q (ln)	2016	0.417	0.337	0.498	0.076	0.681	1.090	-0.976	3.190

2.4.2. Control variables

Based on finance literature, several control variables are included in the analysis. In line with the existing literature, we control for investment inefficiency using under- (over-) investment dummy variable corresponding to observations obtained from a dynamic model estimator by opting Richardson (2006) model. Among alternative methods, this model's prediction, in particular, is based on an accountancy basis to account for the investment expenditures. Thus, the variable underinvestment (Underinvest) in our model specifications represents the dummy with a value 1 when a firm's abnormal investment shows a negative prediction (underinvestment) and 0 otherwise for a positive prediction (overinvestment). Prior research indicates that corporate hedging in financial risk management is largely driven by underinvestment problems, information asymmetry, and corporate governance quality (Smith and Stulz, 1985; Géczy *et al.*, 1997; Bartram *et al.*, 2009; Allayannis *et al.*, 2012). In the presence of agency conflicts between managers and shareholders, corporate hedging decisions may provide beneficial means of investment efficiency and the expected reduction in the costs of financial distress (Tufano, 1998). For instance, Jensen (1986) suggests that managers may have incentives to investment opportunities beyond the optimum for their interests. Other research suggests that information asymmetry, through which the managers gain perceived information when the firm accesses to financing arrangements (Dierkens, 1991), is substantially relative in hedging decisions using financial derivatives (Naik and Yadav, 2003).

However, the extent of corporate governance quality is more likely to draw inferences on hedging incentives behind the use of financial derivatives (Allayannis *et al.*, 2012). Consistent with Aretz and Bartram (2010) and the model proposed by Gay and Nam (1998), our choice of control variables includes investment inefficiency, asymmetric information, corporate governance, institutional ownership, and other firm characteristics.

We control for firm characteristics such firm size, value, profitability, and financial distress. We use logarithmic values of range variables, including firm characteristics and governance proxies among others since the distribution of some variables are skewed in our sample. We use the natural log of total assets as a proxy for firm size, the number of analysts' following the firm and the percentage of independent directors of total board membership as proxies for information asymmetry, and the natural log of governance-score as a proxy for corporate governance mechanism. The measures of profitability and financial distress controls include return on assets, leverage, and Altman's Z-score, respectively. Firms may have more hedge incentives to alleviate bankruptcy costs that proxied in our model using Altman's Z-score (Smith and Stulz, 1985; Froot *et al.*, 1993; Géczy *et al.*, 1997). Additionally, the industry dummy is used to control for sources of industry heterogeneity and industry variation among the firms, in our sample, those are from different industry categories. Firms' related industries vary in their hedging incentives. This means we try to mitigate endogeneity concerns using industry fixed effects as well as year fixed effects to control for time trends.

2.5. Empirical results

2.5.1. Baseline results

Using a panel data of nonfinancial UK firms listed in the FTSE-All share index over the period of 2005-2012 supports strong evidence of existing under- and over-investment scenarios among corporations, through which it can empirically explain the correlations between investment inefficiency and corporate hedging. Using Richardson's (2006) accounting-based framework, we measure under- and over-investment (abnormal investment) as follows.

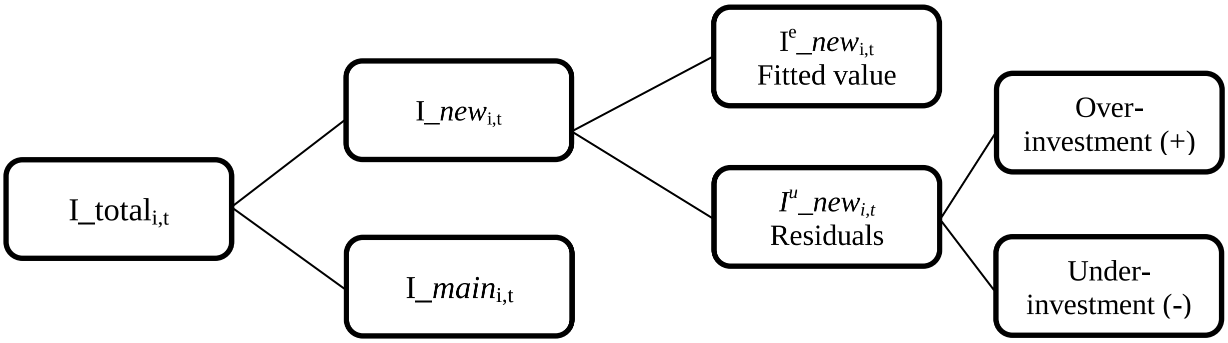

Fig. 1. The estimation of investment inefficiency (under- or over-investment) using Richardson's (2006) accounting-based framework.

To compute the abnormal investment ($I^u\_new_{i,t}$), where under- or over-investment expenditures are predicted by negative or positive residuals, or in other words is the difference between real investment and optimal investment ($I^e\_new_{i,t}$) using the following model:

$$I\_new_{i,t} = \alpha_0 + \alpha_1 I\_new_{i,t-1} + \alpha_2 \text{Tobin's Q}_{i,t-1} + \alpha_3 \text{Leverage}_{i,t-1} + \alpha_4 \text{Size}_{i,t-1} + \alpha_5 \text{Age}_{i,t-1} + \alpha_6 \text{Cash}_{i,t-1} + \alpha_7 \text{Stock return}_{i,t-1} + \text{Industry FE} + \text{Year FE} + \varepsilon_{i,t} \quad (4)$$

Where $I\_new_{i,t}$ is the new investment expenditure in place that takes the difference between total investment ($I\_total_{i,t}$) and required investment expenditure to maintain assets in place ($I\_main_{i,t}$). All control variables are lagged to control for unobserved factors. We use the natural logarithm of market-to-book ratio (Tobin's Q); with leverage, the ration of short-term and long-term debt to total assets; firm size, the natural logarithm of total assets; age, the natural logarithm of number of years since the firm listed in the FTSE-All share index ; cash, is the ratio of cash and cash equivalents to total assets; and stock return, is the ratio of difference in stock prices at the end of firm's fiscal year between time *t* and *t-1* scaled by stock price at the end of previous fiscal year (*t-1*). We control for industry fixed effects and time fixed effects; by including industry dummies, using SIC code industry-specific category and time dummies for time invariant. Finally, $\varepsilon_{i,t}$ is idiosyncratic errors component. We next convert the predicted residuals or the abnormal investment expenditure ($I^u\_new_{i,t}$) into dummies with value 1 if the difference between real investment and optimal investment is negative (as a proxy for underinvestment problems), and 0 if the difference between real investment and optimal investment is positive (as a proxy for overinvestment problems).

We argue that the dynamic investment expectation model presented in Table 3 is suitable for estimating the investment inefficiency residuals. Our panel, in Table 3 is unbalanced, and hence uses the system difference system GMM estimator that allows the reduction of potential selection bias and endogeneity problems.[10] For this reason, the final panel consists of 252 listed firms, which corresponds to 1512 firm-year observations.

[10] The difference system GMM has been developed by Roodman (2009) and provides a pedagogic introduction to linear GMM, these estimators, and "*xtabond2*" command. The estimators are designed for dynamic "small-T, large-N" panels that may contain fixed effects and. This method initially has been developed by, see, i.e., Arellano and Bond (1991); Arellano and Bover (1995). We use system GMM alternatively instead of fixed effects model to take advantages of controlling unobserved omitted variables and partial adjustment mechanisms in the differences.

Table 3

Dynamic Model of Investment Expenditure

This table estimates the expected investment expenditure (I^e_new$_{i,t}$) and abnormal investment expenditure (I^u_*new*$_{i,t}$) by using the dynamic panel GMM estimator. We adopt Richardson's (2006) method to predict abnormal investment (under- or over-investment). The dependent variable is the new investment expenditure (I_*new*$_{i,t)}$, which is calculated by taking the difference between total investment expenditure (I_total) and investment maintenance (I_main). All variable except Tobin's Q $_{i,t-1}$,Size $_{i,t-1}$ and Age$_{i,t-1}$ are scaled by total assets. In this regression we implement two tests to verify the validity of the instruments used. First, The *Hansen test* of overidentification shows that we do not reject the null hypothesis that all instruments are strong and valid. That means there is no over-identification problem in our model. Second, the *difference-in-Hansen* test of exogeneity shows that instruments used are exogenous. Robust standard errors are shown in parentheses. The symbols ***, **, * and * indicate statistical significance at the 10%, 5%, and 1% levels, respectively. The variable definitions are in Table 1.

	Dependent Variable: I_*new*$_{i,t}$
Variables	
I_*new* $_{i,t-1}$	0.049 (0.176)
Tobin's Q $_{i,t-1}$	0.077** (0.031)
Leverage $_{i,t-1}$	-0.216* (0.130)
Size $_{i,t-1}$	0.004 (0.005)
Age $_{i,t-1}$	(0.007) (0.036)
Cash $_{i,t-1}$	0.182** (0.085)
Stock return $_{i,t-1}$	0.000 (0.007)
Intercept	-0.028 (0.148)
Year-fixed effects	Yes
Industry-fixed effects	Yes
Wald $\chi2$	182.530***
Hansen test of over-identification (p-value)	0.260
Diff-in-Hansen tests of exogeneity (p-value)	0.177
Observations	1512

Table 4 reports descriptive statistics - including the mean and median of the explanatory variables - for full sample and subsamples (under- and over-investment). The table also contains results from nonparametric Wilcoxon tests for differences between under- and over-investment subsamples. Consistent with investment inefficiency and information asymmetry hypotheses, underinvestment listed firms have higher institutional ownership and are statistically significant. With the intervention of corporate governance hypothesis, underinvestment listed firms have higher overall governance-score in mean difference and are statistically significant. Therefore, the results from Table 4 also provide strong support for the role of interventions of corporate governance with under- and over-investment problems and are more likely to induce corporate hedging activities to increase correspondence to observations, respectively, of the distribution of investment inefficiency. The results of Table 4 for univariate tests with regards to firms' characteristics, though statistically significant, reveals an economically lower firm size and lower financial distress in underinvestment corporations, but with higher profitability and current ratio.

Table 4

Univariate Tests of Risk factors and Derivatives Use

This table presents the number of observations (N), mean, median and difference in mean of risk factors and firms' characteristics for under-investment vs. over-investment. The univariate tests report the difference in distribution between two samples whether is statistically significance. The last column presents *p*-value of Wilcoxon rank sum tests between under-investment vs. over-investment, where ***, **, and * denote significance at the 1%, 5%, and 10% level, respectively. The variable definitions are in Table1.

	Full sample			Under-investment			Over-investment			Mean Diff.	Wilcoxon
variable name	N	Mean	Median	N	Mean	Median	N	Mean	Median		*p*-value
Panel A. Corporate Governance											
Institutional ownership	2016	0.812	0.843	831	0.820	0.850	681	0.807	0.837	0.012*	0.166
Independence	2016	0.502	0.500	831	0.514	0.500	681	0.502	0.500	0.012	0.040
Analysts (ln)	2016	0.880	0.954	831	0.949	1.040	681	0.927	1.000	0.022	0.167
Governance score (ln)	2016	3.910	3.950	831	3.940	3.950	681	3.910	3.950	0.027**	0.174
Panel B. Firm characteristics											
Firm size	2016	13.700	13.700	831	13.700	13.700	681	13.900	13.900	-0.205**	0.010
Book-to-market	2016	0.626	0.453	831	0.640	0.492	681	0.769	0.518	-0.129***	0.000
Leverage	2016	0.221	0.203	831	0.157	0.137	681	0.302	0.280	-0.146***	0.000
Z score	2016	4.170	3.340	831	4.500	3.750	681	3.450	2.810	1.054***	0.000
Return on assets (ROA)	2016	0.056	0.055	831	0.065	0.059	681	0.040	0.045	0.025***	0.000
Current ratio	2016	1.520	1.240	831	1.620	1.300	681	1.350	1.140	0.269***	0.000
Earnings-price ratio (E/P)	2016	0.084	0.067	831	0.093	0.071	681	0.095	0.073	-0.002	0.560
Revenue (ln)	2016	13.400	13.400	831	13.600	13.600	681	13.400	13.400	0.263***	0.002

2.5.2. Using a probit regression estimator

In the multivariate analysis, we first examine the effect of underinvestment problems on corporate hedging decisions. The dependent variable, in models (1) – (3) of Table 5, is a dummy variable that is equal to one if the firm hedges foreign currency (FX), interest rate (IR) or commodity price (CM) risks, respectively, and zero otherwise. The results, in the first columns of models (1) - (3), are obtained from *probit* estimates in panel dataset, and we control for industry and year fixed effects in all regressions. The results in model (1) of Table 5 show that the coefficient (0.593) of underinvestment problems in association with hedging foreign currency (FX) risk is positive and statistically significant at 10%, that is, supporting the argument that underinvestment problems induce the likelihood of hedging decisions. Furthermore, the findings in model (2) and (3) indicate that hedging interest rate (IR) and commodity price (CM) risk incentives are related to an increase in underinvestment problems and the coefficients are positive but insignificant. The signs on the other control variables are, generally, consistent with prior corporate risk management research. For instance, leverage has positive drivers for corporate hedging decisions. For example, Bartram *et al.* (2009) show that corporate hedging is more likely to increase with firms associated with more financial distress.

To ease the exposition of the economic significance, the second columns of models (1) - (3) of Table 5 report marginal effect estimates from *probit* model structured in Eq. 1. The marginal effects are evaluated at the means of independent variables in our models. The estimated effects of underinvestment problems on the likelihood of hedging decisions (H, FX or IR) are positive, except CM risk which is negative and insignificant. Interestingly, the estimated effects of underinvestment problems on hedging foreign currency risk (FX) are positive and significant at the 10% level. For instance, in column 2 of model (1), the marginal effect of underinvestment problems is 0.044, which means that being an underinvestment can lead to a marginal change in the probability of using derivatives by 4.4% when a 1-unit increases in underinvestment from 0 to 1.[11] The possible explanation is that the magnitude of risk exposures linked with underinvestment problems is subject to agency problems and financial distress. Overall, the baseline results suggest that underinvestment problems is positively related to the likelihood of hedging financial risks, consistent with Hypothesis 1.

[11] Because the probit models are nonlinear, the marginal effect of a variable of interest (i.e., dummy variable) is calculated from predictions of a previously fit model at fixed values of some covariates and averaging or otherwise integrating over the remaining covariates. (see for example, Akbulut (2013)). However, we obtain the marginal effects by using the Stata command "*margins, dydx*" following the probit regression.

Table 5

Probit Regression Estimates of the Likelihood of Hedging Financial Risks and Underinvestment

This table reports *probit* regression estimates of the likelihood of hedging decisions including: foreign currency risk (FX), interest rate risk (IR) and commodity price risk (CM). First column of each model shows predicting the *probit* regression estimation in a panel data model, and the second column reports marginal effects estimated at means from the *probit* model for the probability of hedging decisions on the explanatory variables. The sample period is 2005-2012. The sample consists of nonfinancial firms listed in the FTSE All-Share Index. Agency costs presented in investment inefficiency (under- or over- investment problems) is an important determinant in corporate hedging. Investment inefficiency is a deviation from the optimum level of investment expenditure, which may be under- or over-investment slop. Underinvestment is a dummy variable that takes the value of 1 if actual investment is less the optimum levels of investment, and zero otherwise. Marginal effects are predicted in the postestimations of probit regression estimates. The marginal effects at variables values of random-effects probit regression is based on Std. variables, evaluated at their means. Thus, each coefficient in marginal effects column indicates that the change in hedging probability if a variable changes from its mean to its mean plus one std. deviation, while all other variables are fixed at their means. All financial variables are measured at the end of firms' fiscal year. In all regressions models, intercepts, year and industry dummy variables are included. Year and industry fixed effects, whose coefficients are suppressed, are based on calendar year and (SIC-code) industry classification dummies, respectively. Likelihood rate test (LR test) statistics for all *probit* regressions models are strongly significant at *p-value*=0.000. Robust standard errors are shown in parentheses. The symbols ***, **, * and * indicate statistical significance at the 10%, 5%, and 1% levels, respectively. The variable definitions are explained in Table 1.

	Dependent variable: Hedging decisions					
	Foreign currency		Interest rate		Commodity price	
	(1)		(2)		(3)	
Variable	Coef.	Marg. Eff.	Coef.	Marg. Eff.	Coef.	Marg. Eff.
Underinvestment	0.593* (0.305)	0.044	0.287 (0.192)	0.039	0.112 (0.251)	0.006
Firm size	0.835*** (0.191)	0.062	1.009*** (0.141)	0.139	0.879*** (0.265)	0.050
Book-to-Market	0.045 (0.245)	0.003	0.109 (0.193)	0.015	-0.339 (0.315)	-0.019
Profitability	3.442** (1.498)	0.254	1.033 (1.334)	0.142	0.687 (1.922)	0.039
Leverage	0.702 (1.415)	0.052	5.708*** (1.070)	0.784	0.918 (1.317)	0.052
Z-Score	-0.229*** (0.076)	-0.017	-0.235*** (0.072)	-0.032	0.059 (0.044)	0.003
Year & industry FE	Yes		Yes		Yes	
Likelihood-Ratio $\chi 2$ (LR)	934.130***		491.370***		483.260***	
Pseudo R^2	0.606		0.397		0.525	
Observations	1470		1506		1470	

To gain further insight on the investment inefficiency-governance interrelation, we also examine the direct interaction between under- or over-investment and corporate governance strength to mitigate agency costs. We then turn our attention on the effects of corporate governance implications on the likelihood of corporate hedging decisions (FX, IR and CM). To the best of our knowledge, this is the first study to investigate the impact of both under- and over-investment on hedging decisions in the presence of corporate governance mechanisms.

We show corporate governance mechanism - governance-score – through which interrelations in the interaction term affect the likelihood of corporate hedging decisions. Importantly, our findings on the positive relation for both under- or over-investment provide new insights into how hedging decisions affect the mitigation of agency costs accordingly. Unlike other prior studies, the focus of this methodology is on both sides of investment inefficiency (under or over), while prior research mainly examined the effects of underinvestment problems. In this regard, this study adds to the literature and shows the real implications of agency costs on hedging decisions.

Table 6 presents the results from estimating Eq. (2). Model (1)-(3) reports the coefficients obtained from a *probit* regression model in panel dataset for hedging financial risk exposures. The results predict the effects of governance-score as a proxy of combined factors, which measure the strength of firm corporate governance that, in general, are not particularly obvious in some other proxies of corporate governance. In settings prone to underinvestment (i.e., Underinvest=1), we find the results in model (1) show that coefficient of interest (3.623) in the presence of higher or stronger governance is positive and statistically significant at 1% level (i.e., where 3.623 in Eq. (2) is the sum of α_1 and α_2. The coefficients of strong corporate governance mechanisms with underinvestment problems, in the interaction term, relatively show that the likelihood of hedging decisions for FX risk exposures increase. More interestingly, firms in settings prone to overinvestment (i.e., Underinvest=0), the predicted estimation of the coefficient of interest in the presence of strong governance control (2.584) is positive and statistically significant at 1% level. Similarly, the results in model (3) of hedging CM price risk exposures are consistent and we observe a positive and statistically significant coefficient at 1% for both scenarios of agency costs (under- or over-investment) in the presence of strong corporate governance that leads to the likelihood of the increase in hedging decisions.

The economic significance is important. To present these effects in economic significance, model (1) of Table 6 shows that a one-standard-deviation increase in governance-score (ln) at firms in settings prone to overinvestment problems (i.e., Underinvest=0) leads to an increase of about 581 basis points the likelihood of hedging FX risk exposures (=2.584 x 0.225, where 0.225 is the standard deviation of governance-score (ln) to hedging FX risk reported in Table 2. Thus, in both under- or over-investment scenario, corporate hedging decisions are more likely to increase correspondingly to strong corporate governance effects to alleviate agency costs or investment inefficiency. Simply, these results conform to a theory of Morellec and Smith (2007) in which both under- or over-investment implies positive incentives as important determinants of corporate hedging decisions in market imperfections. It means hedging decisions are more likely to increase in the presence of agency costs.

Table 6

Probit Regression Estimates of the Likelihood of Hedging Financial Risks and Corporate Governance

This table reports *probit* regression estimates of hedging decisions including: foreign currency risk (FX), interest rate risk (IR) and commodity price risk (CM). Models 1-3 show the intervention of corporate governance with investment inefficiency (under- or over-investment). We use the natural logarithm of governance-score as a proxy for corporate governance mechanism. The sample period is 2005-2012. The sample consists of nonfinancial firms listed in the FTSE-All share index. Investment inefficiency (under- or over- investment problems) is an important determinant in corporate hedging under our hypotheses H1-H3. Underinvestment is a dummy variable that takes the value of 1 if actual investment is less the optimum levels of investment, and zero otherwise. All financial variables are measured at the end of firms' fiscal year. In all regressions models, intercepts, year and industry dummy variables are included. Year and industry fixed effects, whose coefficients are suppressed, are based on calendar year and (SIC-code) industry classification dummies, respectively. Likelihood rate test (LR test) statistics for all *probit* regressions models are strongly significant at *p-value*=0.000. Robust standard errors are shown in parentheses. The symbols ***, **, * and * indicate statistical significance at the 10%, 5%, and 1% levels, respectively. The variable definitions are explained in Table 1.

	Hedging decisions		
	Foreign currency	Interest rate	Commodity Price
Variable	(1)	(2)	(3)
Governance x underinvestment	1.039	-0.407	-3.117
	(1.026)	(0.814)	(2.048)
Governance-score	2.584***	0.314	6.390***
	(0.862)	(0.913)	(2.117)
Underinvestment	-3.433	1.877	12.341
	(3.938)	(3.192)	(8.234)
Firm size	0.864***	1.004***	0.745**
	(0.168)	(0.155)	(0.328)
Book-to-Market	0.008	0.109	-0.271
	(0.214)	(0.194)	(0.328)
Profitability	3.771***	1.047	0.371
	(1.337)	(1.338)	(1.922)
Leverage	0.393	5.712***	1.450
	(1.066)	(1.071)	(1.572)
Z-Score	-0.209***	-0.238***	0.060
	(0.049)	(0.073)	(0.046)
Year & industry FE	Yes	Yes	Yes
Likelihood-Ratio $\chi 2$ (LR)	931.010***	489.730***	467.160***
Pseudo R^2	0.610	0.397	0.524
Observations	1470	1506	1470

2.5.3. Information Asymmetry

Using insights taken from DeMarzo and Duffie (1995) and DaDalt *et al.* (2002), we explore our hypothesis H3 and testing additional beneficial benefits of corporate hedging decisions in the presence of investment inefficiency. We base our measures of information asymmetry on the theory of hedging risk and information asymmetry literature. Consistent with prior empirical evidence, Dionne and Triki (2013) suggest that reducing information asymmetry costs is another motive for corporate hedging decisions beyond financial distress costs and the presence of free cash flow and liquidity. In the baseline regression model, we structure the control variables for exceptional convenience focus on the two key determinants of hedging risk that mainly associated with underinvestment problems and financial distress. Further, we alter our initial model in this section to build on this literature and empirical tests, where asymmetric information cushions are important determinants of corporate hedging.

To test hedging motives associated with a reduction of information asymmetry costs, we follow the existing literature and use two proxies for asymmetric information: board independence and the number of analysts following the firm. Since asymmetric information is unobservable factor, Kumar and Rabinovitch (2013), among others (e.g., Borokhovich *et al.* (2004)) use board independence as a proxy for the information asymmetry on whether firms hedge because of managerial incentives and the characteristics of the board of directors play a critical role in risk management policies. The literature also employs empirical proxies for asymmetric information, where Géczy *et al.* (1997) use the number of analysts following the firm; and DaDalt *et al.* (2002) use the analysts' forecast accuracy. In the following analysis, we test our hypothesis H3 whether information asymmetry issues are more important determinants of corporate hedging.

Table 7 shows the results of estimating Eq. (3). Consistent with predicted hypothesis signs in prior research, the board independence in Panel A in model 1 and 2 for FX and IR risk hedging has a negative impact on corporate hedging, but statistically insignificant. The results in model 4 and 5 in Panel B also show that the number analysts following the firm has a negative impact on corporate hedging while it is positive on CM risk hedging, but statistically insignificant. To this point, we focus on the relationship between the information asymmetry and corporate hedging. We expect that greater asymmetric information leads to more corporate hedging because a lower percentage of board independence or number of analysts following the firm will lead to a higher degree of asymmetric information about the firm's outcome variance.

The theoretical and empirical evidence provided in prior research has generally been supportive of the asymmetric information hypothesis in the market imperfections. To capture the extent of this intuition, we observe that the coefficients on investment inefficiency (i.e, underinvestment = 1) are: statistically positive and significant in model (1) of Panel A; positive and negative in models 2-3, respectively, but statistically insignificant, indicating that firms in settings prone to underinvestment problems induce the likelihood of the corporate risk hedging to increase to mitigate agency costs. Therefore, it appears that firm's corporate hedging is not only affected by the degree of asymmetric information level, but also by the extent of agency costs.

Similarly, the results in model (4) of Panel B show that the coefficient of underinvestment problem is positively and statistically significant at 5% level, indicating that corporate hedging of FX risk alleviates the degree of investment inefficiency, hence growth opportunities in geographical or industrial diversification strategies will be in line with shareholders' value-maximisation perspective.

Table 7

Probit Regression Estimates of the Likelihood of Hedging Financial Risks and Information Asymmetry

This table reports *probit* regression estimates of hedging decisions including: foreign currency (FX), interest rate (IR) and commodity price (CM) risk, respectively. Models 1-3 (Panel A) show predicting the *probit* regression estimation of the likelihood of hedging financial risks in a panel data model in the presence of board independence as a proxy for information asymmetry. Models 4-6 (Panel B) show predicting the *probit* regression estimation of the likelihood of hedging financial risks in a panel data model in the presence of analysts following the firm as a proxy for information asymmetry. The dependent variable in column 1 and 4 is foreign currency (FX) risk hedge that is equal to value 1 if firms use derivatives for hedging FX risk, and 0 otherwise. The dependent variable in column 2 and 5 is Interest rate (IR) risk hedge that is equal to value 1 if firms use derivatives for hedging IR risk, and 0 otherwise. The dependent variable in column 3 and 6 is commodity price (CM) risk hedge that is equal to value 1 if firms use derivatives for hedging CM risk, and 0 otherwise. In Panel A, board independence is defined as the percentage of independent directors of total board membership. In Panel B, Analysts is defined as the natural logarithm of number of analysts following the firm and making recommendations. Continuous variables have been winsorised at the 1% and 99% levels to control for outliers. The sample period is 2005-2012. The sample consists of nonfinancial firms listed in the FTSE All-Share Index on the London Stock Exchange. Investment inefficiency (under- or over- investment problems) is an important determinant in corporate hedging. Underinvestment is a dummy variable that takes the value of 1 if actual investment is less the optimum levels of investment, and zero otherwise. All financial variables are measured at the end of firms' fiscal year. In all regressions models, intercepts, year and industry dummy variables are included. Year and industry fixed effects, whose coefficients are suppressed, are based on calendar year and (SIC-code) industry classification dummies, respectively. Likelihood rate test (LR test) statistics for all *probit* regressions models are strongly significant at *p-value*=0.000. Robust standard errors are shown in parentheses. The symbols ***, **, * and * indicate statistical significance at the 10%, 5%, and 1% levels, respectively. The variable definitions are explained in Table 1.

	Panel A. Board Independence			Panel B. Analysts		
	FX	IR	CM	FX	IR	CM
Variable	(1)	(2)	(3)	(4)	(5)	(6)
Underinvestment (dummy)	0.587**	0.284	-0.067	0.679**	0.293	-0.115
	(0.258)	(0.193)	(0.253)	(0.288)	(0.193)	(0.248)
Independence	-0.615	-0.580	2.707			
	(1.096)	(0.938)	(1.463)			
Analysts				-1.101	-0.512	0.027
				(0.652)	(0.517)	(0.710)
Firm size	1.234***	1.028***	0.816***	0.941***	1.103***	0.801***
	(0.191)	(0.147)	(0.221)	(0.207)	(0.173)	(0.203)
Book-to-market	0.134	0.096	-0.326	0.016	0.086	-0.359
	(0.222)	(0.195)	(0.314)	(0.211)	(0.194)	(0.305)
Profitability	4.034***	1.041	0.943	3.736***	1.104	0.563
	(1.362)	(1.356)	(1.943)	(1.417)	(1.347)	(1.941)
Leverage	0.993	5.738***	1.245	0.243	5.880***	0.901
	(1.151)	(1.081)	(1.352)	(1.410)	(1.087)	(1.245)
Z-Score	-0.187***	-0.230***	0.055	-0.243***	-0.209***	0.057
	(0.056)	(0.072)	(0.043)	(0.073)	(0.074)	(0.042)
Institutional ownership	2.986	-1.878*	0.366	2.913	-1.798*	0.512
	(1.207)	(1.035)	(1.415)	(1.194)	(1.036)	(1.342)
Year & industry FE	YES	YES	YES	YES	YES	YES
Likelihood-Ratio $\chi2$	938.700	493.190	476.010	940.580	490.630	481.940
Pseudo R^2	0.610	0.399	0.523	0.611	0.398	0.524
Observations	1470	1506	1470	1470	1506	1470

As we noted earlier, we need to check the robustness of our results for endogeneity issues and the heteroscedasticity in the error terms. However, we address our hypothesis H3 and the results could merely be reflective of potential endogeneity concerns or issues in our models. We address this possibility in the following analysis using the special regressor method, which is likely to deal with various forms of unknown heteroscedasticity and when one or more explanatory variables are endogenous but not necessary to be continuously distributed.

2.5.4. Robustness results

Like any other study on corporate hedging characteristics, endogeneity concerns may hamper the interpretation of our analysis. Recently, Géczy *et al.* (1997) show that firms with greater growth opportunities and tighter financial constraints are more likely to increase corporate hedging to alleviate financial flexibility and underinvestment problems. Therefore, our additional robustness tests for endogeneity concerns should be viewed as suggestive. We address these concerns by conducting our model specified for the association of underinvestment problems and corporate hedging decisions using the special regressor (V) method in heteroskedastic binary response models (Baum *et al.*, 2003; Dong and Lewbel, 2015; Lin and Wooldridge, 2015; Chen *et al.*, 2016). [12]

Conditions on the support of the special regressor estimator require that firm leverage is statistically positive and associated with the likelihood of hedging decisions, which is fully satisfied. These conditions of a special regressor seem to suggest that there exists a link between financial distress and investment inefficiency in distinct ways in such a *probit* semiparametric model of corporate hedging. This is a surprising insight, as Gay and Nam

[12] Unlike other methods such as maximum likelihood, control function, and two stage least squares linear probability models, which are generally only valid when one or more endogenous explanatory variables are continuous, the special regressor (V) method can be used efficiently in this study to treat the endogeneity concerns of underinvestment problem (discrete). This estimator enables us to control for the possible endogeneity of regressors, as well as omitted variables bias and allow the model errors (ε) to be heteroscedasticity.

(1998) show that, firms with enhanced investment opportunities are more likely to increase corporate hedging decisions when they face a relatively greater financial distress.

In our model, we identify return on assets (ROA) to be a critical variable in the heteroscedasticity of the special regressor (leverage). The association between two variables (ROA and leverage) can be seen and neither firm profitability as a proxy of performance provides a greater impact on the firm's financial distress. This is consistent with the findings from Bartram *et al.* (2009), which show that in imperfection markets, hedgers have significantly higher leverage and are also associated with more profitability. The special regressor (V) requires to be conditionally continuous and positively associated with the likelihood of hedging decisions with a large support to provide consistent estimates of the model coefficients identified in Eq (3) (Dong and Lewbel, 2015; Lin and Wooldridge, 2015).

Table 8 reports marginal effects obtained from *probit* estimate of the risk hedging decisions including FX, IR, and CM risk exposure. In this table, we use the special regressor method with ordinary bootstrap option, which is desirable to obtain standard errors and test statistics.[13] We use two proxy variables to measure information asymmetry: the board independence and the number of analysts following the firm. Panel A of Table 8 presents the effects of the board independence on corporate risk hedging (FX, IR, and CM) in the presence of underinvestment problems, as well as Panel B presents the effects of analysts following the firm on corporate hedging decisions.

Reporting marginal effects is substantial. First, column 1 of Table 8 shows that the marginal effect for FX hedging decisions is 0.350, which suggests that a firm in settings prone to underinvest may lead to a marginal change in the probability of FX hedging by 35.0% when a 1-unit increases in underinvestment from 0 to 1. Column 2 and 3 of Table 8

[13] To obtain standard errors estimate with bootstrapping, and possibly improve efficiency, the parameters in Eq (3) can be estimated using nonparametric kernel density estimator.

show that the marginal effects with respect to underinvestment for IR and CM price risks are 29.4% and 22.6%, respectively, and statistically significant at 1%. Consistent with predictions of hypothesis H1, corporate hedging decisions are more likely to increase in response to investment inefficiency arises. Since our dependent variables, in Panel A, are corporate hedging FX, IR, and CM risk, respectively, the marginal effects of board independence are negative in column 1 and 2, but positive in column 3 and statistically insignificant in all regressions; the results indicate that there is no clear evidence that the board independence efficiently reacts with corporate hedging to the current concerns discussed above.

In contrast, we observe in Panel B of Table 8 that when we use the number of analysts following the firm as a proxy for asymmetric information, the marginal effects of analysts following the firm in columns 4-6 are -6.2%, -11.0%, and -8.0%, respectively and statistically significant at 1% level; which suggests that an increase in the number of analysts following the firm will lead to a lower likelihood of hedging FX, IR, and CM price risk, respectively. These marginal sensitivities support DeMarzo and Duffie (1991) information asymmetry explanation for corporate risk hedging, as evidence of the negative marginal effects from *probit* estimates on the natural log of the number of analysts following the firm. An explanation consistent with this result is that firms associated with a large number of analysts following the firm means a lower level of the degree of asymmetric information costs. Therefore, the propensity of corporate hedging decisions decreases. In order to evaluate the validity of the correct specification of the model, a diagnostic test is used in the special regressor (V) estimation. The *Kurtosis* test is for the special regressor (V) restrictions that should be greater than 3.0. Two options are included in our model specification. The first is bootstrapping with integer (10), as default, to calculate marginal effects with standards errors. The second, heteroskedastic option to be used is in order to provide one or more identified variables assumed to play a role in the heteroskedasticity of the special regressor (V). Third, the data set is trimmed using the option "trim" in the model specifications and restricted with integer (2-5). We consider a lower integer value in our model, unless the volatility is not settled down, to be used for the sorted data density estimator pioneered by Lewbel and Schennach (2007), who design the estimator with weighted average.

Because the decisions of investment opportunities may be associated with unobserved variables that possibly affect the hedging decisions of financial risks (FX, IR and CM).[14] The special regressor estimator has also an advantage to employ instrumental variables to alleviate endogeneity concerns due to omitted variables and control for binary choice models with heteroskedastic errors. We first identify more than one instrumental variable with respect to investment expenditures. Specifically, we derive probabilities where investment expenditures will be determined by the preference for financial flexibility or ability to growth, which considers related instruments such as current ratios, earnings-price share (E/P) (Bartram *et al.*, 2009) and sales (ln) (Gomariz and Ballesta, 2014). We confirm the validity of these instruments by performing the Anderson underidentification test and the Sargan-Hansen test of overidentification, where these specification tests are conducted at the last stage of the *special regressor* model estimation. For example, in model 1 of Table 8, the Anderson underidentification test has a p-value of (0.000) and The Sargan-Hansen overidentification test has a p-value of (0.494), therefore the post estimations tests confirm the validity of instruments used in our model. [15]

[14] The results from the special regressor method regress the corporate risk hedge on underinvestment problems using two-stage regression model with vector of instruments.

[15] Underidentification test (Anderson LM) examines the null hypothesis that the instruments are uncorrelated with endogenous regressors and hence the underidentification problem exists. Overidentification test (Sargan-Hansen) examines the null hypothesis that the instruments set is valid, that is, the instruments are uncorrelated with the error term and the excluded instruments (from the second-stage regression) are correctly excluded from the estimated equation.

Table 8

Probit Regression Estimates of the Likelihood of Hedging Financial Risks and Endogeneity

This table reports marginal effects from binary choice model using the special regressor (V) method with endogenous regressors or with heteroskedastic errors. Marginal effects are calculated as the change in the probability of hedging decisions when moving 1 standard deviation away from the means for continuous variables, and from 0 to 1 for indicator variables, while keeping all other variables at their means. This estimator has some significant advantages, that is, the special regressor method efficiently allows for heteroscedasticity of unknown form in the model's error process. In our regressions, we use board independence and analysts following the firm as proxies for information asymmetry. Panel A of Table 6 represents regressions estimates of hedging decisions in the presence of board independence, while Panel B represents regressions estimates of hedging decisions in the presence of analysts following the firm. The sample period is 2005-2012. Investment inefficiency is a deviation from the optimum, which may be under- or over-investment slop. Under-investment is a dummy variable of 1 if a firm's investment is negative (under the optimum), and zero otherwise. Standard errors (presented in parentheses) obtained with bootstrapping option to improve efficiency (Dong and Lewbel, 2015) . All financial variables are measured at the end of firms' fiscal year. We identify firm leverage as a special regressor (V) that appears additively to ε in the model. The special regressor estimator requires (V) to be conditionally distributing with a large support and positively associating with corporate hedging decisions. The special regressor model defined depending on assumptions made about the distribution in Kurtosis of V. (Leverage) is greater than 3.000 for results validity. The density estimator adopted in this method is based on standard kernel density approach, making use of Jann's kdens. Nonparametric kernel density estimator is employed in the special regressor model. We use "trim" (2-5) common option with as desirable to trim the data when some observations are extremely large in magnitude before running the second stage regressions for efficient estimations. In all regressions models, intercepts and year and industry dummy variables are included. Year and industry fixed effects, whose coefficients are suppressed, are based on calendar year and (SIC-code) industry classification dummies, respectively. The variable definitions are in Table 1. Continuous variables have been winsorised at the 1% and 99% levels to control for outliers. In the 1st stage of regression, the instruments variables are used to predict the fitted value of underinvestment (binary variable). The instruments employed for investment inefficiency (under-/over-investment) are current ratio%, earnings-price share (E/P) ratio, and revenue (ln) which reflecting financial constraints, agency conflicts of debt and sales growth, respectively. Endogeneity test examines the null hypothesis that the variable is exogenous. The Anderson underidentification test and the Sargan-Hansen test of overidentification were performed at the last stage of the model estimation, and confirmed the validity of the three instruments. The symbols ***, **, and * indicate the coefficient is statistically different from 0 at the 1%, 5%, and 10% levels, respectively.

	Panel A. Board Independence			Panel B. Analysts		
	FX	IR	CM	FX	IR	CM
Variable	(1)	(2)	(3)	(4)	(5)	(6)
Underinvestment (dummy)	0.350***	0.294***	0.226***	0.361***	0.297***	0.229***
	(0.070)	(0.023)	(0.039)	(0.057)	(0.023)	(0.025)
Independence	-0.055	-0.057	0.010			
	(0.037)	(0.044)	(0.024)			
Analysts				-0.062***	-0.110***	-0.080***
				(0.018)	(0.024)	(0.017)
Firm size	0.015***	0.032***	0.010***	0.025***	0.046***	0.024***
	(0.005)	(0.006)	(0.003)	(0.006)	(0.008)	(0.005)
Book-to-market	0.022***	0.043***	0.012***	0.022*	0.038***	0.009
	(0.006)	(0.011)	(0.004)	(0.011)	(0.012)	(0.006)
Profitability	-0.038	-0.217*	-0.125***	-0.012	-0.147*	-0.069
	(0.040)	(0.119)	(0.047)	(0.056)	(0.084)	(0.063)
Leverage	0.295***	0.899***	0.292***	0.297***	0.842***	0.265***
	(0.068)	(0.129)	(0.071)	(0.050)	(0.098)	(0.039)
Z-Score	-0.001	-0.003	0.005	0.001	-0.001	0.007
	(0.002)	(0.002)	(0.001)	(0.002)	(0.002)	(0.002)
Institutional ownership	-0.004	-0.047	-0.051*	0.020	0.004	-0.025
	(0.033)	(0.069)	(0.031)	(0.033)	(0.052)	(0.039)
Year & industry FE	YES	YES	YES	YES	YES	YES
Kurtosis of V. >3.000	3.732	3.732	3.732	3.732	3.732	3.732
Wald test (p-value)	0.000	0.000	0.000	0.000	0.000	0.000
Anderson test (p-value)	0.000	0.000	0.000	0.000	0.000	0.000
Sargan-Hansen test (p-value)	0.494	0.387	0.079	0.494	0.387	0.079
Observations	1500	1500	1500	1500	1500	1500

Overall, these results confirm that firms with underinvestment problems may increasingly lead to a greater likelihood of corporate hedging decisions to limit agency costs. These results are not only helpful for understanding the economic significance of corporate hedging decisions which mitigate investment inefficiency, but they also highlight a significant reduction in asymmetric information costs issues. When controlling possible endogeneity issues and any types of heteroscedasticity form, we efficiently obtain coefficients estimation and derive marginal effects more consistent with previous predictions signs in hypotheses H1 and H3.

Our empirical results add to literature the predictions when possible endogeneity problems are controlled with discrete regressors in the binary model estimation. When using leverage as a proxy for financial distress in the special regressor (V) model, we find also corporate hedging improves investment efficiency accordingly in the presence of financial distress as predicted in theoretical and empirical research. Overall, our evidence strongly suggests permitting the financing of under- or over-investments, which otherwise might be pursued, to increase the likelihood of corporate hedging decisions. Moreover, one interpretation of our evidence is that the elimination of investment inefficiency, as a result of agency problems, may lead to the optimum levels of investment and growth opportunities more appropriate in the framework of corporate risk management.

2.6. Conclusions

In this chapter, we provide a portrait of the nature of corporate risk management in UK nonfinancial firms and agency problems, giving a picture of the extent to which the corporate hedging can alleviate agency costs. Typically, it is challenging to assess both sides of investment inefficiency in binary models with endogenous discrete explanatory variables. Existing theories (Gay and Nam, 1998; Morellec and Smith, 2007) suggest that corporations can benefit from corporate hedging activities, in context to which individual managers are often reluctant to invest in settings prone to underinvestment or overinvestment problems that may distort their own interests.

We document a strong association between investment inefficiency and hedging decisions, as an important rational for hedging incentives. To our best knowledge, this study is the first to employ the especial regressor method to control for endogeneity problems in discrete choice models, with one or more binary explanatory variables taking advantages of maximum likelihood, control function and nonlinear 2SLS methods. The intervention of corporate governance mechanisms with investment inefficiency often occurs when hedging decisions are subject to alleviate agency costs.

Overall, when controlling for endogeneity concerns, our findings suggest that underinvestment problems can lead to a higher likelihood of hedging FX, IR, and CM price risks, respectively. Our results imply that why firms with underinvestment problem might opt for hedging policies, that is, as they anticipate that adopting such policies will mitigate agency costs and sub-optimal investment decisions. Overall, in line with predicted theories in literature, our evidence strongly suggests that under- or overinvestment problems can lead firms with strong corporate governance mechanisms to positively increase the likelihood of corporate hedging decisions for alleviating agency costs. We also find that firms when firms hedge risk exposures, in the presence of underinvestment problems, there is a reduction of information asymmetry costs. Therefore, we add to the growing number of studies that demonstrate that corporate hedging, when alleviating investment inefficiency, generates positive economic outcome associated with a reduction of agency costs and information asymmetry costs.

The limitation of this study, however, is whether the optimal level of investment expenditure has a partial adjustment with corporate hedging. Further research is recommended to investigate the range of optimal level of investment efficiency effects on corporate hedging intensity since these firms would be unlikely to respond further. Future studies can examine how the quality of hedge accounting and financial disclosures, with concerns of investment efficiency, may affect the hedge performance and economic outcome.

CHAPTER 3

Which Derivative Instruments Should Companies Use and When?

3.1. Introduction

Financial derivatives usage[16] is considered as an important part of the risk management strategy of firms, but whether these strategies are in line with corporate hedging theories is debatable (Tufano, 1996; Bartram *et al.*, 2009). Higher exposures to specific types of financial risks, overcoming costly external financing, information asymmetries and agency costs have all been argued to influence corporate hedging strategies in practice (Aretz and Bartram, 2010; Bartram *et al.*, 2011; Lel, 2012). Many non-financial firms have adopted different types of derivatives in hedging financial risks for pure risk mitigation or value creation purposes (Smith and Stulz, 1985; Bartram, 2000). Risk management theories (Smith and Stulz, 1985; Bessembinder, 1991; Froot *et al.*, 1993; Leland, 1998) advocate that due to capital market imperfections, the use of derivatives for hedging may affect firm value, for instance, by reducing the expected taxes and financial distress costs, mitigating underinvestment and increasing debt capacity to take advantage of debt tax-shields.[17] Allayannis and Weston (2001), Carter *et al.* (2006), and Pérez-González and Yun (2013), among others, provide empirical support for the benefits of hedging.

There are still a number of unexplored research questions in the extant literature. One of them is: *which derivatives should firms use?* This consideration is relevant because understanding the effects of instrument choices on value and performance can provide further evidence as to why firms hedge and which hedging strategies work. In practice, the majority

[16] As of 2015, the level of notional amounts outstanding for the over-the-counter (OTC) derivatives is about USD553 trillion and 78.6% of these is for interest rate contracts (Bank for International Settlements, BIS).
[17] Leland (1998) investigates the effect of hedging on debt capacity. Froot *et al.* (1993) examine the effect of hedging on investment policies. Smith and Stulz (1985) analyse the motivation behind corporate hedging as well as hedging for specific risks only.

of non-financial firms routinely use the popular derivatives but not all of them are likely to add value or improve performance. Despite the popularity of some derivatives used for foreign currency and commodity price risk hedging (i.e., forwards), other types are being used for interest rate risk hedging (i.e., options and swaps).[18] In sum, there are considerable conclusions in literature implying that the use of some favourable derivative instruments increases firm value. For example, Bessembinder (1991) documents that corporate risk hedging with forward (FO) contracts, among nonfinancial firms, is driven by reducing the underinvestment problems. However, as hedging with some derivative instruments requires coordination costs (e.g., up-front payment), Adam (2009) finds evidence using a sample of U.S. mining gold firms that firms' motivation to use options in CM price risk hedging strategy is consistent with firms in settings prone to financial constraints. However, derivative instruments choices constitute a significant part in corporate risk management strategies of many firms, but why firms hedge with specific instruments instead of other in portfolio management still ambiguous because of hedging or speculation purposes is limited.

We examine how different types of derivatives for hedging foreign currency, interest rate and commodity price risks could impact differently performance and value. The second question is: *when should firms hedge?* It is reasonable to expect that firms would act differently if 'high commodity prices, high interest rates and stable markets' times become 'low commodity prices, low interest rates and volatile markets' times. As a consequence, the necessity and the level of commitment to hedging activities, and the impact of hedging on value and performance of firms may evolve overtime. The third question is: *hedging which financial risk yields more favorable outcomes*? The importance of this issue has been raised

[18] For example, Tesco plc utilizes interest rate swaps as the main hedging instruments to manage interest rate risk. The group reported losses in cash flow hedge recognized in the group income statement for £54m and £132m in 2011 and 2012, respectively. Rolls-Royce Holdings plc reported mixed results of net gains (£2m) and losses (£85m) in 2012 and 2011, respectively, when using various instruments to hedge its exposure to foreign currency, interest rate and commodity risks arising from foreign operations, debt financing and investing activities abroad.

by Nelson *et al.* (2005) who find that although overall hedging is associated with abnormal stock returns it is actually foreign currency hedging that leads to this positive outcome, not the interest rate or commodity price hedging. To address these questions and hence to complement the literature, we use hand-collected data for 275 non-financial firms listed in the FTSE-All Share Index over the time period between 2005 and 2012.

An important issue raised by the extant studies relates to potential endogeneity problems or self-selection bias in regressions when predicting the influence of derivatives usage on performance or value.[19] Furthermore, although prior studies examined whether hedging a specific risk or using a specific contract affects firm value, e.g., (Bessembinder, 1991; Carter *et al.*, 2006; Bartram and Bodnar, 2007; Allayannis *et al.*, 2012), comparing the effect of specific derivatives in hedging a specific financial risk in a comprehensive way has not been attempted.[20]

Our key findings are as follows: First, the endogeneity-adjusted results reveal that foreign currency (FX) hedging increases both performance and value, commodity price (CM) hedging improves value whereas interest rate (IR) hedging impedes both firm outcomes.[21] Moreover, the association of performance and value with hedging varies across different derivatives even for the same risk type: FX hedging via forwards and swaps improves performance and value, but IR hedging via options and swaps reduces performance; FX hedging via options decreases value; IR hedging via swaps and options reduces value, but it improves value when forwards are used. The selection bias-adjusted results largely confirm

[19] Hedging decisions are unlikely to be exogenous to firms, and for hedgers and nonhedgers the value or importance of hedging can be very different. These issues are further explored in section 4. Chen (2011) addresses the endogeneity problem by using the 2SLS method for the determinants of derivatives use and performance. Chen and King (2014) use various methods to ensure the endogeneity or self-selection problems are mitigated.

[20] Bessembinder (1991) investigates forwards; Carter *et al.* (2006) study commodity price risk hedging; Bartram and Bodnar (2007), and Allayannis *et al.* (2012) examine foreign exchange risk hedging.

[21] Chernenko and Faulkender (2012) highlight the fact that some firms use IR hedging via swaps for speculative purposes. Similarly, Faulkender (2005) implies that managers can get myopic (as an irrational attitude) and use IR hedging contracts to time the market. These issues may partly explain as to why IR hedging yields negative outcomes.

these findings. Second, the propensity score matching (PSM) method confirms that matched firms in the FX (IR) hedgers sample are linked to higher (lower) performance and value, compared to the nonhedgers, and the results are statistically significant and economically sizeable. On the other hand, for the matching of the CM hedging, the value is higher but performance is lower for hedgers, compared to the nonhedgers. Regarding the matching of the IR hedging, the incremental effects on performance and value are negative (positive) for options or swaps (forwards). Regarding the matching for the CM hedging, the incremental effect on performance is negative for futures and forwards, but it is positive for options and swaps; and the incremental effect on value is negative for forwards but it is positive for futures, options and swaps. These results again suggest that the relationship between hedging and performance and value depends on the type of financial contracts *even* for the same risk type. Third, the positive effect of FX hedging on performance (value) is higher after (before) the 2007-2009 financial crisis period, compared to the pre (post)-crisis period. However, when the crisis years and non-crisis years are compared, the incremental positive effect is higher for the former (latter) regarding the outcome of performance (value). More interestingly, the negative incremental effect of IR hedging on performance is more apparent after the post-crisis years and it is even more severe during the crisis years. Furthermore, the incremental negative (positive) effect of CM hedging on performance (value) is more obvious for the pre-crisis and crisis years when compared to the post-crisis and non-crisis years, respectively. This set of results implies that it matters when the hedging is conducted.

This study is distinct from the previous literature in the following aspects: first, it studies the use of four derivative contracts: futures, forwards, options and swaps on the hedging of three types of risks: FX, IR and CM. Previous studies rely on samples that focus either on a specific risk, without specifying which derivatives are used for hedging, or on specific derivatives without specifying which risks the derivatives used is hedging, or on the study of whether the use of derivatives for hedging is associated with firm value and performance.[22] We consider both the risks that are hedged and the derivatives used in the hedging, and to the best of our knowledge there is no study that analyzes the impact of hedging with respect to various derivative contracts. Second, our analysis examines univariately and multivariately the use and effectiveness of hedging activities across different years and time periods (pre-crisis and post-crisis periods, during crisis and non-crisis years).[23] Such analyses would be appropriate to figure out whether there are specific years or time periods when hedging provides particular benefits and when it actually impedes performance or value. Third, our econometric techniques provide robust analyses by using the instrumental variables technique with generalized method of moments (IV-GMM) to address the endogeneity problem, PSM with new features and treatment effects (TE) methods to consider the selection bias problem. Furthermore, we use the recently developed technique called difference-in-differences approach combined with PSM (DDM) to compare the results across different time periods (i.e., pre-crisis, post-crisis and during crisis years); to our best knowledge, no study has analyzed the impact of hedging on firm outcomes across different times using this method. The importance and relevance of such robust methods are shown in this study as some of our regression results are sensitive to whether we control for the econometric issues of endogeneity or sample-selection bias problems. Overall, we contribute to the literature by confirming that the real effect of hedging on firm value and performance can be better understood when the analysis is conducted separately for each derivative contract and we also show that the impact of hedging on value and performance is time-variant.

[22] There are studies, e.g., (Bodnar *et al.*, 2013) which provide statistics on both the usage of various derivatives for hedging different risks but these studies have a qualitative nature where respondents are asked to rank the derivatives they use without linking each of the derivatives to a specific risk management.

[23] Bartram *et al.* (2011) focused on the economic downturn in 2001-2002 in the USA and Panaretou (2014) focused on the latest crisis period covering years 2007 to 2010 in the UK. However, we use more robust and appropriate techniques to address the issue whether hedging would have different effects on firm value and performance at different times.

This chapter is structured as follows. Section 2 reviews the literature. Section 3 describes our sample, the data collection procedures and presents the descriptive statistics. Section 4 reports the empirical results. Section 5 concludes.

3.2. Literature Review

Classic theory has established that risk management is irrelevant if markets are perfect. For instance, Modigliani and Miller (1958) show that as investors can replicate whatever risk management strategies firms decide to follow there is no need for financial risk hedging. Nelson *et al.* (2005) study the effect of hedging on the market value of equity for 1,308 U.S. firms during 1995-1999. Their results show that only 21.6% of the firms are engaged with hedging activities and the hedgers outperform the nonhedgers by 4.3% per annum, on average. For the oil and gas industry, Jin and Jorion (2006) investigate the effect of hedging on firm value and find no significant differences between the hedgers and nonhedgers. For the airline industry, Carter *et al.* (2006) show that firms can benefit from following appropriate hedging strategies and firms value is positively associated with the intensity of the hedging. For the oil refinery industry, MacKay and Moeller (2007) find that hedging improves value when firms hedge concave revenues but leave concave costs exposed. Therefore, the literature provides mixed evidence.

Several theoretical models in literature attempt to predict indirect evidence on the motives beyond some contracts rather than others, for example, Froot *et al.* (1993) show that firms are in settings prone to financial constraints, the risk hedging with option contracts are more likely to achieve the value-maximising hedge. Consistent with Moschini and Lapan (1995), corporate risk hedging with options contracts rather forwards in some circumstances is due to the hedging policy required to add nonlinear instruments to reach optimal hedging positions. While Adam (2009) argues that when gold mining firms use options instead of linear contracts (i.e., forwards) that because of firms in setting to hedge risk exposures with options , those contracts are to obtain low-cost financing. Therefore, when evaluating separately the effects of each hedging contract on the value-maximising risk hedge, the results vary depending on the risk type, and the time of hedging. Prior research, e.g., (Allayannis and Weston, 2001; Bartram *et al.*, 2011; Aabo and Ploeen, 2014) examines the effect of active risk management policies with specific derivatives across countries or industries. For example, Bartram *et al.* (2011) show in their univariate analysis that examining various derivatives contracts can give rise to an interesting investigation of the effectiveness of derivatives. As multinational firms are regularly exposed to risks related to cash flows in foreign currency and investments in various countries, Chang and Wong (2003) provide strong evidence for the optimality of using options and futures in FX risk hedging. In fact, studies on risk hedging with derivatives such as a survey by Bodnar *et al.* (2013) provide mixed results for estimating the probability of IR risk hedging with forwards and options. Pérez-González and Yun (2013) find a positive relationship between weather derivatives and firm value for the energy firms. Similarly, Chernenko and Faulkender (2012) find that interest rate swaps are being used especially by high-investment firms possibly due to costly external finance. This implies how financial hedging via different instruments can lead to different outcomes with respect to cost of borrowing, value or performance.

The existing literature reports a number of firm-specific factors that affect hedging decisions and finds that geographic diversification policy affects firms' commitment to hedging and the hedging affects firm value, e.g., (Berger and Ofek, 1995; Bartram *et al.*, 2011; Allayannis *et al.*, 2012) suggest that the use of derivatives for foreign currency risk hedging is positively associated with a value premium if firms have a strong internal (firm-level) or external (country-level) governance. Unlike Pérez-González and Yun (2013), Tufano (1996) finds weak evidence that risk management maximizes shareholders' value and shows that firms whose managers hold more stocks are more prone to hedge the gold price risk. Borokhovich *et al.* (2004) find a positive and significant relationship between the relative influence of outside directors and interest rate risk hedging, using a sample of 370 firms listed in the S&P 500 index. Dhanani et al. (2007) survey based on 564 UK non-financial listed firms examines whether tax, regulatory arbitrage, managing the variability of reported earnings, managerial incentives, economies of scale and lowering the likelihood of financial distress determine interest rate risk hedging. While some responses support the above theories, others do not. Conventional wisdom says that mandatory hedging, for instance through debt covenants, does not help firms maximize value. There are also studies providing mixed results for the effect of hedging on value and performance. For instance, Dhanani *et al.* (2007) argue that the effect of hedging on firm value varies across countries and is affected by the tax regime and regulatory rules, and Fauver and Naranjo (2010) argue that the link between hedging and firm value is negative for firms with weak corporate governance. Additionally, Faulkender (2005) reports a strong association between the slope of the yield curve and interest rate risk hedging; Géczy *et al.* (2007) argue that derivatives can be used to inflate performance-based compensation, given that it is difficult to distinguish between the use of derivatives for hedging and speculative purposes. Also, Aabo and Ploeen (2014) find that there is an inverse U-shaped link between business internationalization and foreign currency risk hedging for non-financial German firms, which supports the view that higher levels of internationalization may reduce the need for foreign currency risk hedging. Bartram *et al.* (2011), relying on a sample which includes 6,888 non-financial firms from 47 countries, show that the use of derivatives reduces firms' total risk, is positively associated with firm value and more prevalent in firms with higher exposures to interest rate, exchange rate and commodity prices risks. Other studies examine whether business geographic diversification affects firms' commitment to hedging and if this is related to firm value

(Berger and Ofek, 1995; Allayannis and Weston, 2001; Allayannis *et al.*, 2012). Bonaimé *et al.* (2014a), on the other hand, show that the need for hedging can be mitigated by more active corporate payout policy.

Despite recent developments in the literature, we still have little theoretical explanatory power to identify which firms ought to use derivatives, noting that sub-optimal, inappropriate or unnecessary usage of derivatives may lead to unwanted effect on firm value or performance. It is possible that the motivation for risk management may be due to factors not yet considered in risk management theories, such as earnings smoothing, industry competition, a manager's self-interest, speculative purpose[24] or signalling,[25] which are challenging to study empirically. Furthermore, most empirical studies fail to account for the endogeneity of variables, which may describe different dimensions of the risk management strategy and financial policies, as stressed by Aretz and Bartram (2010).

3.3. Data and descriptive statistics

3.3.1. Data sources and sample construction

In this sub-section, we describe the construction of the sample and the process of data collection. We examine the effect of derivatives use on value and performance of the non-financial firms listed in the FTSE-All Share Index[26]during 2005 to 2012.

In the UK, after the implementation of Financial Reporting Standard (FRS) 13 ('*derivatives and other financial instruments: disclosures*') in 1999, the firms were required to report externally their hedging activities based on financial instruments. Prior to January 2005, they

[24] In perfect markets, one would expect the gains from speculative hedging to be zero or negative given the transaction costs. Also, Adam and Fernando (2006) and Brown *et al.* (2006) suggest that the gains from speculating hedging appear small.

[25] During the financial crisis period (2008-2009), firms may have used derivatives for signaling investors that their business was protected against unfavorable market moves.

[26] The FTSE-All Share Index is a capitalization-weighted index with a base level of 100 which started in April 1962. Currently it comprises over 640 constituents, from a group of more than 2,000 firms quoted on the London Stock Exchange, and it captures roughly 98% of the UK's market capitalization.

accounted for derivatives in accordance with UK generally accepted accounting principles (GAAP) on their income statements albeit non-detailed information. From April 2005, hedge accounting for the quoted firms has then been shaped by International Financial Reporting Standards (IFRS). The International Accounting Standards (IAS) 32 ('*financial instruments disclosures and presentation*') and IAS 39 ('*financial instruments: recognition and measurement*') increased both the transparency and the quality of risk management-related information provided in the annual reports.[27] Following the adoption of IAS 39 (that replaced FRS 13) in 2005, firms recognized the hedging instruments at fair value on their balance sheets as it became mandatory for them to disclose all documentations.

The data on derivatives usage were hand-collected from annual reports whereas the remaining data were collected from Thomson Reuters Datastream. Annual reports were downloaded from firms' official websites. We followed the methods of Nelson *et al.* (2005) and Bartram *et al.* (2011) to identify the hedgers and nonhedgers.[28] For the hedgers, we gathered information on the hedging of the FX, IR and CM risks, with futures, forwards, options and swaps.[29,30] Our initial sample included 379 firms (3,032 observations) but 104 of these firms were acquired, merged, or delisted. Our final sample comprises information on 275 firms with 2,200 observations.

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[27] The new hedging accounting standards seek to inform investors of the results of the hedging activities by reporting information on the risks that are hedged and the effects of hedging over a given time period.

[28] We used a number of keywords in searching hedging activities in the annual reports, which are as follows: "risk management", "hedging", "derivatives", "derivative financial instruments", "hedge accounting", "fair value hedging", "cash flow hedging", "net investment hedging", "risk exposure", "foreign currency risk", "interest rate risk", "commodity risk", "futures", "forwards", "options", "swaps", "floating rate", and "fixed rate". We also considered any comments reported under the *derivative financial instruments disclosures* that explain in detail corporate hedging policies and activities.

[29] We also collected data on the use of "other" derivatives but since they accounted for less than 1% of the total sample they were not considered in this study.

[30] In some cases annual reports provide further details, for instance, stating: floating to fixed interest rate swap, or fixed to floating interest rate swap, or interest rate cap, or interest rate collar. However, our dataset does not go into that level of detail.

3.3.2. Definition of variables

This section presents the dependent and explanatory variables of our regression models.[31] Detailed definitions of the variables are provided in Table 1.

[31] The Pearson correlation coefficients were not reported for brevity but they are available upon request. The variance inflation factors (VIFs) are less than 10, suggesting the absence of multicollinearity problem in the models.

Table 1. Variable definition

Variable	Definition	Data Source
Derivatives use:		
Hedging decisions	Dummy variable with value 1 if firms use derivative securities for hedging FX, IR or CM risks, and 0 otherwise.	Annual report
Foreign currency hedge	Dummy variable with value 1 if firms use derivative securities for hedging FX risk, and 0 otherwise.	Annual report
Foreign currency futures	Dummy variable with value 1 if firms use futures contracts for hedging FX risk, and 0 otherwise.	Annual report
Foreign currency forwards	Dummy variable with value 1 if firms use forward contracts for hedging FX risk, and 0 otherwise.	Annual report
Foreign currency options	Dummy variable with value 1 if firms use option contracts for hedging FX risk, and 0 otherwise.	Annual report
Foreign currency swaps	Dummy variable with value 1 if firms use swap contracts for hedging FX risk, and 0 otherwise.	Annual report
Interest rate hedge	Dummy variable with value 1 if firms use derivative securities for hedging IR risk, and 0 otherwise.	Annual report
Interest rate futures	Dummy variable with value 1 if firms use futures contracts for hedging IR risk, and 0 otherwise.	Annual report
Interest rate forwards	Dummy variable with value 1 if firms use forward contracts for hedging IR risk, and 0 otherwise.	Annual report
Interest rate options	Dummy variable with value 1 if firms use option contracts for hedging IR risk, and 0 otherwise.	Annual report
Interest rate swaps	Dummy variable with value 1 if firms use swap contracts for hedging IR risk, and 0 otherwise.	Annual report
Commodity price hedge	Dummy variable with value 1 if firms use derivative securities for hedging CM risk, and 0 otherwise.	Annual report
Commodity futures	Dummy variable with value 1 if firms use futures contracts for hedging CM risk, and 0 otherwise.	Annual report
Commodity forwards	Dummy variable with value 1 if firms use forward contracts for hedging CM risk, and 0 otherwise.	Annual report
Commodity options	Dummy variable with value 1 if firms use option contracts for hedging CM risk, and 0 otherwise.	Annual report
Commodity swaps	Dummy variable with value 1 if firms use swap contracts for hedging CM risk, and 0 otherwise.	Annual report
Firm characteristics:		
Revenues	Total revenues (or net sales) of the firm	Datastream
Total Assets	Total assets of the firm	Datastream
Return on Assets	Earnings before finance costs and tax / book value of total assets.	Datastream
Net income	Net income after depreciation, interest, taxes and other expenses.	Datastream
Firm Market Value	The share price of the company's stock at its fiscal year end multiplied by the number of common shares outstanding.	Datastream
Tobin's Q (ln)	Ln [total assets – book value of equity + market value of equity) /total assets. This measure is used as a proxy for firm value.	Datastream
Firm Size	Natural logarithm of the book value of total assets in 2005 prices.	Datastream
Firm Age (ln)	Natural logarithm of the number of years since the stock of the firm first appears in London Stock exchange.	Datastream
Leverage	Book value of total debt, including short and long debt / book value of total assets.	Datastream
Floating Rate Debt	Dummy variable with value 1 if firm has borrowings debt in floating interest rate.	Annual report
Fixed Rate Debt	Dummy variable with value 1 if firm has borrowings debt in fixed interest rate.	Annual report
Dividends Per Share	Dividends per share (in pence).	Datastream
Dividends dummy	Dummy variable with value of 1 if DPS is greater than zero, and 0, otherwise.	Datastream
Capex/assets	Capital expenditures divided by book value of assets.	Datastream
R&D/assets	Research and development expense divided by book value of assets.	Datastream
Geographic Diversification	Dummy variable with value 1 if firms have subsidiaries outside the UK, and 0 otherwise.	Datastream
Foreign Sales Ratio	The ratio of foreign sales to revenues (or net sales).	Annual report
Foreign Expenditures	Dummy variable with value 1 if firms have foreign expenditures abroad, and 0 otherwise.	Annual report
Commodity Purchases	Dummy variable with value 1 if firms buy commodity for use in operations, and 0 otherwise.	Annual report
Commodity Oil and Gas	Dummy variable with value 1 if firms sell or produce oil, gas or mining related commodities, and 0 otherwise.	Annual report

3.3.2.1. Dependent variables

We use return on assets (ROA) as a proxy for performance and Tobin's Q as proxy for value following Allayannis and Weston (2001), Pramborg (2004), Clark and Judge (2008), and Pérez-González and Yun (2013), among others.[32] ROA is earnings before finance costs and tax divided by total assets; Tobin's Q is total assets less book value of equity plus market value of equity divided by total assets.

3.3.2.2. Hedging-related explanatory variables

Allayannis *et al.* (2012) and Belghitar *et al.* (2013) show that hedging FX risk enhances value. Nelson *et al.* (2005) find little evidence that hedging IR risk is associated with abnormal market return. Jin and Jorion (2006) show that CM hedging is not necessarily positively associated with a market value premium. Panaretou (2014) finds that the presence of hedging activities and firm value are not correlated for the interest rate and commodity price risks but this correlation is significant and positive for currency hedging. The empirical literature, therefore, implies that the effect of hedging on firm outcomes depends on the risk type being hedged. These findings suggest the relevance of decomposition of risk types when studying this relationship. To account for this, we use a dummy variable *i*) which is 1 if firms hedge the FX risk in a given year; 0, otherwise; *ii*) which is 1 if firms hedge the IR risk; 0, otherwise; *iii*) which is 1 if firms hedge the CM risk; 0, otherwise.

3.3.2.3. Control variables

The literature shows that firm size can affect firm value, e.g., Lang and Stulz (1994). We use the natural logarithm of total assets to measure size. We use the natural logarithm of the

[32] We also used return on invested capital (ROIC) as a proxy for performance, where ROIC is defined as earnings before finance costs and tax divided by the average of last year's and current year's total capital plus short-term debt and current portion of long-term debt. The results are quite similar and therefore, to save space, we do not report them. The distribution of Tobin's Q in our sample is skewed; hence, we use the logarithmic transformation for this variable.

firm age since this factor has been shown to affect firm performance, e.g., Aktas *et al.* (2015). Further, high investment growth may induce firms to hedge more (Smith and Watts, 1992; Froot *et al.*, 1993; Géczy *et al.*, 1997) and high investment growth implies higher firm value (Myers, 1977). We use capital expenditures to total assets and R&D to total assets as proxies for investment growth opportunities and expect them to be positively associated with value and performance. Leland (1998) shows that increasing leverage reduces tax obligations and increases a managers' commitment to the firm. However, higher debt increases financial distress costs, see e.g., Shleifer and Vishny (1997). Purnanandam (2008) finds a positive relationship between leverage and hedging if firms hold high financial distress costs. Allayannis and Weston (2001) include debt-equity ratio in their regression models and we use the proxy of total debt over total assets to control for the effect of financing mix. Aretz *et al.* (2007) and Bartram *et al.* (2009) find that dividend policy affects value and performance. Thus, another control factor that we adopt is a binary dummy variable indicating if firms pay dividends. If geographic diversification (GD) is implemented optimally it might enhance value and performance but it can also lead to overinvestment, eroding both value and performance, see, e.g., (Lang and Stulz, 1994; Berger and Ofek, 1995). Morck and Yeung (1991), Bodnar and Weintrop (1997) and Pramborg (2004), among others, find that GD is positively linked with value. We use a dummy variable to control for the effect of GD, which is 1 if firms have subsidiary outside the UK; 0, otherwise. Finally, the involvement of firms with hedging may be industry-related, as highlighted by Tufano (1996) and Lievenbrück and Schmid (2014). We use the two-digit Standard Industrial Classification (SIC) codes to classify firms into nine groups. It is also reasonable to expect that exogenous factors that are time-varying would exert influence on firm outcomes. To account for such fixed effects, we use a set of industry and time dummies.

3.3.3. Descriptive analysis

Table 2 Panel A provides summary statistics on hedging activities over the sample time period. It shows the percentage of hedgers and nonhedgers of the FX, IR and CM risks. Our results reveal that the proportion of hedgers has increased over time for both the FX and CM risks whereas for the IR risk we find a slight reduction in years 2011 and 2012. More specifically, between 2005 and 2012, the percentage of firms that hedge the FX, IR and CM risks increased from 61.1% to 72.7%, 60.0% to 62.9% and 12.7% to 15.6%, respectively. Furthermore, 68.3% of the firms hedge the FX risk, 63.7% of the firms hedge the IR risk and 14.3% of the firms hedge the CM risk.

Table 2

Sample firms and hedging behaviour by type and time period

This table reports statistics on the popularity of hedging for each financial risk and derivative contract, for the period between 2005 and 2012. Panel A reports the number and the percentage of hedgers (H>0) and nonhedgers (H=0) for the financial risks. The percentage of hedgers and nonhedgers is computed based on a total sample of 275 firms. Panel B shows the popularity of each derivatives contract: futures (FU), forwards (FO), options (OP) and swaps (SW) for hedging different types of risks: foreign currency (FX), interest rate (IR) and commodity price (CM). Panel C provides summary statistics on the hedgers (H>0) and the nonhedgers (H=0) with (GD>0) and without (GD=0) "business geographic diversification". N refers to the number of observations.

Panel A: Hedging financial risks by year

Time period	Foreign currency hedging				Interest rate hedging				Commodity price hedging			
	H > 0	%	H = 0	%	H > 0	%	H = 0	%	H > 0	%	H = 0	%
2005	168	61.1%	107	38.9%	165	60.0%	110	40.0%	35	12.7%	240	87.3%
2006	177	64.4%	98	35.6%	168	61.1%	107	38.9%	38	13.8%	237	86.2%
2007	184	66.9%	91	33.1%	173	62.9%	102	37.1%	36	13.1%	239	86.9%
2008	188	68.4%	87	31.6%	177	64.4%	98	35.6%	41	14.9%	234	85.1%
2009	192	69.8%	83	30.2%	181	65.8%	94	34.2%	39	14.2%	236	85.8%
2010	195	70.9%	80	29.1%	183	66.5%	92	33.5%	40	14.5%	235	85.5%
2011	199	72.4%	76	27.6%	181	65.8%	94	34.2%	43	15.6%	232	84.4%
2012	200	72.7%	75	27.3%	173	62.9%	102	37.1%	43	15.6%	232	84.4%
Average	196	68.3%	92	31.7%	184	63.7%	104	36.3%	40	14.3%	248	85.7%

Panel B: Derivative contracts by year

Time periods	Foreign currency hedging				Interest rate hedging				Commodity price hedging			
	FU	FO	OP	SW	FU	FO	OP	SW	FU	FO	OP	SW
2005	1	155	17	81	1	16	36	162	9	17	11	15
	(0.4%)	(56.4%)	(6.2%)	(29.5%)	(0.4%)	(5.8%)	(13.1%)	(58.9%)	(3.3%)	(6.2%)	(4.0%)	(5.5%)
2006	3	161	22	81	1	13	40	164	11	22	13	14
	(1.1%)	(58.5%)	(8.0%)	(29.5%)	(0.4%)	(4.7%)	(14.5%)	(59.6%)	(4.0%)	(8.0%)	(4.7%)	(5.1%)
2007	3	167	23	87	1	15	36	169	10	22	14	13
	(1.1%)	(60.7%)	(8.4%)	(31.6%)	(0.4%)	(5.5%)	(13.1%)	(61.5%)	(3.6%)	(8.0%)	(5.1%)	(4.7%)
2008	2	173	23	90	1	14	32	176	11	24	12	16
	(0.7%)	(62.9%)	(8.4%)	(32.7%)	(0.4%)	(5.1%)	(11.6%)	(64.0%)	(4.0%)	(8.7%)	(4.4%)	(5.8%)
2009	2	178	24	92	2	14	30	179	8	25	12	16
	(0.7%)	(64.7%)	(8.7%)	(33.5%)	(0.7%)	(5.1%)	(10.9%)	(65.1%)	(2.9%)	(9.1%)	(4.4%)	(5.8%)
2010	2	180	23	93	3	12	30	180	9	23	10	16
	(0.7%)	(65.5%)	(8.4%)	(33.8%)	(1.1%)	(4.4%)	(10.9%)	(65.5%)	(3.3%)	(8.4%)	(3.6%)	(5.8%)
2011	2	183	24	100	3	15	28	177	9	24	10	15
	(0.7%)	66.5%	(8.7%)	(36.4%)	(1.1%)	(5.5%)	(10.2%)	(64.4%)	(3.3%)	(8.7%)	(3.6%)	(5.5%)
2012	1	183	19	96	3	14	27	169	9	27	11	14
	(0.4%)	(66.5%)	(6.9%)	(34.9%)	(1.1%)	(5.1%)	(9.8%)	(61.5%)	(3.3%)	(9.8%)	(4.0%)	(5.1%)
Average	2	181	24	93	2	14	33	172	10	24	12	15
(%)	0.7%	62.7%	8.0%	32.7%	0.7%	5.1%	11.8%	62.5%	3.5%	8.4%	4.2%	5.4%

Panel C: Hedging financial risks and geographic diversification by year

Geographic diversification	2005		2006		2007		2008		2009		2010		2011		2012		Total N
	H > 0	H =0	H > 0	H =0	H > 0	H =0	H > 0	H =0	H > 0	H =0	H > 0	H =0	H > 0	H =0	H > 0	H =0	
GD > 0																	
N	166	50	172	46	177	40	184	36	190	32	196	30	196	31	193	33	1772
%	60.4%	18.2%	62.6%	16.7%	64.4%	14.5%	66.9%	13.1%	69.1%	11.6%	71.3%	10.9%	71.3%	11.3%	70.2%	12.0%	
GD = 0																	
N	47	12	47	10	50	8	49	6	46	7	42	7	40	8	41	8	428
%	17.1%	4.3%	17.1%	3.6%	18.2%	2.9%	17.8%	2.2%	16.7%	2.6%	15.3%	2.5%	14.5%	2.9%	14.9%	2.9%	
Full sample																	
N	213	62	219	56	227	48	233	42	236	39		37	236	39	234	41	2200
%	77.5%	22.5%	79.6%	20.4%	82.5%	17.5%	84.7%	15.3%	85.8%	14.2%	86.5%	13.5%	85.8%	14.2%	85.1%	14.9%	

Table 2 Panel B provides information on the use of various contracts. We conclude that forwards are most popular for hedging both the FX and the CM risks, and swaps are most popular for hedging the IR risk. More specifically, for FX risk hedging, 62.7% of the firms use forwards, 32.7% use swaps and 8% use options; futures are only marginally used, with less than 1%. For the IR risk hedging, 62.5% of the firms use swaps, 11.8% use options, and 5.1% use forwards; futures are again only marginally used. For CM risk hedging, 8.4% of the firms used forwards, and 5.4%, 4.2% and 3.5% use swaps, options and futures, respectively.

Table 2 Panel C provides information on the number and percentage of hedgers and nonhedgers with and without geographic diversification (GD) over the sample time period. We observe that the percentage of hedgers with GD has increased from 60.4% in 2005 to 70.2% in 2012 whereas the percentage of nonhedgers with GD decreased from 18.2% in 2005 to 12% in 2012. On the other hand, the percentage of hedgers without GD varies between 17.1% and 18.2% between 2005 and 2007, and decreased to 14.9% in 2012 whereas the percentage of nonhedgers without GD decreased from 4.3% in 2005 to 2.9% in 2012. These results support the view that firms with business abroad are more likely to hedge, mainly because they are more exposed to the FX risk.

Table 3 provides summary statistics for our variables for the full sample (Panel A), for firms with GD (Panel B) and for firms without GD (Panel C). For overall FX risk hedging, the mean value is 76.3% in Panel B but it is only 35.3% in Panel C. For overall IR risk hedging, the mean value is 60% in Panel B and 79% in Panel C. For overall CM risk hedging, the mean value is 16% in Panel B and 7.2% in Panel C. The corresponding mean value differences in two sub-samples are all statistically significant at the 1% level. We conclude, therefore, that firms with business GD are more engaged with hedging the FX and CM risks and less devoted to the hedging the IR risk than firms without business GD.

Moreover, the mean values in Panel A for Revenue, Total Assets and Market Value are £3,559, £4,821 and £3,806 million, respectively. The mean value for firm age in Panels B and C is very similar and around 20 years. In addition, foreign sales represent 51.4% of the revenues in Panel A and 63.8% of the revenues in Panel B. The mean value of the leverage ratios are 21.9% in Panel A, 20.7% in Panel B and 26.8% in Panel C, although the difference in means value between the two subgroups is statistically insignificant.

Table 3

Descriptive Statistics

This table shows summary statistics for 275 non-financial firms listed on the London Stock Exchange over the time period between 2005 and 2012 on firms characteristics and the usage of derivatives. Panel A presents the results for the full sample whereas Panel B and C provide the results for the firms with and without business segments outside the UK, respectively. The last column presents the mean differences between the results provided in Panels B and C, where ***, **, and * denote significance at the 1%, 5%, and 10% level, respectively. All variables are defined in Table 1.

	Panel A: Full Sample						Panel B: Sub-sample (GD > 0)						Panel C: Sub-sample (GD = 0)						Mean diff.
Variable name	No. obs.	Mean	Std. dev.	Min.	Median	Max.	No. obs.	Mean	Std. dev.	Min.	Median	Max.	No. obs.	Mean	Std. dev.	Min.	Median	Max.	
Hedging decisions	2200	0.835	0.372	0	1	1	1772	0.832	0.374	0	1	1	428	0.846	0.362	0	1	1	-0.014
Foreign currency hedge (FX)	2200	0.683	0.465	0	1	1	1772	0.763	0.425	0	1	1	428	0.353	0.478	0	0	1	0.410***
Foreign currency futures	2200	0.007	0.085	0	0	1	1772	0.009	0.095	0	0	1	428	0	0	0	0	0	0.009**
Foreign currency forwards	2200	0.627	0.484	0	1	1	1772	0.718	0.450	0	1	1	428	0.252	0.435	0	0	1	0.465***
Foreign currency options	2200	0.080	0.271	0	0	1	1772	0.091	0.288	0	0	1	428	0.030	0.172	0	0	1	0.061***
Foreign currency swaps	2200	0.327	0.469	0	0	1	1772	0.357	0.479	0	0	1	428	0.203	0.403	0	0	1	0.154***
Interest rate hedge (IR)	2200	0.637	0.481	0	1	1	1772	0.600	0.490	0	1	1	428	0.790	0.408	0	1	1	-0.190***
Interest rate futures	2200	0.007	0.082	0	0	1	1772	0.008	0.092	0	0	1	428	0	0	0	0	0	0.008*
Interest rate forwards	2200	0.051	0.221	0	0	1	1772	0.049	0.215	0	0	1	428	0.063	0.243	0	0	1	-0.015
Interest rate options	2200	0.118	0.322	0	0	1	1772	0.097	0.296	0	0	1	428	0.203	0.403	0	0	1	-0.106***
Interest rate swaps	2200	0.625	0.484	0	1	1	1772	0.591	0.492	0	1	1	428	0.769	0.422	0	1	1	-0.178***
Commodity hedge (CM)	2200	0.143	0.350	0	0	1	1772	0.160	0.367	0	0	1	428	0.072	0.260	0	0	1	0.088***
Commodity futures	2200	0.035	0.183	0	0	1	1772	0.040	0.196	0	0	1	428	0.012	0.108	0	0	1	0.028***
Commodity forwards	2200	0.084	0.277	0	0	1	1772	0.092	0.289	0	0	1	428	0.049	0.216	0	0	1	0.043***
Commodity options	2200	0.042	0.201	0	0	1	1772	0.050	0.218	0	0	1	428	0.009	0.096	0	0	1	0.041***
Commodity swaps	2200	0.054	0.226	0	0	1	1772	0.062	0.241	0	0	1	428	0.021	0.144	0	0	1	0.041***
Revenue (£bn.)	2200	3.559	12.637	0	0.678	236.000	1772	3.989	13.928	0	0.684	236.000	428	1.777	3.719	0.001	0.662	25.424	2.212***
Total Assets (£bn.)	2200	4.821	14.879	0.005	0.863	188.000	1772	5.335	16.320	0.005	0.788	188.000	428	2.693	5.459	0.008	1.020	47.335	2.642***
Return on Assets	2200	0.052	0.112	-2.790	0.054	0.697	1772	0.057	0.113	-2.790	0.056	0.697	428	0.034	0.107	-0.786	0.046	0.285	0.023***
Net Income (£bn.)	2200	0.475	1.644	-4.989	0.060	20.610	1772	0.551	1.814	-4.989	0.063	20.610	428	0.162	0.373	-0.152	0.053	3.600	.389***
Market Value (£bn)	2200	3.806	11.119	0.003	0.649	134.000	1772	4.370	12.247	0.003	0.703	134.000	428	1.470	2.797	0.019	0.555	25.139	2.900***
Tobin's Q (ln)	2200	0.413	0.487	-0.964	0.332	2.710	1772	0.462	0.495	-0.964	0.383	2.710	428	0.210	0.392	-0.839	0.131	1.820	0.252***
Size (ln Assets)	2200	13.700	1.760	8.590	13.700	19.100	1772	13.700	1.840	8.590	13.600	19.100	428	13.800	1.420	8.990	13.800	17.700	-0.138
Age (ln)	2200	2.970	0.831	0	3.090	4.530	1772	2.970	0.848	0	3.090	4.530	428	2.990	0.759	0	3.090	3.870	-0.016
Leverage	2200	0.219	0.181	0	0.199	0.998	1772	0.207	0.171	0	0.189	0.998	428	0.268	0.211	0	0.265	0.954	-0.061***
Floating Rate Debt	2200	0.891	0.311	0	1	1	1772	0.891	0.312	0	1	1	428	0.895	0.307	0	1	1	-0.004
Fixed Rate Debt	2200	0.705	0.456	0	1	1	1772	0.692	0.462	0	1	1	428	0.759	0.428	0	1	1	-0.067***
Dividends per share	2200	0.131	0.192	0	0.078	1.950	1772	0.131	0.203	0	0.073	1.950	428	0.133	0.141	0	0.095	0.810	-0.002
Dividends dummy	2200	0.840	0.367	0	1	1	1772	0.832	0.374	0	1	1	428	0.871	0.335	0	1	1	-0.039**
Capex/assets	2200	0.046	0.046	0	0.033	0.383	1772	0.046	0.046	0	0.033	0.383	428	0.049	0.048	0	0.034	0.246	-0.003
R&D/assets	2200	0.017	0.055	0	0	0.755	1772	0.019	0.053	0	0	0.755	428	0.010	0.059	0	0	0.552	0.009***
Geographic diversification	2200	0.805	0.396	0	1	1	1772	1	0	1	1	1	428	0	0	0	0	0	1.000
Foreign Sales Ratio	2200	0.514	0.387	0	0.584	1	1772	0.638	0.327	0	0.756	1	428	0	0	0	0	0	0.638***
Foreign Expenditures	2200	0.852	0.355	0	1	1	1772	0.973	0.162	0	1	1	428	0.350	0.478	0	0	1	0.622***
Commodity Purchases	2200	0.169	0.375	0	0	1	1772	0.192	0.394	0	0	1	428	0.072	0.260	0	0	1	0.120***
Commodity Oil and Gas	2200	0.098	0.298	0	0	1	1772	0.116	0.321	0	0	1	428	0.023	0.151	0	0	1	0.093***

Table 4 reports the mean and median values for a set of variables for the full sample and for the sub-samples of hedgers and nonhedgers. Panel A reports the variables for selected risk factors that are usually associated with the use of derivatives whereas Panel B shows the firm characteristics variables.[33] In the last column, we report the Wilcoxon test statistics which show that the median differences between the variables of two subsamples are mostly statistically significant. A similar pattern is observed in the penultimate column where we compare means. The figures show that nonhedgers have higher foreign sales ratio than hedgers (59% vs. 50%). In addition, although the mean value for ROA is higher for hedgers (5.4% vs. 4.3%), the opposite is true for the mean value of Tobin's Q (0.384 vs. 0.531, in logs).

[33] The company annual reports that we examined suggest that a) foreign sales, foreign expenditure and geographic diversification foster FX risk exposures; b) floating rate and fixed rate debt are inputs for IR risk exposures; and c) commodity purchases for operations and commodity or mining producers are related to commodity price volatility in commodity markets.

Table 4

Univariate Tests of Risk factors and Derivatives Use

This table presents the number of observations (N), mean, median and difference in mean of risk factors and firms' characteristics for hedgers vs. nonhedgers. The univariate tests report the difference in distribution between two samples whether is statistically significance. The last column presents *p*-value of Wilcoxon rank sum tests between hedgers vs. nonhedgers, where ***, **, and * denote significance at the 1%, 5%, and 10% level, respectively. All variables are defined in Table 1.

	Full sample			Hedgers			Nonhedgers			Mean Diff.	Wilcoxon
Variable name	N	Mean	Median	N	Mean	Median	N	Mean	Median		*p*-value
Panel A. Risk factors											
Foreign Sales Ratio	2200	0.514	0.584	1836	0.499	0.563	364	0.590	0.735	-0.091***	0.000
Foreign Expenditures	2200	0.852	1	1836	0.875	1	364	0.734	1	0.142***	0.000
Geographic diversification	2200	0.805	1	1836	0.803	1	364	0.819	1	-0.016	0.485
Floating Rate Debt	2200	0.891	1	1836	0.941	1	364	0.640	1	0.301***	0.000
Fixed Rate Debt	2200	0.705	1	1836	0.777	1	364	0.343	0	0.433***	0.000
Commodity Purchases	2200	0.169	0	1836	0.207	0	364	0.063	0	0.144***	0.000
Commodity Oil and Gas	2200	0.098	0	1836	0.084	0	364	0.168	0	-0.083***	0.000
Panel B. Firm characteristics											
Revenue (£bn)	2200	3.559	0.678	1836	4.183	0.828	364	0.412	0.150	3.771***	0.000
Total Assets (£bn)	2200	4.821	0.863	1836	5.652	1.100	364	0.628	0.230	5.024***	0.000
Return on Assets (ROA)	2200	0.052	0.054	1836	0.054	0.054	364	0.043	0.064	0.011*	0.253
Net Income (£bn)	2200	0.475	0.060	1836	0.559	0.079	364	0.054	0.019	.504***	0.000
Market Value (£bn)	2200	3.806	0.649	1836	4.518	0.766	364	0.673	0.284	3.845***	0.000
Tobin's Q (ln)	2200	0.413	0.332	1836	0.384	0.315	364	0.531	0.445	-0.147***	0.000
Size (ln Assets)	2200	13.700	13.700	1836	14.015	13.900	364	12.322	12.300	1.693***	0.000
Age (ln Age)	2200	2.970	3.090	1836	3.038	3.180	364	2.641	2.770	0.398***	0.000
Capex/assets	2200	0.046	0.033	1836	0.046	0.035	364	0.049	0.024	-0.003	0.004
R&D/assets	2200	0.017	0	1836	0.015	0	364	0.027	0	-0.012***	0.038
Leverage	2200	0.219	0.199	1836	0.238	0.221	364	0.124	0.066	0.113***	0.000
Dividends dummy	2200	0.840	1	1836	0.884	1	364	0.618	1	0.266***	0.000

3.4. The models and empirical findings

3.4.1. Regression models

We study the effect of hedging the FX, IR and CM risks on value and performance, using the following regression model:

$$Y_{it} = \beta_0 + \beta_1 Hderiv_{it} + \theta X'_{it} + \varepsilon_{it} \qquad (1)$$

where Y_{it} represents ROA and the Tobin's Q of firm *i* in year *t; Hderiv* is one of the dummy variables which is 1 if firm *i* hedges in year *t* the FX, IR or CM risks with any of the contracts; 0, otherwise; *β*s and *θ*s are estimable parameters, X'_{it} is a vector of a set of control variables; and ε_{it} is the error term.

Our methods include the use of ordinary least squares (OLS), instrumental variables (IVs) with generalized method of moments (GMM) estimator, treatment effects (TE), propensity score matching (PSM), and difference-in-differences with PSM (i.e., DDM) analyses. More specifically, we use the IV-GMM specification to deal with endogeneity problem, TE regressions to deal with self-selection bias, PSM technique to reduce the selection bias for our matched sample tests, and the DDM specification to provide and compare estimations across different time periods.

3.4.2. The OLS regressions

Table 5 presents the OLS results for performance (ROA).[34] Columns (1) to (3) show that hedging the FX risk is positively and significantly associated with ROA and hedging the IR and CM risks are negatively and significantly associated with performance. Columns (4) to

[34] The use of FU contracts for hedging the FX and IR risks are very marginal (accounting for less 1% of the total observations) and, therefore we omit these contracts from our regression analyses. Also, alternative to ROA, we use return on invested capital (ROIC): as the regressions results are very similar we only report the findings for ROA.

(13) show the effect of hedging a specific risk with given derivatives on ROA. Our findings show that hedging the FX risk is always positively associated with performance regardless of the derivatives type used in the hedging. For the hedging of the IR and CM risks we find mixed results. For the former case, hedging with forwards is positively associated with performance whereas hedging with options or swaps is negatively associated with performance. For the latter case, hedging with futures and forwards is negatively associated with performance whereas hedging with options and swaps is positively associated with performance - none of these results are, however, statistically significant.

Table 5

OLS Regressions: The Effect of Overall Hedging and Hedging With Some Specific Derivatives on Firm Performance

This table presents the OLS regressions coefficients for return on assets (ROA) as a proxy for financial performance. More specifically, columns 1-3 report our results for the effect of hedging the FX, IR and CM risks on firm performance, respectively-ignoring which derivatives are used for hedging. Columns 4-6 report our results for the effect of hedging the FX risk with forwards, options and swaps, respectively. Columns 7-9 report the results for the effect of hedging the IR risk with forwards, options and swaps, respectively. Columns 10-13 report our results for the effect of to hedging the CM risk with futures, forwards, options and swaps, respectively. Robust standard errors are in between parentheses. ***, **, and * denote significance at the 1%, 5%, and 10% level, respectively. All variables are defined in Table 1.

	Firm Performance (ROA)												
Variables	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)
Foreign currency hedge	0.015***												
	(0.005)												
Interest rate hedge		-0.016***											
		(0.005)											
Commodity price hedge			-0.007*										
			(0.005)										
<u>Currency derivatives</u>													
Forwards				0.015***									
				(0.005)									
Options					0.014**								
					(0.006)								
Swaps						0.001							
						(0.004)							
<u>Interest rate Derivatives</u>													
Forwards							0.030***						
							(0.010)						
Options								-0.006					
								(0.007)					
Swaps									-0.014***				
									(0.005)				
<u>Commodity derivatives</u>													
Futures										-0.010			
										(0.007)			
Forwards											-0.006		
											(0.005)		
Options												0.002	
												(0.007)	
Swaps													0.001
													(0.005)
<u>Firm Characteristics</u>													
Firm size	-0.001	0.002	0.001	-0.001	0.000	0.000	-0.001	0.000	0.002	0.001	0.001	0.000	0.000
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.002)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
Firm age	-0.004	-0.002	-0.003	-0.004	-0.003	-0.003	-0.003	-0.003	-0.002	-0.003	-0.003	-0.003	-0.003
	(0.003)	(0.003)	(0.004)	(0.003)	(0.004)	(0.004)	(0.004)	(0.003)	(0.003)	(0.004)	(0.004)	(0.004)	(0.004)
Capex/assets	0.128	0.121	0.132	0.129	0.129	0.127	0.128	0.128	0.122	0.128	0.131	0.126	0.127
	(0.093)	(0.092)	(0.093)	(0.093)	(0.093)	(0.093)	(0.093)	(0.093)	(0.092)	(0.093)	(0.094)	(0.094)	(0.093)

Table 5 (continued)

Variables	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)
R&D/assets	-0.090	-0.088	-0.080	-0.092	-0.080	-0.081	-0.079	-0.083	-0.087	-0.080	-0.081	-0.080	-0.080
	(0.084)	(0.085)	(0.085)	(0.084)	(0.085)	(0.085)	(0.085)	(0.086)	(0.085)	(0.085)	(0.085)	(0.085)	(0.085)
Leverage	-0.079***	-0.066***	-0.082***	-0.079***	-0.080***	-0.081***	-0.080***	-0.080***	-0.068***	-0.081***	-0.082***	-0.081***	-0.081***
	(0.020)	(0.020)	(0.020)	(0.020)	(0.020)	(0.020)	(0.020)	(0.020)	(0.020)	(0.020)	(0.020)	(0.020)	(0.020)
Dividend dummy	0.077***	0.081***	0.080***	0.077***	0.079***	0.079***	0.080***	0.079***	0.081***	0.080***	0.079***	0.079***	0.079***
	(0.011)	(0.012)	(0.012)	(0.012)	(0.012)	(0.012)	(0.012)	(0.012)	(0.012)	(0.012)	(0.012)	(0.012)	(0.012)
Constant	0.024	-0.018	-0.004	0.021	0.003	0.003	0.017	0.000	-0.016	-0.003	-0.002	0.002	0.001
	(0.030)	(0.030)	(0.031)	(0.031)	(0.031)	(0.033)	(0.031)	(0.031)	(0.030)	(0.031)	(0.031)	(0.031)	(0.031)
Time effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Industry effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
No. of observations	2200	2200	2200	2200	2200	2200	2200	2200	2200	2200	2200	2200	2200
Adjusted R^2	0.102	0.102	0.100	0.103	0.100	0.099	0.102	0.100	0.102	0.099	0.099	0.099	0.099

Table 6 present the OLS results for firm value. Columns (1) to (3) show that hedging both FX and CM risks are positively associated with value, although only the former is statistically significant, and the hedging the IR risk is negatively associated with value.[35] Columns (4) to (6) show that hedging the FX risk with forwards and swaps is positively and significantly associated with value, whereas hedging FX risk with options is negatively but insignificantly associated with value. Columns (7) to (9) reveal that hedging IR risk with options and swaps is negatively and significantly associated with value, whereas hedging IR with forwards is positively and significantly associated with value. Finally, columns (10) to (13) reveal that hedging CM risk with futures, options or swaps is positively and significantly associated with value whereas hedging CM with forwards is negatively but insignificantly related to value. Combining the results reported in Tables 4 and 5 we conclude that the effect of hedging on value and performance depends on both the risk that is hedged and the derivatives type being used.

[35] Our univariate analysis shows that most of the firms are exposed to the fixed interest rates and use swaps to hedge IR risk.

Table 6

OLS Regressions on Derivatives Use and Firm Value

This table presents the OLS regressions coefficients for Tobin's Q as a proxy for firm value. More specifically, columns 1-3 report the results for the effect of hedging financial risks (FX, IR and CM) on firm value, respectively-ignoring which derivatives are used for hedging; columns 4-6 report the results for the effect of derivatives usage with forwards, options and swaps to hedge FX risks, respectively. Columns 7-9 report the results for the effect of derivatives contracts usage with forwards, options and swaps to hedge IR risks, respectively; columns 10-13 report the results for the effect of derivatives contracts usage with futures, forwards, options and swaps to hedge CM risks, respectively. All variables are defined in Table 1. Robust standard errors are in between parentheses; ***, **, and * denote significance at the 1%, 5%, and 10% level, respectively.

	Firm Value (lnQ)												
Variables	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)
Foreign currency hedge	0.093*** (0.020)												
Interest rate hedge		-0.090*** (0.024)											
Commodity price hedge			0.020 (0.021)										
Currency derivatives													
Forwards				0.109*** (0.019)									
Options					-0.004 (0.030)								
Swaps						0.074*** (0.020)							
Interest Rate Derivatives													
Forwards							0.098** (0.048)						
Options								-0.082*** (0.026)					
Swaps									-0.067*** (0.024)				
Commodity derivatives													
Futures										0.101*** (0.034)			
Forwards											-0.039 (0.027)		
Options												0.121*** (0.035)	
Swaps													0.078*** (0.024)
Firm Characteristics													
Firm size	-0.058*** (0.006)	-0.040*** (0.006)	-0.051*** (0.006)	-0.058*** (0.005)	-0.049*** (0.005)	-0.060*** (0.007)	-0.053*** (0.006)	-0.049*** (0.005)	-0.042*** (0.006)	-0.051*** (0.005)	-0.047*** (0.006)	-0.052*** (0.006)	-0.051*** (0.006)
Firm age	-0.077*** (0.012)	-0.068*** (0.012)	-0.070*** (0.012)	-0.078*** (0.012)	-0.070*** (0.012)	-0.076*** (0.013)	-0.071*** (0.012)	-0.068*** (0.012)	-0.069*** (0.012)	-0.071*** (0.012)	-0.071*** (0.012)	-0.071*** (0.012)	-0.070*** (0.012)

Table 6 (continued)

Variables	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)
Capex/assets	0.824***	0.784***	0.803***	0.834***	0.817***	0.796***	0.820***	0.823***	0.794***	0.809***	0.843***	0.742***	0.784***
	(0.278)	(0.274)	(0.281)	(0.276)	(0.279)	(0.280)	(0.277)	(0.277)	(0.275)	(0.279)	(0.282)	(0.281)	(0.279)
R&D/assets	2.633***	2.651***	2.695***	2.605***	2.695***	2.662***	2.698***	2.661***	2.665***	2.690***	2.693***	2.695***	2.702***
	(0.239)	(0.236)	(0.238)	(0.240)	(0.238)	(0.236)	(0.238)	(0.238)	(0.237)	(0.238)	(0.238)	(0.238)	(0.239)
Leverage	0.037	0.108	0.027	0.039	0.025	0.025	0.028	0.039	0.087	0.028	0.021	0.034	0.026
	(0.081)	(0.077)	(0.083)	(0.081)	(0.083)	(0.082)	(0.082)	(0.082)	(0.078)	(0.083)	(0.083)	(0.083)	(0.083)
Dividend dummy	0.074**	0.098**	0.087**	0.069*	0.088**	0.088**	0.092**	0.084**	0.095**	0.085**	0.087**	0.087**	0.087**
	(0.037)	(0.038)	(0.038)	(0.037)	(0.038)	(0.038)	(0.038)	(0.038)	(0.038)	(0.038)	(0.038)	(0.038)	(0.038)
ROA	1.544***	1.547***	1.566***	1.538***	1.565***	1.564***	1.554***	1.560***	1.552***	1.568***	1.564***	1.564***	1.565***
	(0.535)	(0.533)	(0.539)	(0.533)	(0.538)	(0.537)	(0.536)	(0.536)	(0.535)	(0.538)	(0.537)	(0.538)	(0.538)
Constant	1.342***	1.096***	1.212***	1.348***	1.198***	1.366***	1.253***	1.187***	1.122***	1.232***	1.185***	1.255***	1.232***
	(0.139)	(0.144)	(0.138)	(0.139)	(0.138)	(0.150)	(0.142)	(0.138)	(0.143)	(0.139)	(0.142)	(0.140)	(0.139)
Time effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Industry effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
No. of observations	2200	2200	2200	2200	2200	2200	2200	2200	2200	2200	2200	2200	2200
Adjusted R^2	0.362	0.361	0.356	0.366	0.356	0.36	0.358	0.359	0.359	0.358	0.357	0.358	0.357

3.4.3. Endogeneity of hedging

Our pooled OLS results may suffer from the endogeneity problem. For instance, value and performance can be affected by non-observable factors, i.e., time-invariant firm characteristics that are encompassed in the error term of the regression model (unobserved heterogeneity). Previous literature has shown that hedging decisions are not exogenous to the firms, see, e.g., (Nance *et al.*, 1993; Bonaimé *et al.*, 2014a; Chen and King, 2014). Therefore, we use the instrumental variables technique with a feasible generalized method of moments (IV-GMM) estimator.[36] We employ the following equations to estimate the IV-GMM coefficients: [37]

1st Stage: $$Hderiv_{it} = \alpha_0 + \beta Z'_{it} + \eta_i + \omega_t + \mu_{it} \quad (2)$$

2nd Stage: $$Y_{it} = \lambda_0 + \lambda_1 \widehat{Hderiv}_{it} + \gamma X'_{it} + \eta_i + \omega_t + \varepsilon_{it} \quad (3)$$

where $Hderiv_{it}$ are dummy variables that are endogenous to value and performance, that equal "1" if firm *i* hedges the FX, IR or CM risk, using FU, FO, OP or SW, in year *t*, and "0" otherwise; η_i and ω_t represent the firm and time effects, respectively; μ_{it} and ε_{it} are the regression error terms; α_0 and λ_0 are the constant terms; λ_1, β and γ are the coefficients to be estimated; Z'_{it} is a set of instruments and control variables; and X'_{it} is a vector of a set of

[36] A common feature of IV-GMM is that the method of moments is more efficient under heteroskedasticity. The GMM method can generate efficient parameters under weak distributional assumptions, in which many moment conditions can be added for guaranteed parameters estimation with consistency, see, Wooldridge (2001). IV-GMM is more efficient than IV-2SLS (two stage least squares) in case of heteroscedastic error terms or overidentified models.

[37] IV-GMM specification presents the optimal weighting matrix at the core of method of moments. Baum *et al.* (2003) point out that the standard IVs estimator is a special case of a GMM estimator. The assumption is that the instruments are exogenous as moment restrictions and hence should be strongly related to excluded variables in the reduced-form equation, and not correlated with the error term of the structural equation. Thus, we need to use IVs approach identification strategy to predict the true effects of hedging financial risks, which is potentially endogenous, in terms of using derivative instruments contracts assuming that observed determinants of hedging or derivative use are exogenous.

control variables. For the second stage, Y_{it} represents the value and performance of firm i in year t; $\widehat{Hderiv}$ is the fitted values of the probability of hedging a given type of risk with a given derivatives contract in the first stage, by regressing the $Hderiv$ dummy on the instrumental variables along with the controls. [38]

Table 7 presents the second stage IV-GMM regressions regarding the effect of hedging on performance. We report several statistics for diagnostic tests (i.e., underidentification, weak identification, overidentification and endogeneity). Overall, the test results confirm the validity of the instruments and the relevance and exclusion conditions are satisfied. First, in columns (1), (4), (6), and (8), Wu-Hausman test of endogeneity is significant at 5% level, which indicates that there is endogeneity problem in the regression models and an IV technique is required to instrument for the endogenous hedging-related variables. Second, LM test of underidentification based on Kleibergen-Paap statistics is reported to check whether the regression model is identified and excluded instruments are relevant in the second stage. In all columns, we strongly reject the null hypothesis that the instruments are uncorrelated with the endogenous regressors, which confirms the absence of the underidentification problem.[39] Third, the Cragg-Donald Wald F statistics of the weak identification test suggest that, when compared to the Stock-Yogo statistics, we again strongly reject in all columns the null hypothesis of weak instruments against the alternative that the instruments are strong, i.e., the excluded instruments are correlated with the

[38] We follow the literature to decide on the instrumental variables that are likely to be associated with the determinants of hedging financial risks: (i) *Foreign Sales Ratio*, *Foreign Expenditure* and *Geographic Diversification* for FX risk hedging (see, e.g., Allayannis *et al.* (2012)) (ii) *Floating Rate Debt* and *Fixed Rate Debt* for IR risk hedging (see, Faulkender (2005)). All variables are defined in Table 1. The (unreported) first-stage results confirm that the instruments used are strong predictors of whether firms are likely to hedge.

[39] Instead of the Anderson LM and Cragg-Donald Wald F statistics, we use the Kleibergen-Paap rank LM and rank Wald F statistics developed recently by Kleibergen and Paap (2006) using the robust GMM estimates, which is a helpful tool to provide a statistical test that can address the diagnostic considerations of heteroscedastic or autocorrelated disturbances in the event of weak instruments. The Stock and Yogo test measures how strong the identification is in our sample if errors are not assumed to be independently and identically distributed.

endogenous regressors. Forth, Hansen's J statistic in the overidentification test is used to test the validity of all instruments. In most columns in Table 7, we do not reject the null hypothesis about the validity of instruments, i.e., the overidentification restrictions are accepted, the instruments are jointly valid and are uncorrelated with the error term. Only in columns (7), (12) and (13) are the *p*-values for Hansen less than 10% but still at acceptable levels.

Overall, the robust IV-GMM estimations in Table 7 suggest that the hedging financial FX risks has a significantly positive impact on firm performance. However, hedging IR financial risk has negative and statistically significant effects on performance. We do not find strong evidence, however, that hedging CM risk could enhance the outcome of firm performance. More importantly, as being the key aspect of this study, the findings suggest that *the link between performance and hedging varies across different derivatives even for the same risk type*. To be more specific, we find strong evidence that some derivatives such forwards and swaps for hedging FX have statistically significant and positive impact on performance, while options and swaps in hedging IR risk are associated with performance significantly but inversely. Other derivatives do not show any significant impact on performance. As a deduction based on the findings in Table 7, it seems that risk management departments of the corporations should be cautious when it comes to decide which contracts to employ for which financial risk.

Table 7

Instrumental Variables Regressions on Hedging Financial Risks and Impact on Firm Performance

This table presents (IV-GMM) estimates on the impact of derivatives use for hedging financial risks (FX, IR and CM) and contracts (futures, forwards, options and swaps) on firm performance based on ROA as a proxy. We run regressions based on another performance measure (i.e., return on invested capital, ROIC) and the results are qualitatively that same (we do not report them to conserve space). The fitted values of hedging-related variables from the first stage regressions are used to run IV-GMM regressions in the second stage which examines the impact of derivatives use on firm performance (ROA). Columns 1-3 report the results for the overall effect of hedging financial risks (FX, IR and CM) on ROA, respectively; columns 4-6 report the results for the effect of derivative contracts usage with forwards, options and swaps to hedge FX risks, respectively. Columns 7-9 report the results for the effect of derivatives usage with forwards, options and swaps to hedge IR risks, respectively; columns 10-13 report the results for the effect of derivatives usage with futures, forwards, options and swaps to hedge CM risks, respectively. Robust standard errors are in the parentheses; ***, **, and * denote significance at the 1%, 5%, and 10% level, respectively. All variables are defined in Table 1.

	Performance (ROA)												
Variables	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)
Foreign currency hedge	0.043***												
	(0.012)												
Interest rate hedge		-0.047**											
		(0.022)											
Commodity price hedge			-0.009										
			(0.007)										
<u>Currency derivatives</u>													
Forwards				0.040***									
				(0.011)									
Options					0.073								
					(0.076)								
Swaps						0.081**							
						(0.036)							
<u>Interest rate derivatives</u>													
Forwards							0.005						
							(0.028)						
Options								-0.092**					
								(0.043)					
Swaps									-0.048**				
									(0.022)				
<u>Commodity derivatives</u>													
Futures										-0.026			
										(0.021)			
Forwards											-0.021		
											(0.014)		
Options												0.013	
												(0.042)	
Swaps													0.001
													(0.033)
<u>Firm Characteristics</u>													
Firm size	-0.003*	0.005**	0.001	(0.003)	0.000	-0.011**	0.000	0.001	0.005**	0.001	0.002	0.000	0.001
	(0.002)	(0.002)	(0.001)	(0.002)	(0.002)	(0.005)	(0.002)	(0.001)	(0.002)	(0.001)	(0.002)	(0.002)	(0.002)
Firm age	-0.003	0.001	-0.002	-0.004	-0.003	-0.009*	0.001	0.001	0.001	-0.003	-0.003	0.001	0.001
	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)	(0.005)	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)

Table 7 (continued)

Variables	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)
Capex/assets	0.064	0.002	0.093	0.077	0.133	0.085	(0.020)	0.083	0.007	0.134	0.139	(0.020)	0.011
	(0.059)	(0.061)	(0.070)	(0.069)	(0.097)	(0.071)	(0.064)	(0.073)	(0.060)	(0.093)	(0.092)	(0.073)	(0.066)
R&D/assets	-0.050	-0.051	-0.064	-0.061	-0.085	-0.106	0.007	-0.091	-0.057	-0.086	-0.079	0.011	0.008
	(0.073)	(0.080)	(0.079)	(0.076)	(0.083)	(0.089)	(0.075)	(0.088)	(0.079)	(0.084)	(0.081)	(0.074)	(0.076)
Leverage	-0.064***	-0.019	-0.077***	-0.067***	-0.075***	-0.077***	-0.054***	-0.055***	-0.019	-0.084***	-0.083***	-0.053***	-0.058***
	(0.015)	(0.024)	(0.018)	(0.017)	(0.019)	(0.017)	(0.016)	(0.015)	(0.024)	(0.020)	(0.020)	(0.016)	(0.016)
Dividend dummy	0.081***	0.096***	0.085***	0.079***	0.078***	0.082***	0.098***	0.081***	0.096***	0.080***	0.079***	0.097***	0.095***
	(0.008)	(0.008)	(0.010)	(0.010)	(0.013)	(0.010)	(0.008)	(0.011)	(0.008)	(0.011)	(0.011)	(0.008)	(0.008)
Constant	0.055	-0.061*	-0.013	0.047	0.010	0.184**	-0.014	-0.017	-0.063*	-0.007	-0.007	-0.009	-0.018
	(0.036)	(0.036)	(0.030)	(0.036)	(0.034)	(0.093)	(0.034)	(0.030)	(0.037)	(0.031)	(0.031)	(0.036)	(0.033)
Time effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Industry effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
No. of observations	2200	2200	2200	2200	2200	2200	2200	2200	2200	2200	2200	2200	2200
F-Statistic	14.490	15.580	15.290	14.180	13.580	13.840	14.700	12.550	15.530	15.290	15.140	14.840	14.680
Adjusted R^2	0.089	0.085	0.099	0.091	0.080	0.019	0.088	0.041	0.083	0.099	0.098	0.088	0.091
LM statistic (p-value)	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Wald F statistic	72.489	57.597	114.009	106.683	47.948	27.053	10.963	28.200	40.036	45.949	65.430	6.123	10.518
Stock-Yogo test	26.870	22.300	24.580	24.580	19.930	9.080	9.080	9.080	24.580	19.930	19.930	5.390	9.080
Hansen J statistic (p-value)	0.371	0.294	0.728	0.271	0.727	0.937	0.086	0.579	0.441	0.433	0.932	0.090	0.054
Wu-Hausman test (p-value)	0.021	0.112	0.751	0.022	0.436	0.017	0.427	0.035	0.107	0.449	0.275	0.855	0.992

Table 8 presents the second stage IV-GMM regressions- with the diagnostic tests satisfied- regarding the effect of hedging on value. Overall, the results reveal that hedging against commodity price risk or currency risk enhances value but the opposite can be said when firms hedge against the interest rate risk. What is more, again, the findings suggest that *the link between value and hedging varies across different derivatives even for the same risk type*. For instance, the use of forward or swap (option) contracts for the FX risk increases (decreases) firm value. On the other hand, when swaps or options are used to manage IR risk, one can see a reduction in firm value but for forwards the association is direct. For the CM risk, there is less heterogeneity as it is only for the forward contracts when we cannot detect a significant link between value and hedging activities; otherwise, the relationship is significant and positive for other contracts.

Another important feature of our analysis is that, when the IV and OLS results are compared, the endogeneity-adjusted coefficient estimates on hedging related variables reveal a discernible increase in magnitude.

Table 8

Instrumental Variables Regressions on Hedging Financial Risks and Impact on Firm Value

This table presents (IV-GMM) estimates on the impact of derivatives use for hedging financial risks (FX, IR and CM) and contracts (futures, forwards, options and swaps) on firm value based on Tobin's Q (ln) as a proxy. The fitted values from the first stage regressions are used in running regressions of (IV-GMM) in the second stage which examines the impact of derivatives use on firm value (lnQ). Columns 1-3 report the results for the overall effect of hedging financial risks (FX, IR and CM) on lnQ, respectively; columns 4-6 report the results for the effect of derivatives usage with forwards, options and swaps to hedge FX risks, respectively. Columns 7-9 report the results for the effect of derivatives usage with forwards, options and swaps to hedge IR risks, respectively; columns 10-13 report the results for the effect of derivatives usage with futures, forwards, options and swaps to hedge CM risks, respectively. Robust standard errors are in between parentheses; ***, **, and * denote significance at the 1%, 5%, and 10% level, respectively. All variables are defined in Table 1.

	Firm Value (lnQ)												
Variables	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)
Foreign exchange hedge	0.449***												
	(0.059)												
Interest rate hedge		-0.099*											
		(0.053)											
Commodity price hedge			0.495***										
			(0.161)										
Currency derivatives													
Forwards				0.414***									
				(0.052)									
Options					-0.844**								
					(0.330)								
Swaps						0.595***							
						(0.089)							
Interest rate derivatives													
Forwards							0.443***						
							(0.153)						
Options								-0.436*					
								(0.258)					
Swaps									-0.098*				
									(0.055)				
Commodity derivatives													
Futures										0.451***			
										(0.155)			
Forwards											-0.080		
											(0.079)		
Options												0.244***	
												(0.059)	
Swaps													0.398**
													(0.167)
Firm Characteristics													
Firm size	-0.090***	-0.039***	-0.086***	-0.082***	-0.040***	-0.134***	-0.067***	-0.047***	-0.039***	-0.058***	-0.045***	-0.056***	-0.060***
	(0.008)	(0.007)	(0.014)	(0.007)	(0.007)	(0.014)	(0.008)	(0.006)	(0.008)	(0.006)	(0.007)	(0.006)	(0.007)
Firm age	-0.102***	-0.067***	-0.063***	-0.100***	-0.076***	-0.119***	-0.075***	-0.058***	-0.067***	-0.073***	-0.069***	-0.075***	-0.065***
	(0.014)	(0.012)	(0.013)	(0.014)	(0.013)	(0.016)	(0.012)	(0.014)	(0.012)	(0.012)	(0.012)	(0.012)	(0.012)

Table 8 (continued)

Variables	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)
Capex/assets	0.944***	0.777***	0.607**	0.967***	0.860***	0.689**	0.792***	0.849***	0.769***	0.864***	0.760***	0.740***	0.586**
	(0.282)	(0.255)	(0.297)	(0.274)	(0.283)	(0.293)	(0.253)	(0.262)	(0.270)	(0.267)	(0.281)	(0.280)	(0.278)
R&D/assets	2.325***	2.658***	2.660***	2.285***	2.613***	2.414***	2.763***	2.511***	2.663***	2.660***	2.755***	2.630***	2.792***
	(0.258)	(0.236)	(0.240)	(0.256)	(0.249)	(0.229)	(0.236)	(0.266)	(0.237)	(0.236)	(0.233)	(0.236)	(0.241)
Leverage	0.052	0.121	0.037	0.052	-0.086	0.019	0.062	0.098	0.122	0.019	0.054	0.017	0.055
	(0.075)	(0.081)	(0.083)	(0.076)	(0.088)	(0.081)	(0.077)	(0.082)	(0.081)	(0.081)	(0.081)	(0.082)	(0.078)
Dividend dummy	0.026	0.098***	0.087**	0.021	0.116***	0.093**	0.096***	0.069*	0.095**	0.082**	0.070*	0.089**	0.070*
	(0.037)	(0.038)	(0.038)	(0.037)	(0.041)	(0.040)	(0.036)	(0.037)	(0.039)	(0.037)	(0.036)	(0.038)	(0.036)
ROA	1.310**	1.580***	1.344**	1.312**	1.381***	1.487***	1.692***	1.535***	1.600***	1.429***	1.862***	1.440***	1.814***
	(0.519)	(0.489)	(0.522)	(0.511)	(0.525)	(0.514)	(0.467)	(0.491)	(0.527)	(0.517)	(0.502)	(0.532)	(0.485)
Constant	1.904***	1.081***	1.510***	1.775***	1.074***	2.542***	1.433***	1.137***	1.083***	1.337***	1.167***	1.324***	1.356***
	(0.174)	(0.152)	(0.158)	(0.162)	(0.148)	(0.255)	(0.162)	(0.140)	(0.154)	(0.145)	(0.145)	(0.142)	(0.151)
Time effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Industry effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
No. of observations	2200	2200	2200	2200	2200	2200	2200	2200	2200	2200	2200	2200	2200
F-Statistic	38.090	45.140	41.110	42.090	34.740	40.120	42.920	41.500	44.940	43.330	44.080	44.530	43.560
Adjusted R^2	0.270	0.361	0.268	0.290	0.144	0.184	0.336	0.308	0.358	0.341	0.352	0.355	0.334
LM statistic (p-value)	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Wald F statistic	156.233	152.353	15.798	199.238	6.013	111.975	12.146	20.774	202.450	19.190	59.705	36.359	14.283
Stock-Yogo test	19.930	22.300	19.930	19.930	5.390	19.930	9.080	19.930	19.930	11.590	19.930	9.080	9.080
Hansen J statistic (p-value)	0.057	0.724	0.102	0.107	0.123	0.609	0.143	0.976	0.457	0.301	0.101	0.098	0.050
Wu-Hausman test (p-value)	0.000	0.834	0.013	0.000	0.011	0.609	0.031	0.149	0.506	0.021	0.560	0.019	0.052

3.4.4. Self-selection bias

The prior analyses suggest that the effects of hedging FX, IR and CM risks with the use of financial derivatives on firm performance and value have mixed results. However, control variables such as firm size, capital structure, and geographic diversification are mainly selected in the presence of firms' categories that have been observed to implement corporate hedging strategy to mitigate financial risks. The effect of hedging financial risks on performance and value can come from other exclusion relative restrictions. For example, although some firms have potential financial risk exposures they may not do hedging; it is plausible that hedgers or nonhedgers treat differently the value of corporate hedging. Therefore, an econometric concern arises when the dependent variable and explanatory variables appear related although the source of relationship is not the exogenous causality but self-selection bias, i.e., in essence they are not related. For example, it is possible that firms with high financial performance are likely to employ hedging strategies in order to keep their financial performance, which implies that the sampling is non-random and there is a potential simultaneity problem. To consider these issues, we utilize the treatment effects (TE) method that can address potential self-selection bias.[40] Therefore, we estimate the TE model for firm performance and value using the following setting.[41]

$$Y_{it} = \beta_0 + \beta_1 Hderiv_{it} + \theta X'_{it} + \varepsilon_{it} \qquad (1)$$

$$Hderiv^*_{it} = \alpha_0 + \alpha_{it} Z'_{it} + \phi_{it} \qquad (4')$$

[40] This method employs two simultaneous equations using full information maximum likelihood estimation: i) probit treatment equation that predicts the probability of hedging financial risks and also derivatives instruments use determined by a set of variables; ii) outcome equations for performance and value (ROA and lnQ) as a function of the fitted values of the treated variables for hedging risks overall (FX, IR and CM) and also derivative contracts (futures, forwards, options and swaps) utilized for each specific risk, among other factors. The variables for the treatment equations are mentioned in notes to table 7 and 8 for firm performance and value regression models, which are in line with the extant literature.

[41] Heckman and Vytlacil (2005) show that the structural approach in treatment effects model can control for self-selection bias if a potential outcome (Y_{it}) is not under the exogenous assumption of treated variable effects, suggesting that included and excluded variables could lead to estimation bias.

where the observable decision (i.e., presence of hedging) denoted by $Hderiv_{it}$ is equal to one if the non-observable latent variable $Hderiv^{*}_{it} > 0$ and zero, otherwise; α_0 is the constant term and α_i are the estimable parameters for the variables represented by the vector Z. We assume that the error terms ϕ_{it} and ε_{it} have a normal bivariate distribution[42] with mean zero and constant covariance matrix, and their correlation is quantified by ρ (rho).

Table 9 presents the results for treatment effects (TE) regressions for firm performance. As reported by the OLS and IV-GMM results, the coefficient for hedging FX risk in column 1 is again positive and statistically significant, which is consistent with the previous studies too. On the other hand, the coefficients for hedging IR and CM risks are negative but insignificant in columns 2 and 3, respectively; which is consistent with our OLS and IV-GMM findings in terms of signs but not of significance levels. The endogeneity-adjusted IV analysis confirms the OLS analysis regarding the effect of overall interest rate hedging on performance but once the results are corrected for the sample-selection bias, the coefficient turns out to be insignificant. For the commodity price hedging, the results are significant only under the OLS specification.

The TE findings in Table 9 further show that hedging FX risk with forward and swap contracts are significantly and positively related to performance, confirming the IV results in Table 6; however, they are not in line with the OLS results regarding the options and swaps. These findings again suggest the importance of addressing the endogeneity or sample-selection bias problems. Regarding the effect of IR risk on performance, the TE and OLS results are the same for all contract types in terms of the sign and significance of coefficients. When comparing the TE and IV results for performance, although the signs do not change the significance levels do; in this case, whether the TE or IV results would be relied upon

[42] It should be noted that the IV specification does not have this assumption but it assumes something else, i.e., the instrumental variables are uncorrelated with the error term.

depends on if a researcher believes endogeneity is more relevant than selection bias, or vice-versa. As for the different contract types to hedge the CM risk, the OLS, IV and TE analyses have a clear consensus as far as the coefficients' significance levels and signs are concerned: hedging CM risk and performance are not correlated.

Table 9

Treatment Effects Regressions Regarding the Impact of Hedging Financial Risks on Firm Performance

This table presents treatment effects estimates for the outcome model regarding the impact of derivatives use for hedging financial risks (FX, IR and CM) and contracts (futures, forwards, options and swaps) on performance based on (ROA) as a proxy. We do not report treatment equation for each model in these regressions. In the treatment equation, we use instrumental and control variables to predict the fitted value of the treated variable. In column (1) FX hedge is regressed on foreign sales ratios, foreign expenditures and geographic diversification and other firm characteristics; in column (2) IR hedge is regressed on floating and fixed interest rates for debt and other firms characteristics; in column (3) CM hedge is regressed on commodity purchase and commodity oil and gas and other firm characteristics; columns 4-6 treated FX derivatives (forwards, options and swaps) based on the same variables used in hedging FX, columns 7- 9 treated IR derivatives contracts (forwards, options and swaps) based on the same variables that have used in hedging IR risk, and columns 10-13 treated CM contracts (futures, forwards, options and swaps) based on the same variables that were used in hedging CM. Likelihood ratio (LR) test reports diagnostic statistics for the null hypothesis that the correlation between the error terms of the treatment and outcome models is zero; i.e., examining whether each model is fitted and estimated coefficients are not biased. We control for time and industry fixed effects. All variables are defined in Table 1. Robust standard errors are reported in the parentheses below each coefficient estimate. ***, **, and * denote significance at the 1%, 5%, and 10% level, respectively.

	Performance (ROA)												
Variables	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)
Foreign exchange hedge	0.025***												
	(0.008)												
Interest rate hedge		-0.019											
		(0.012)											
Commodity price hedge			-0.004										
			(0.014)										
<u>Currency derivatives</u>													
Forwards				0.025***									
				(0.008)									
Options					0.022								
					(0.017)								
Swaps						0.023*							
						(0.012)							
<u>Interest rate derivatives</u>													
Forwards							0.043**						
							(0.020)						
Options								-0.002					
								(0.016)					
Swaps									-0.019				
									(0.014)				
<u>Commodity derivatives</u>													
Futures										-0.002			
										(0.022)			
Forwards											-0.002		
											(0.020)		
Options												0.010	
												(0.022)	
Swaps													0.018
													(0.017)

Table 9 (continued)

Variables	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)
Firm Characteristics													
Firm size	-0.002	0.002	0.001	-0.001	0.000	-0.003	-0.001	0.000	0.002	0.001	0.001	0.000	0.000
	(0.002)	(0.002)	(0.002)	(0.002)	(0.001)	(0.002)	(0.002)	(0.001)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)
Firm age	-0.004	-0.002	-0.003	-0.004	-0.003	-0.005	-0.003	-0.003	-0.002	-0.003	-0.003	-0.003	-0.003
	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)
Capex/assets	0.130**	0.120**	0.133**	0.131**	0.129**	0.130**	0.127**	0.128**	0.121**	0.127**	0.128**	0.125**	0.125**
	(0.052)	(0.053)	(0.053)	(0.052)	(0.053)	(0.053)	(0.052)	(0.053)	(0.053)	(0.053)	(0.055)	(0.053)	(0.053)
R&D/assets	-0.097**	-0.089*	-0.079*	-0.090*	-0.080*	-0.087*	-0.079*	-0.083*	-0.089*	-0.079*	-0.081*	-0.080*	-0.080*
	(0.046)	(0.046)	(0.046)	(0.046)	(0.046)	(0.046)	(0.046)	(0.046)	(0.046)	(0.046)	(0.046)	(0.046)	(0.046)
Leverage	-0.077***	-0.065***	-0.082***	-0.080***	-0.080***	-0.081***	-0.080***	-0.080***	-0.066***	-0.081***	-0.082***	-0.081***	-0.081***
	(0.014)	(0.015)	(0.014)	(0.014)	(0.014)	(0.014)	(0.014)	(0.014)	(0.015)	(0.014)	(0.014)	(0.014)	(0.014)
Dividend dummy	0.077***	0.081***	0.080***	0.077***	0.079***	0.080***	0.080***	0.079***	0.081***	0.080***	0.079***	0.079***	0.079***
	(0.007)	(0.007)	(0.007)	(0.007)	(0.007)	(0.007)	(0.007)	(0.007)	(0.007)	(0.007)	(0.007)	(0.007)	(0.007)
Constant	0.029	-0.017	-0.004	0.013	0.002	0.039	0.018	-0.001	-0.015	-0.003	-0.003	0.000	0.001
	(0.036)	(0.035)	(0.035)	(0.035)	(0.034)	(0.041)	(0.035)	(0.034)	(0.035)	(0.035)	(0.035)	(0.035)	(0.035)
Time effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Industry effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
No. of observations	2200	2200	2200	2200	2200	2200	2200	2200	2200	2200	2200	2200	2200
Wald $\chi2$	272.440	268.370	267.500	269.480	267.160	270.890	272.020	265.940	265.480	267.750	267.570	267.070	268.440
Prob > $\chi2$	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Log likelihood	759.858	621.041	1157.436	570.128	1239.364	807.708	1398.235	1054.052	618.954	1559.017	1277.241	1506.997	1413.194
LR test statistics, $\chi2$ (p-value)	0.119	0.749	0.834	0.126	0.687	0.164	0.627	0.773	0.709	0.767	0.853	0.755	0.441

Table 10 presents the TE results for firm value. The OLS, IV and TE specifications have another clear consensus: the effect of overall FX (IR) hedging on value is significant and positive (negative). However, for the overall effect of CM hedging, the OLS and TE methods suggest that the concerned association is positive but statistically insignificant whereas the IV technique generates a positive and significant coefficient.[43]

The results provide different patterns when Table 10 is examined according to the effect of various financial hedging instruments. The TE and IV results are qualitatively the same as both methods suggest that using forwards or swaps (options) enhances (reduces) value when they are used for FX hedging; the OLS results too reveal a similar pattern. What is more convincing is that the OLS, IV and TE methods all suggest that if the UK quoted companies use forwards (options or swaps) to hedge the IR risks this decision increases (decreases) significantly their firm value. Furthermore, the OLS and IV results are confirmed by the TE results with respect to the positive and significant effect of various contracts used to hedge the CM risk, other than the effect of the forwards which has a negative and significant link with firm value when the sample selection bias is accounted for in Table 10 (column 11).

In sum, the results suggest that not all derivatives types would enhance value or improve performance. Moreover, whether financial risk management via derivatives generates value and good performance seems to depend on the type of the risk that is being managed. It maybe that some derivatives for hedging FX, IR or CM risk exposures are preferable to over-the-counter (OTC) in derivatives markets. The regression analyses also show that, although not in all cases, not controlling for endogeneity or sample-selection bias would yield misleading results.

[43] For the TE setting, the null hypothesis in the likelihood ratio test statistics (LR) is that the correlation between the error terms of the outcome model and treatment model is zero (i.e., Ho: ρ=0). In Table 8, the results show that there is no significant self-section bias although the models 1 and 4 have *p*-values that are very close to 10%. However, except in a few models in Table 9, we strongly reject this hypothesis, suggesting that self-selection bias is indeed a significant issue to be addressed.

Table 10

Treatment Effects Regressions Regarding the Impact of Hedging Financial Risks on Firm Value

This table presents treatment effects estimates for the outcome model regarding the impact of derivatives use for hedging financial risks (FX, IR and CM) and contracts (futures, forwards, options and swaps) on firm value based on Tobin's Q (ln) as a proxy. We do not report treatment equation for each model in these regressions. In the treatment equation, we use instrumental and control variables to predict the fitted value of the treated variable. In column (1) FX hedge is regressed on foreign sales ratios, foreign expenditures and geographic diversification and other firm characteristics; in column (2) IR hedge is regressed on floating and fixed interest rates for debt and other firms characteristics; in column (3) CM hedge is regressed on commodity purchase and commodity oil and gas and other firm characteristics; columns 4-6 treated FX derivatives (forwards, options and swaps) based on the same variables used in hedging FX, columns 7- 9 treated IR derivatives contracts (forwards, options and swaps) based on the same variables that have used in hedging IR risk, and columns 10-13 treated CM contracts (futures, forwards, options and swaps) based on the same variables that were used in hedging CM. Likelihood ratio (LR) test reports diagnostic statistics for the null hypothesis that the correlation between the error terms of the treatment and outcome models is zero; i.e., examining whether each model is fitted and estimated coefficients are not biased. We control for time and industry fixed effects. All variables are defined in Table 1. Robust standard errors are reported in the parentheses below each coefficient estimate. ***, **, and * denote significance at the 1%, 5%, and 10% level, respectively.

	Firm Value (lnQ)												
Variables	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)
Foreign exchange hedge	0.156***												
	(0.040)												
Interest rate hedge		-0.130***											
		(0.033)											
Commodity price hedge			0.003										
			(0.062)										
Currency derivatives													
Forwards				0.188***									
				(0.058)									
Options					-0.166*								
					(0.096)								
Swaps						0.393***							
						(0.083)							
Interest rate derivatives													
Forwards							0.564***						
							(0.075)						
Options								-0.280***					
								(0.083)					
Swaps									-0.090***				
									(0.034)				
Commodity derivatives													
Futures										0.624***			
										(0.054)			
Forwards											-0.255***		
											(0.069)		
Options												0.650***	
												(0.056)	
Swaps													0.565***
													(0.048)

Table 10 (continued)

Variables	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)
Firm Characteristics													
Firm size	-0.062***	-0.040***	-0.050***	-0.060***	-0.049***	-0.072***	-0.054***	-0.046***	-0.042***	-0.054***	-0.044***	-0.056***	-0.055***
	(0.006)	(0.006)	(0.006)	(0.006)	(0.005)	(0.007)	(0.006)	(0.006)	(0.006)	(0.005)	(0.006)	(0.005)	(0.005)
Firm age	-0.082***	-0.064***	-0.070***	-0.078***	-0.070***	-0.072***	-0.070***	-0.067***	-0.067***	-0.062***	-0.068***	-0.062***	-0.064***
	(0.011)	(0.011)	(0.011)	(0.011)	(0.011)	(0.011)	(0.011)	(0.011)	(0.011)	(0.011)	(0.011)	(0.011)	(0.011)
Capex/assets	0.866***	0.789***	0.804***	0.855***	0.825***	0.787***	0.822***	0.808***	0.795***	0.677***	0.828***	0.642***	0.714***
	(0.195)	(0.194)	(0.195)	(0.193)	(0.195)	(0.193)	(0.193)	(0.194)	(0.194)	(0.193)	(0.196)	(0.193)	(0.192)
R&D/assets	2.581***	2.621***	2.690***	2.599***	2.689***	2.706***	2.674***	2.636***	2.652***	2.758***	2.679***	2.771***	2.777***
	(0.172)	(0.171)	(0.171)	(0.169)	(0.170)	(0.171)	(0.168)	(0.171)	(0.171)	(0.170)	(0.171)	(0.170)	(0.170)
Leverage	0.041	0.125**	0.029	0.025	0.025	-0.019	0.039	0.044	0.096*	0.052	0.035	0.059	0.053
	(0.052)	(0.057)	(0.053)	(0.053)	(0.052)	(0.052)	(0.052)	(0.052)	(0.057)	(0.053)	(0.052)	(0.053)	(0.052)
Dividend dummy	0.073***	0.099***	0.087***	0.070***	0.087***	0.082***	0.094***	0.084***	0.095***	0.079***	0.090***	0.086***	0.084***
	(0.025)	(0.025)	(0.025)	(0.025)	(0.025)	(0.025)	(0.025)	(0.025)	(0.026)	(0.025)	(0.026)	(0.025)	(0.025)
ROA	1.543***	1.549***	1.566***	1.538***	1.559***	1.623***	1.605***	1.548***	1.553***	1.577***	1.539***	1.567***	1.573***
	(0.079)	(0.079)	(0.079)	(0.078)	(0.079)	(0.084)	(0.081)	(0.079)	(0.079)	(0.080)	(0.080)	(0.080)	(0.080)
Constant	1.362***	1.094***	1.217***	1.330***	1.203***	1.415***	1.222***	1.169***	1.118***	1.188***	1.115***	1.172***	1.172***
	(0.131)	(0.129)	(0.129)	(0.129)	(0.127)	(0.134)	(0.129)	(0.127)	(0.129)	(0.121)	(0.128)	(0.121)	(0.122)
Time effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Industry effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
No. of observations	2200	2200	2200	2200	2200	2200	2200	2200	2200	2200	2200	2200	2200
Wald $\chi2$	1265.930	1230.200	1254.040	1276.650	1254.690	1282.820	1299.080	1290.570	1211.300	1398.550	1293.650	1385.640	1380.930
Prob > $\chi2$	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Log likelihood	-2046.562	-1990.524	-1475.816	-2345.767	-1661.551	-2222.140	-1474.888	-1772.354	-2062.907	-1243.942	-1549.908	-1295.914	-1351.894
LR test statistics, $\chi2$ (p-value)	0.064	0.102	0.760	0.112	0.203	0.050	0.001	0.071	0.369	0.000	0.021	0.000	0.000

3.4.5. Matching

In this section, related to the sample selection bias caused by non-randomness in deciding to use financial hedging instruments, we employ the PSM approach for further robustness. The section first provides the details of the relevant estimation method before discussing the estimation results.

3.4.5.1. Propensity Score Matching (PSM) Method

Following Rosenbaum and Rubin (1983) and Heckman *et al.* (1997), our Eq. (5) implies that estimating the conditional probability (i.e., propensity) of using derivatives is given by the function of $e(x) = pr(z = 1|x)$.

$$pr(z_1, \dots, z_n | x_1, \dots, x_n) = \prod_{i=1}^{N} e(x_i)^{z_i} [1 - e(x_i)]^{1-z_i} \qquad (5)$$

where $e(x)$ is the propensity score; z_i is 1 if the firm is treated (i.e., used hedging) and 0, if untreated; x are the observed covariates based on the pre-treatment firm-specific characteristics that are likely to influence hedging decisions.

It is not possible to compare and match two firms that are internally identical other than having different preferences for hedging and under identical external conditions. Given this challenge, the main advantage of using the PSM setting is that it finds firms that are *similar* (not identical) except their choice for resorting to derivatives to hedge financial risk by calculating the non-hedgers' expected probability of using derivatives (i.e., instead of true propensity, the estimated propensity is used). Then, the matching is executed based on the highest similarity scores. PSM calculates the average difference between users vs. non-users of derivatives based on the matched sample's scores; the average estimation on the treatment model is the difference between the two counterfactual situations. In other terms, the observed difference in firm value or performance across all pairs can be considered as the robust estimate of the impact of derivatives use. The PSM method first constructs a logit or probit model for the determinants of hedging financial risks and then predicts the outcome of performance and firm value with regards to derivatives effects.[44] The use of the PSM method has been increasing in the related hedging literature (see e.g., Bartram *et al*. (2011); Chen and King (2014)).

Given the complexity of matching on covariates as discussed by (Imbens, 2015) , the matching estimator we run is consistent under the generalized assumptions of the PSM method in order to estimate the average treatments effects of hedging financial risks for finite samples. Various specifications in the PSM approach (e.g., regression adjustment with or without inverse-probability weighting and nearest-neighbor matching) have recently been introduced to reduce bias in observational studies.

In our analysis, the functional options of the PSM procedure are based on the nearest-neighbor estimators for fixed numbers of matches for each observation when the samples of each type of risks and its related derivatives use are small (i.e., especially our commodity price risk sub-sample) (Busso *et al.*, 2014). Motivated by the suggestions of (Abadie and Imbens, 2006, 2011, 2012), we adopt in this study the PSM approach based on *Abadie-Imbens standard errors* (*AI std*) in predicting treatment assignment in the treatment model. We use this approach with its enhanced features with the conditioning that the propensity score is a balancing score (Rosenbaum and Rubin, 1983) to eliminate a potential bias in the inferences. The Abadie-Imbens specification minimizes the Mahalanobis distance between the vector of observed covariates for non-hedgers and hedgers: as the controls can be used more than once (i.e., multi matching with all tied observations) the estimation bias is reduced

[44] In the Heckman model that addresses the sample selection bias the researcher can differentiate between the factors affecting the outcome (in our case value or performance) and treatment (i.e., hedging decision). This may cause some concerns including the multicollinearity among the determining factors. However, the advantage of the PSM method is that it does not require such a differentiation.

via a bias-correction component, compared to the matching without replacement. Abadie and Imbens produce robust standard errors to control for potential bias correction in the estimation that have advantages over weighting matching and bootstrap estimators.

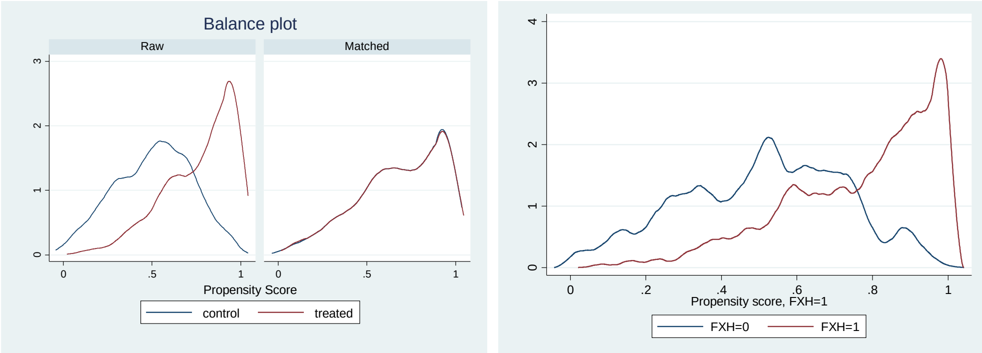
In order to ensure the validity of the PSM results, two formal tests should be passed. The first one is called Common Support Condition (CSC) *aka* Overlap Test. The CSC examines the condition for each covariate that the probability of treating or not treating the observation is between zero and one, i.e., the treated observations are on support. There may be observations for which no match can be found within the specified caliper distance. Our PSM procedure with the nearest-neighbor matching approach drops such observations from the analysis and considers only the remaining sub-sample. The second test is called Balancing Test (BT) or Independence Assumption which examines the difference in the means of the covariates between the control and treated groups to confirm that the matching procedure has eliminated significant differences across the groups. Our PSM results in this study are robust to these tests as shown in Figures A1 and A2.[45, 46]

[45] In this study, estimating the effects of hedging FX and IR on value and performance in PSM method is based on a *probit* treatment model with Stata 14®'s "*teffects psmatch*" command and the default option *nneighbor(1)* that specifies the number of matches per observation. However, in estimating the effects of hedging CM risk overall and its related derivatives, we increase the fixed number of matches to *nneighbor (5;10;20)* in robustness checks when the PSM specification is violated by covariate imbalances. Using a fixed number for the nearest-neighbor approach is robust to more efficient matching estimators until the balance and overlap assumptions are settled down.

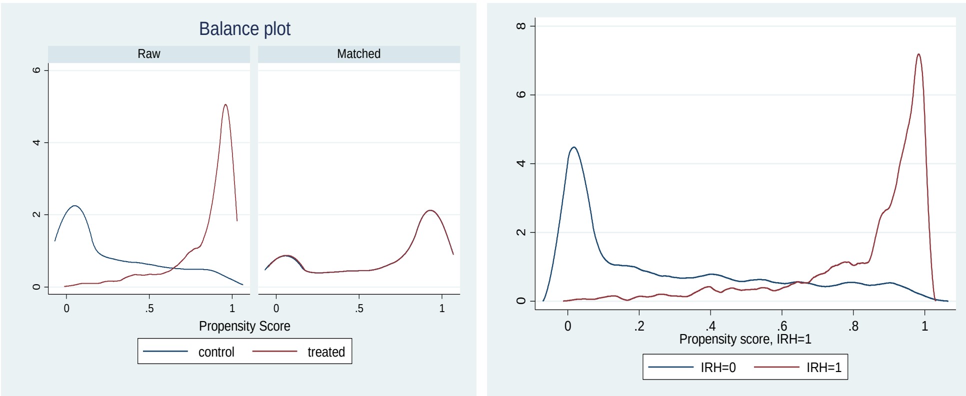
[46] We did not need to manually set any further scalar options like "*caliper*" with "*nneighbor"* to specify the maximum distance for which two observations are potential neighbors. We used "*caliper*" matching with "*pstolerance*" option only when examining the effect of FX on performance using options to satisfy the balance test. Moreover, we kept the default bandwidth in the estimator in the levels of significance given that using the bandwidth is a common choice in empirical applications (e.g., Busso *et al.* (2014)). Such an adjustment with "*nneighbor*" is important for the scalar propensity score to be sufficient to remove or eliminate bias, especially in small observations in a finite sample (Rosenbaum and Rubin, 1983). Matching estimators require a good overlap that asserts that the propensity score is strictly between 0 and 1 for a vector of covariates (Busso *et al.*, 2014). Therefore, we further used a scalar option "*pstolerance"*, using the default value of *1e-5 or value of 1e-10*, when the overlap assumption on the model was violated, which ensures that the estimated propensity score is greater than this value.

Figure A1. Tests for the PSM results: firm performance and financial risks

(i) Firm performance and FX risk



(ii) Firm performance and IR risk



(iii) Firm performance and CM risk

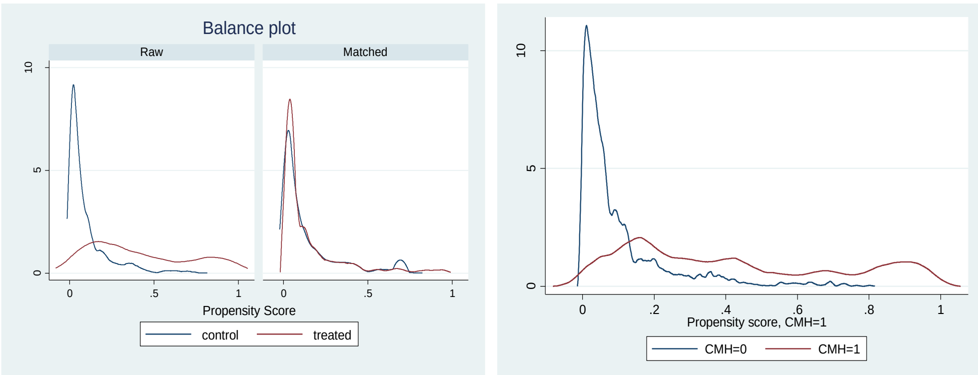
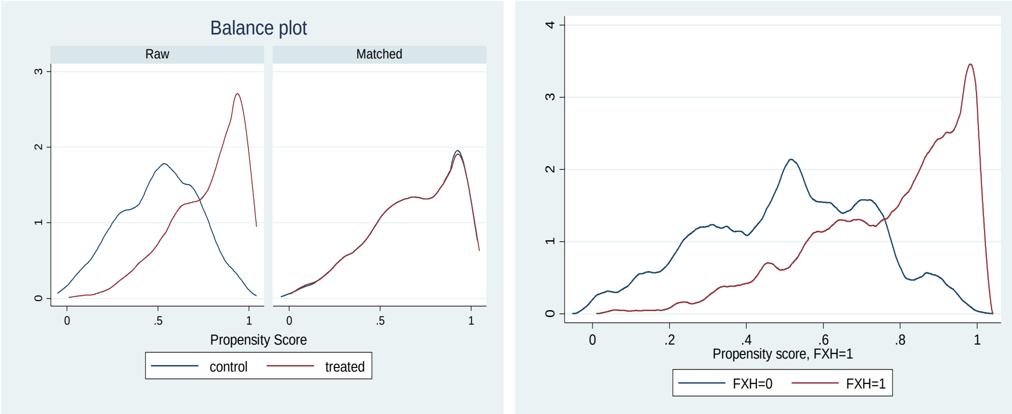
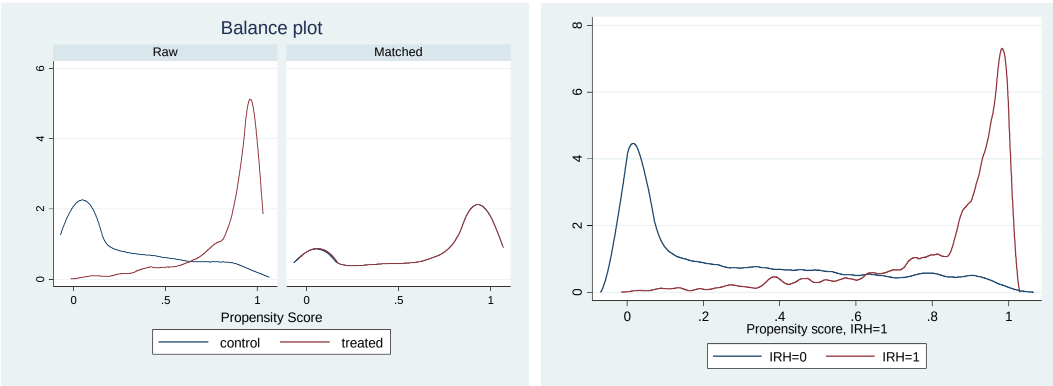


Figure A2. Tests for the PSM results: firm value and financial risks

(i) Firm value and FX risk



(ii) Firm value and IR risk



(iii) Firm value and CM risk

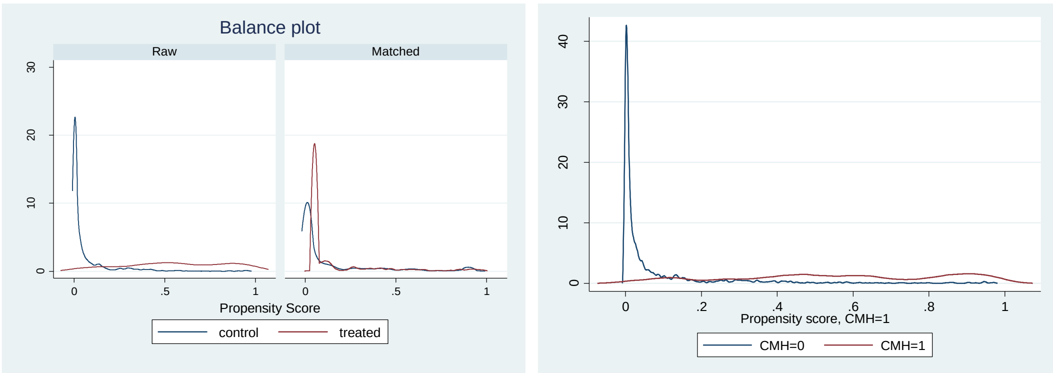


Figure A1 and Figure A2 provide the balance and overlap tests for the PSM method for performance and value, respectively, in line with the overall financial risks exposures (FX, IR and CM) as reported in Table 10 Panel A, using the advanced Stata options (i.e., *caliper*, *pstolerance* and *nneighbor*) (Rosenbaum and Rubin, 1983; Abadie and Imbens, 2006). The balance tests on the left-hand side plots of both figures show that matching process provided good balance in the covariate distributions in the treated and control groups. The plots on the right-hand side reveal that the overlap tests are satisfactory, except for the sub-sample of hedging for the CM risk where the probability mass tends to be near 0. The issue with the CM risk may stem from the sample size: i.e., it has 315 observations (14.3%) compared to 1,503 (68.32%) and 1,401 (63.7%) observations for FX and IR risks, respectively. However, our approach for such sub-samples is consistent with the common support limitation when finite sample in specific type of variables is limited during the matching process and also we imposed advanced options to ensure this critical assumption is passed in our tests. The CM risks-related results may still be interpreted with cautious.

3.4.5.2. The PSM estimations

Table 11 Panel A shows the difference between hedgers and non-hedgers for financial risks exposures in terms of value and performance using the PSM specification. The results suggest that the effect of hedging currency risk on performance and value is positive and statistically significantly at the 1% level, which confirms our OLS, IV and TE results. The matched firms in the users sample have higher outcomes (performance and value) compared to the derivatives non-users peers: the differential effect between hedger vs. nonhedgers on firm performance and value is 1.9% and 0.095 (in logs), respectively.

On the other hand, the impact of hedging interest rate risk on performance and value is *negative* and statistically significantly at the 1% level, which again confirms our OLS, IV and TE results. The corresponding differential effect between hedger vs. nonhedgers on firm performance and value with respect to the IR risk is 1.8% and 0.126 (in log values), respectively.

The PSM findings further show that the impact of hedging commodity price risk on performance is negative and statistically significant at the 10% level, and the magnitude of the differential effect is 0.4%. In our previous results, although all the methods yielded negative coefficient estimates the association was significant only under the OLS specification. The differential effect on value is positive and significant at the 1% level with the magnitude of 0.166, supporting our previous IV results.

Table 11, Panel B focuses on the types of derivatives in hedging currency risk. The results are significant and positive in all cases except for the differential effect of using the options contract on value that is negative and significant at the 10% level. In Panel C, we turn our attention to the derivatives for hedging IR risk: the differential effects on value and performance are negative and significant when options or swaps are used but when the forward contracts are used the effects become positive for both outcomes, and sizeable (5.3%) and statistically significant for performance only.

Finally, the PSM results in Table 11 Panel D are related to hedging the CM risk with different contracts. The differential effects on performance are negative and statistically significant at the 1% level for futures and forwards, which is different from our OLS, IV and TE methods that yielded insignificant coefficients. Moreover, the differential effect on value (performance) is negative (positive) and significant at the 1% level for forwards (futures). As for the options and swaps, the differential effects on both value and performance are consistently positive and statistically significant at the 5% or 1% level: these PSM results regarding the outcome of value are consistent with the OLS, IV and TE results but they are inconsistent regarding the outcome of performance since the latter methods again yield insignificant estimates.

Table 11

Matched Sample Tests: Propensity Score Matching

This table presents the differential effects of hedging on the outcome (i.e., value and performance) variables by comparing the non-users with the users of derivative instruments during the period from 2005 to 2012. Last two columns report difference between the coefficients pertaining to the two groups and the corresponding standard errors, respectively. Panel A shows the results for the overall hedging decisions. Panel B (C) (D) shows the results for the FX (IR) (CM) risk using different derivative contracts. All estimations use robust Abadie and Imbens standard errors (see section 4.5.1. for further details). Regressions in the pre-treatment variables modelling hedging are based on *Probit* model with determinants of derivatives use that were explained in the previous tables. We do not report estimations for all explanatory variables to conserve space. We also control for industry effects by using industry dummies based on SIC codes and control for time effects by using year dummies. All variables are defined in Table 1. ***, **, and * denote significance at the 1%, 5%, and 10% level, respectively.

Variables	Users Sample	Non-users Sample	Difference	*Robust* S.E.
		Panel A. Hedging Decisions		
Foreign currency hedge (FX)				
ROA	0.059	0.040	0.019***	0.005
lnQ	0.423	0.328	0.095***	0.025
Interest rate hedge (IR)				
ROA	0.046	0.064	-0.018***	0.006
lnQ	0.337	0.463	-0.126***	0.039
Commodity price hedge (CM)				
ROA	0.047	0.051	-0.004*	0.002
lnQ	0.581	0.415	0.166***	0.026
		Panel B. Derivatives Use for Hedging FX Risks		
Forwards (FO)				
ROA	0.054	0.033	0.021***	0.006
lnQ	0.429	0.268	0.161***	0.033
Options (OP)				
ROA	0.068	0.053	0.015***	0.006
lnQ	0.328	0.410	-0.082*	0.049
Swaps (SW)				
ROA	0.066	0.054	0.012*	0.007
lnQ	0.442	0.398	0.044**	0.021
		Panel C. Derivatives Use for Hedging IR Risks		
Forwards (FO)				
ROA	0.104	0.051	0.053**	0.022
lnQ	0.440	0.402	0.037	0.054
Options (OP)				
ROA	0.042	0.053	-0.011**	0.005
lnQ	0.257	0.414	-0.157***	0.024
Swaps (SW)				
ROA	0.048	0.068	-0.020***	0.005
lnQ	0.331	0.435	-0.103***	0.022
		Panel D. Derivatives Use for Hedging CM Risks		
Futures (FU)				
ROA	0.035	0.053	-0.018***	0.007
lnQ	0.526	0.409	0.117***	0.040
Forwards (FO)				
ROA	0.032	0.052	-0.020***	0.006
lnQ	0.256	0.409	-0.153***	0.046
Options (OP)				
ROA	0.063	0.052	0.011**	0.005
lnQ	0.538	0.405	0.133***	0.032
Swaps (SW)				
ROA	0.066	0.052	0.014***	0.003
lnQ	0.483	0.403	0.080**	0.033

3.4.6. The effects of derivatives use across time periods

The recent financial crisis tarnished the reputation of the financial markets and created the perception that derivatives might be harmful tools, supporting Warren Buffet's view that "derivatives are financial weapons of mass destruction".[47] The question of whether the use of derivatives during, before or after financial crises enhances or impedes value or performance of firms relative to non-crisis or pre-crisis times is worth addressing. Particularly, one would need to consider the benefits and costs of hedging financial risks with derivatives during extraordinary times when high risk and uncertainty prevail. For instance, Bartram *et al.* (2011) find that during the economic downturn in 2001-2002 the usage of derivatives was associated with higher value and return. Similarly, in this chapter we identify the differential impact of hedging on performance and value in times that include the financial crisis years (i.e., 2007-2009).[48] Our goal in this sub-section is, therefore, to assess the effects of derivatives use across different time periods using the difference-in-differences (DiD) method with PSM (DDM).

[47] See "Chairman's Letter to Shareholders, Berkshire Hathaway Inc, 2002 Annual Report.

[48] We conducted a series of tests similar to those done for Table 11 to compare the varying effects of derivatives use on performance and value in each year (in total, 208 separate PSM regressions). The results are unreported for brevity but available upon request, which can be summarized as follows: The incremental ROA effects are positive and statistically significant during the crisis period of 2008-2009 for the case of overall FX risk but with minor changes for hedging IR and CM risks. In all years, hedging the FX risk has significant and positive incremental impact on ROA; the effect is lowest in 2011 (1%) and highest in 2008 (1.8%). In all years again, hedging the IR and CM risks overall have significant but negative effects on ROA; the incremental effect is lowest during the crisis period for the CM risk (0.5%) and highest during the crisis period for the IR risk (1.7%). Hedging IR risk via forwards in 2011 led to 5.8% increase in ROA whereas hedging IR risk via swaps in 2006 led to 2.5% incremental reduction in ROA, compared to the non-hedging firms. On the other hand, hedging the FX risk has significantly positive incremental impact on value; the effect is lowest in 2009 (0.084, in logs) and highest in 2006 and 2012 (0.097, in logs). Although in all years the effects stemming from hedging the IR risk are negative and statistically significant the opposite can be observed for the CM risk. Hedging CM risk via options in 2008 led to 0.177 units incremental increase in firm value whereas hedging CM risk via forwards in 2010 led to an incremental reduction by 0.154 units in value, compared to the non-hedging firms. Overall, the contrasting findings for ROA and Tobin's Q that are economically sizeable may suggest that the impact of hedging the same risk depends on *when* the hedging is conducted and *which* derivative contract is used.

3.4.6.1. The DDM method

The empirical literature provides evidence based on the time series analysis of annual differences in dependent variables due to hedging financial risks in an attempt to unearth potential year-specific results.[49] Alternatively, we adopt the DiD method together with the matched sample approach (i.e., DDM) that includes a treatment group (derivatives users) comparable with control group (non-users). This methodology compares the outcome of a sample of treatment firms vs. control firms in hedging financial risks by considering the possibility that the impact of exogenous factors on performance and value might vary across times that coincide with 'before, during and after' the 2007-2009 financial crisis.

The DDM estimator developed by (Heckman *et al.*, 1997) is shown to be more effective than the conventional matching methods in bias-correction caused by the serial correlation. This specification addresses the econometric concerns related to omitted variables, non-observable firm characteristics and reverse causality (see e.g., Fang *et al.* (2014)).[50]

Consider the below equation:

$$\theta_{it} = E(Y_{it}) \qquad (6)$$

where $E(Y_{it})$ is the expected value for Tobin's Q or ROA; *i* is 0 for the control (non-hedger) group, and it is 1 for the treated (hedger) group; *t* is 0 for the pre-crisis period (2005-2007), and it is 1 for the post-crisis period (2008-2012) when the comparison is between the pre-crisis and post-crisis years; *t* is 0 for the non-crisis years (2005, 2006, 2010-2012) and it is 1

[49] Relative changes in outcome variables due to the switching values of binary explanatory variables (i.e., derivatives use) could be assessed with interaction terms given a specific research hypothesis (see e.g., Chen and King (2014)). Furthermore, time series analysis is part of incremental value approach suggested by Faulkender and Wang (2006). In this study, it is less appropriate to assess the incremental value or economic significance of binary explanatory variables (derivatives use dummy) on continuous outcome variables (performance or value) changes across time year-to-year differences.

[50] In corporate finance literature, among others, this approach has been adopted by Berger *et al.* (2014) and Cheung *et al.* (2015). For a thorough discussion of this DDM setting, see also Blundell and Costa Dias (2000).

for the for the crisis period (2007-2009) when the comparison is between the crisis and non-crisis years. The standard 'differences' estimate regarding the role of hedging on the outcome for each sub-period is "θ_{11}-θ_{01}" whereas the DDM estimate is "(θ_{11}-θ_{01})-(θ_{10}-θ_{00})" that considers both the effect of exogenous shocks and hedging policy simultaneously. Examine also the regression model as shown below:

$$Y_{it} = \alpha_0 + \alpha_1 Hderiv_{it} + \alpha_2 Time_t + \alpha_3 (Hderiv_{it} * Time_t) + \beta Z'_{it} + \varepsilon_{it} \qquad (7)$$

where Y_{it} represents the value or performance of firm *i* in year *t*; *Hderiv* is an indicator variable that shows if the firm hedged against financial risk in a particular year; *Time* is an indicator variable that shows if the specific year coincides with the "post-crisis" period or "during-crisis" period as explained above. Z'_{it} is a set of explanatory variables as discussed in the previous sub-sections. β's and α's are estimable parameters; ε is the error term. Assessing (6) and (7) together, it can be shown via the probability limit (*plim*) formula that α_0 = θ_{00} (baseline average, i.e., no treatment and before period or no treatment and non-crisis years); α_1 = θ_{10}-θ_{00} (the difference in means between hedgers and non-hedgers before the treatment); α_2 = θ_{01}-θ_{00} (time trend or exogenous shocks impacting both groups after period); α_3 = (θ_{11}-θ_{01})-(θ_{10}-θ_{00}) (the overall DDM estimate as the difference in the changes over time after the treatment, i.e., our coefficient of interest that represents additional effect of the hedgers' mean value after the treatment). The two-tailed *t*-statistics examines the null hypothesis that the DDM estimators are zero.

3.4.6.2. The DDM and PSM results across time periods

Table 12 Panel A provides the PSM findings for the pre-crisis, post-crisis, during crisis and non-crisis periods whereas Panel B reports the DDM results by comparing two periods at a time.[51] For each model in Panel A, the coefficients capture the average treatment effects (ATE) of hedging on performance and value. In Panel B, on the other hand, the DDM method calculates the differences in the matched samples between the baseline period and the following period: i.e., the coefficients represent the difference between mean treatment difference between two time periods and mean control difference between two time periods.

Table 12 Panel A1 shows that having implemented FX (IR) hedging policies had incremental increase (reduction) on both value and performance whereas implementing CM hedging policies had negative (positive) incremental effect on performance (value) in all time periods. For ROA, the post-crisis effect (0.025) is significant and higher than the pre-crisis effect (0.001) for the FX hedging. This difference is substantiated in model 5 of Panel B1 by the DDM results (0.037). This first set of results implies that the incremental benefit of FX hedging during the pre-crisis years is almost zero but for the post-crisis years it is 2.5 percentage points higher, which is statistically significant and economically sizeable. Therefore, one can contend that hedging for foreign currency risk after the latest financial crisis has proved more beneficial, and related to this, the statistically significant DDM coefficient of 0.037 suggests that the relative incremental benefit of the FX hedging is 3.7 percentage points higher when it is conducted during the post-crisis times as opposed to the years before the crisis. For value (*lnQ*), the pre-crisis effect (0.132) is significant and higher than the post-crisis effect (0.091) for the FX hedging. The second set of results implies that the incremental benefit of FX hedging during the pre-crisis years is 0.132 units higher and for the post-crisis years it corresponds to additional 0.091 units, which are statistically significant and economically sizeable. We can hence argue that hedging for foreign currency risk before

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[51] See notes to Table 12 for the steps and procedures followed to conduct the DDM analysis in Stata 14®. We use the recently developed "*diff*" Stata command that is based on the combination of Kernel PSM with DiD by which the control covariates can be used to match treated and control groups. See, Villa (2016) for a detailed discussion about this new user-written command.

the latest financial crisis has proved more beneficial as far as the firm value is concerned. The related DDM coefficient of 0.027 implies that the relative incremental benefit of the FX hedging is 0.027 units higher when it is conducted before the crisis years as opposed to the years after the crisis but this difference is statistically insignificant although economically considerable.

Models 3 and 4 in Panel A1 show that the differential effect of FX hedging on ROA is higher during the crisis (0.03) compared to the non-crisis years (0.01). The related DDM coefficient of 0.044 implies that the relative incremental benefit of the FX hedging is 4.4 percentage points higher when it is adopted during the crisis years as opposed to the non-crisis years and this difference is statistically significant. In the same models, the findings reveal that the positive incremental effect on *lnQ* is higher when the FX hedging is done during non-crisis years, i.e., 0.078 vs. 0.063. The corresponding DDM coefficient of 0.011 implies that the relative incremental effect of the FX hedging is 0.011 units higher when it is conducted during the crisis years as compared with the non-crisis years but this difference is statistically insignificant.

Table 12 Panel A1 further shows that, the negative incremental effect of IR hedging on ROA is more apparent during the post-crisis times (-0.024) than during the pre-crisis period (-0.006). The related DDM estimate in Panel B1 is “-0.026”, which suggests that the relative incremental effect of the IR hedging is 2.6 percentage points lower when it is adopted during the years following the crisis as opposed to the pre-crisis period and this difference is statistically significant. Furthermore, the negative incremental effect of IR hedging on ROA is more severe during the crisis times (-0.03) than during the non-crisis period (-0.014) and both estimates are statistically significant. However, the DDM estimate of “-0.004” in Panel B1 related to these PSM estimates is statistically insignificant, suggesting that adopting IR-related hedging policies during the crisis did lead to additional losses but this differential effect is immaterial. Regarding the outcome of firm value, the magnitude of negative incremental effect is higher during the pre-crisis period (-0.136) when compared to the post-crisis period (-0.052) and it is higher for the non-crisis years (-0.115) when compared to the crisis years (-0.103). Although these PSM estimates are statistically significant, the corresponding DDM estimates (-0.028 and -0.012, respectively) are insignificant.

Moreover, Table 12 Panel A1 indicates that the incremental negative effect of CM hedging on ROA is more pronounced for the pre-crisis period (-0.013) relative to the post-crisis period (-0.005), and it is more pronounced for the crisis period (-0.018) relative to the non-crisis years (-0.002); but the corresponding DDM estimates (-0.016 and -0.004, respectively) in Panel B1 are insignificant. However, when we examine the effect of CM hedging on firm value, the contrasting results were found: the magnitude of the positive incremental effect of CM hedging on *lnQ* is larger during the pre-crisis period (0.218) when compared to the post-crisis period (0.162) and it is larger for the crisis period (0.205) when compared to the non-crisis years (0.19). Again, although these PSM estimates are statistically significant, the corresponding DDM estimates (0.003 and 0.002, respectively) in Panel B1 are statistically insignificant.

For brevity, we will not explain in detail the results from Panel A2 to Panel B4 in Table 12 which report the PSM and DDM estimates across different hedging contracts. The key findings in those panels are summarized as follows: *i)* The positive incremental effect of FX hedging on ROA across different time periods remains to be the case irrespective of the type of the derivatives contracts in Table 12 Panel A2. However, the positive incremental effect of FX hedging on *lnQ* is reported only for the forwards and swaps; the effect is negative for the options but the results are statistically insignificant. *ii)* Table 12 Panel A3 shows that the overall negative incremental effect of IR hedging on ROA is observed when the hedging is based on the options or swaps contracts and the DDM findings that are significant in Panel

B3 strengthen this observation. The PSM findings show that across all periods the differential effect of IR hedging on ROA is actually *positive* when the contract type is forwards. *iii)* Table 12 Panel A4 reveals the overall negative incremental effect of CM hedging on ROA across various time periods appears to be originated from the use of *forwards* contracts but for the remaining three contract types the effects are generally positive and statistically significant as per the PSM results as well as the DDM findings in model 5 of Panel B4. *iv)* Table 12 Panel A4 further reveals that although the overall incremental effect of CM hedging on *lnQ* is positive across the time periods, this effect turns out to be negative and significant when the *forwards* are used; for the other contracts the positive effects that are also supported by the DDM results in Panel B4 remains to be the case.

Overall, once again, the effect of hedging on the value and performance of the listed UK firms varies depending on which financial risk they are attempting to manage and which hedging instruments/contracts they are using. In addition, the findings of this sub-section suggest that the impact of hedging varies, as the third dimension, across time periods. It appears that firms benefit greatly from the use of only some type of derivatives before, during or after the crisis, which implies that corporate hedging strategies ought to be reviewed and updated as a reaction to the changes in the markets.

Table 12

Firm Performance and Value with Derivatives Use Across Time Periods

This table presents the differential effects of hedging on firm value and performance by comparing the non-users with the users of derivative instruments during different time periods using the DDM and PSM settings. The dependent variable is ROA for performance, and Tobin's Q for value. Panel A reports the PSM estimates for four sub-periods whereas Panel B reports the DDM estimates by comparing two sub-periods. The first step of the DDM method is based on a *Probit* model that estimates the propensity to hedge, using robust *Abadie and Imbens* standard errors (see section 4.5.1. for further details) with five nearest-neighbors (*nneighbor*) with replacement and *pstolerance* (1e-10) robustness options. In this step, the same factors (i.e., the firm-specific characteristics and industry fixed effects) of our previous analyses were utilized as the variables influencing hedging decisions. In the second step, the DiD estimations based on the *nearest-neighbor* PSM specification obtain the difference between outcomes regarding the two periods, using robust *Epanechnikov Kernel* standards errors with default bandwidth (0.06) to alleviate concerns about serial correlation. The 'with replacement' option produces more reliable matching than the 'without replacement' option as in the former one firm can be used more than once as a match. The DDM method performs the PSM technique that generates reweighted treatment and control group in both time periods, i.e., the baseline and follow-up periods. We have panels of reasonably balanced treatment and control groups in the matched samples within each sub-period. To conserve space, we do not report estimations for all explanatory variables and the R^2 values that range from 2% (7%) to 6% (14%) for ROA (lnQ). The columns in each of six models report both the coefficient estimates for these semi-parametric methods and the corresponding standard errors. Panels A1 and B1 show the results for the overall hedging decisions. Other sub-panels show the results for the foreign currency, interest rate and commodity price risks using different derivative contracts. We control for industry effects by using industry dummies based on the SIC codes. All variables are defined in Table 1. ***, **, and * denote significance at the 1%, 5%, and 10% level, respectively.

	Panel A. PSM Estimations								Panel B. DDM Estimations			
	Pre-crisis (1)		Post-crisis (2)		During crisis (3)		Non-crisis (4)		Post-crisis vs. Pre-crisis (5)		During crisis vs. Non-crisis (6)	
	Coef.	S.E.	Coef.	S.E	Coef.	S.E	Coef.	S.E	Coef.	S.E	Coef.	S.E
	Panel A1. Hedging Decisions								Panel B1. Hedging Decisions			
Foreign currency hedge (FX)												
ROA	0.001	0.006	0.025***	0.007	0.030***	0.008	0.010	0.006	0.037***	0.013	0.044**	0.022
lnQ	0.132***	0.038	0.091***	0.023	0.063**	0.028	0.078***	0.007	0.027	0.063	0.011	0.060
Interest rate hedge (IR)												
ROA	-0.006	0.012	-0.024***	0.007	-0.030***	0.010	-0.014**	0.007	-0.026**	0.012	-0.004	0.016
lnQ	-0.136*	0.059	-0.052*	0.032	-0.103*	0.062	-0.115***	0.028	-0.028	0.087	-0.012	0.092
Commodity price hedge (CM)												
ROA	-0.013*	0.007	-0.005	0.007	-0.018**	0.009	-0.002	0.006	-0.016	0.014	-0.004	0.009
lnQ	0.218*	0.122	0.162*	0.086	0.205**	0.102	0.190***	0.070	0.003	0.091	0.002	0.131
	Panel A2. Derivatives Use for Hedging FX Risks								Panel B2. Derivatives Use for Hedging FX Risks			
Forwards (FO)												
ROA	0.012	0.010	0.025**	0.011	0.032***	0.012	0.013**	0.005	0.002	0.008	0.024	0.022
lnQ	0.156***	0.033	0.078***	0.018	0.094**	0.037	0.124***	0.025	0.025	0.064	-0.009	0.065
Options (OP)												
ROA	0.024**	0.011	0.019***	0.005	0.025***	0.008	0.018***	0.007	-0.002	0.015	0.014	0.013
lnQ	-0.028	0.060	-0.029	0.045	-0.032	0.051	-0.035	0.067	-0.029	0.073	-0.017	0.074
Swaps (SW)												
ROA	0.007	0.010	0.019**	0.008	0.026**	0.011	0.012	0.011	0.007	0.013	0.011	0.014
lnQ	0.007	0.076	0.066**	0.031	0.043	0.038	0.098*	0.056	0.027	0.069	-0.032	0.065
	Panel A3. Derivatives Use for Hedging IR Risks								Panel B3. Derivatives Use for Hedging IR Risks			
Forwards (FO)												
ROA	0.046*	0.025	0.072**	0.034	0.066	0.045	0.032***	0.007	-0.029	0.021	-0.013	0.021
lnQ	-0.175	0.153	-0.128	0.108	-0.176***	0.018	-0.236**	0.100	-0.062	0.124	0.001	0.118

Table 12 (continued)

	Pre-crisis (1)		Post-crisis (2)		During crisis (3)		Non-crisis (4)		Post-crisis vs. Pre-crisis (5)		During crisis vs. Non-crisis (6)	
Options (OP)												
ROA	0.015	0.014	-0.017***	0.003	-0.003	0.014	0.013	0.010	-0.025*	0.014	-0.013	0.017
lnQ	-0.114*	0.064	0.071	0.107	-0.018	0.090	-0.077**	0.037	0.012	0.060	-0.012	0.065
Swaps (SW)												
ROA	-0.004	0.009	-0.028***	0.007	-0.042***	0.010	-0.024**	0.009	-0.008	0.014	-0.035**	0.016
lnQ	-0.062**	0.029	-0.081*	0.047	-0.151**	0.071	-0.075***	0.017	-0.056	0.093	-0.160*	0.094
	Panel A4. Derivatives Use for Hedging CM Risks								Panel B4. Derivatives Use for Hedging CM Risks			
Futures (FU)												
ROA	0.009	0.011	0.006	0.010	-0.012	0.008	-0.006	0.012	0.023	0.018	-0.005	0.013
lnQ	0.024	0.064	0.157***	0.019	0.125***	0.037	0.122***	0.041	0.115*	0.066	-0.013	0.087
Forwards (FO)												
ROA	-0.004	0.007	-0.015***	0.004	-0.040**	0.018	-0.014*	0.008	-0.002	0.018	-0.022	0.015
lnQ	-0.106**	0.046	-0.141***	0.038	-0.208**	0.093	-0.192***	0.038	-0.014	0.078	-0.032	0.071
Options (OP)												
ROA	0.005	0.010	0.014***	0.004	0.057***	0.011	0.005*	0.003	0.031	0.025	-0.015	0.027
lnQ	0.008	0.055	0.096*	0.051	0.203***	0.044	0.082***	0.022	0.163**	0.077	0.009	0.091
Swaps (SW)												
ROA	-0.010	0.008	0.035***	0.012	0.023**	0.012	0.028***	0.004	0.025*	0.014	0.007	0.011
lnQ	0.015	0.084	0.224***	0.061	0.210**	0.099	0.153*	0.088	0.133**	0.065	0.029	0.077

3.5. Conclusion

We examine the impact of hedging decisions on performance and value of non-financial UK firms during 2005-2012. When evaluating separately the effects of each hedging contract, the results vary depending on the risk type, the contract type and the time of hedging. We use various techniques to mitigate endogeneity and sample-selection bias problems. The main findings are summarized as below:

First, the IV-GMM results suggest that FX (IR) hedging has a positive (negative) impact on ROA. The link between ROA and hedging varies across different derivatives even for the same risk type: forwards and swaps for hedging FX have positive impact on ROA whereas options and swaps in hedging IR risk are negatively associated with ROA. Hedging IR (CM or FX) risk impedes (enhances) value. Similarly, using forwards or swaps (options) for the FX risk increases (decreases) value; and when swaps or options (forwards) are used for the IR risk firm value reduces (increases).

Second, the TE method reveals that, for ROA, the coefficient for FX (IR and CM) hedging is positive (negative). Hedging FX risk with forwards and swaps are positively linked to ROA. The effect of overall FX (IR) hedging on value is positive (negative). Using forwards or swaps (options) enhances (reduces) value when they are used for FX hedging and if forwards (options or swaps) are used for the IR risks this increases (decreases) value. We report positive impacts for various derivatives for the CM risk on value but not for forwards.

Third, the PSM technique finds that the matched firms in the FX hedgers sample have higher ROA and value compared to the nonhedgers: the differential effect between the two groups on ROA and value is 1.9% and 0.095 units, respectively. The impact of IR hedging on ROA and value is negative and the corresponding differential effects on ROA and value are 1.8% and 0.126, respectively. The impact of hedging CM risk on ROA (value) is negative (positive) with the differential effect of 0.4% (0.166 units). For various derivatives in hedging FX risk, the incremental effects are positive in all cases except options. For hedging IR risk, the differential effects on value and ROA are negative for options or swaps but for forwards the effects become positive for both outcomes. The differential effects on ROA are negative for futures and forwards hedging CM risk; the effect on value (ROA) is negative (positive) for forwards (futures); for options and swaps, the effects on both value and ROA are positive.

Fourth, the DDM method in conjunction with PSM shows that-for overall hedging- the FX (IR) generated incremental increase (reduction) on both value and ROA but CM hedging generated negative (positive) incremental effects on ROA (value) across various sub-periods. For the effect of FX hedging on ROA, the post-crisis impact is higher than the pre-crisis impact with the incremental (relative) benefit of 2.5% (3.7%). The pre-crisis positive effect on value is higher than the post-crisis effect for the FX hedging, with the incremental benefit of 0.132 units. The differential impact of FX hedging on ROA is higher during the crisis times and the relative benefit is 4.4% higher compared to the non-crisis years. Interestingly, the positive incremental effect on value is higher when the FX hedging is done during non-crisis years and the relative effect is 0.011 additional units. The negative incremental effect of IR hedging on ROA is more apparent during the post-crisis times when the relative effect is 2.6% lower; this negative effect is even more severe during the crisis times. For value, the negative incremental effect is higher during the pre-crisis period when compared to the post-crisis period and it is higher for the non-crisis years when compared to the crisis years. The incremental negative effect of CM hedging on ROA is more obvious for the pre-crisis period relative to the post-crisis period, and it is more apparent for the crisis period relative to the non-crisis years. However, the positive incremental effect of CM hedging on value is larger during the pre-crisis period when compared to the post-crisis period and it is larger for the crisis period when compared to the non-crisis years.

Our results tend to suggest that IR hedging is beneficial when forwards are used and it is unrewarding when options and swaps are used. This raises a question and opens a debate as to whether optimal levels of usage for a particular instrument would be more advantageous. The fact that the association of hedging with value and performance varies depending on the type of risk, the type of derivatives and the time period clearly warrants some further research to unearth the underlying reasons. Some of the above findings can be helpful in improving risk management practices and policies of corporations.

CHAPTER 4

The Cost of Equity Capital and Corporate Hedging

4.1. Introduction

Given the central role played by corporate risk management in financial theory, it is not surprising that the common view in the literature is that firms generally hedge to reduce returns variability in market imperfections (Smith and Stulz, 1985; Nance *et al.*, 1993; Aretz *et al.*, 2007; Bartram *et al.*, 2011; Minton and Schrand, 2016). Using a sample of 2000 firm-year observations from 2005 to 2012 in the UK, we examine the association between corporate risk hedging and stock returns volatility and also the cost of equity capital implied in stock prices, in which exploring this association is subject to potential endogeneity concerns. This study is motivated by a growing body of analytical and empirical research that investigates the relationship between the use of derivative financial instruments and the cost of equity. On the theory side, several recent studies suggest that corporate hedging may lead to a lower cost of equity.

Prior research provides empirical conclusions on the economic benefits of hedging financial risks. Overwhelming evidence exists in the field of risk management theories that corporate hedging is the source of reduction in financial distress costs (Smith and Stulz, 1985; Froot *et al.*, 1993), systematic risk (Guay, 1999; Bartram *et al.*, 2011) and the cost of equity capital (Gay *et al.*, 2011). Chen and King (2014) suggest that much of the economic value of hedging financial risks on excess stock returns related to corporate hedging decisions is left unexplained in literature. Firms normally are exposed to fluctuations in stock returns and volatility risk that is inherent in their normal course of business strategies. Indeed, unexpected fluctuations in foreign currency exchange rates, interest rate or commodity price changes risk may affect firm earnings and therefore, the market value of share prices.

A large part of the previous theoretical literature links the relationship between the risk and return (Fama and MacBeth, 1973; Fama and French, 1993; Cochrane, 2005). Nonetheless, a large part of previous empirical research focuses on the impact of the use of derivative instruments on firm value and performance (Allayannis and Weston, 2001; Adam and Fernando, 2006; Jin and Jorion, 2006; Allayannis *et al.*, 2012), while other studies directly investigate firms' motives beyond hedging activities (Stulz, 1984; Smith and Stulz, 1985; Nance *et al.*, 1993). Smith and Stulz (1985) develop a positive theory of hedging, in the context to which hedging risk exposures, as one part of the firm's financing decisions, can reduce the variability of the firm's expected earnings.

The existing literature fails to provide comprehensive determinants of the cost of equity capital. Interestingly, prior research predicts the relationship between corporate hedging and cost of equity capital. For example, Gay *et al.* (2011) find that hedging financial risks is an important determinant of the cost of equity capital. Since the 1960s, different capital asset pricing models (Sharpe, 1964; Lintner, 1965; Fama and French, 1993) have been developed to address the theoretical convex relation between risk and expected returns. Prior empirical studies identify a monotonic lower cost of equity capital for derivative users than non-users for the purpose of hedging financial risks (foreign currency, interest rate or commodity price risk) (Bartram *et al.*, 2011; Chen and King, 2014).

Motivated by Berk and Van Binsbergen (2016) that propose more robust argument for the new method of testing pricing models, this study utilises the recently developed methods in the field of the implied cost of equity capital. The empirical findings that the traditional capital asset pricing model (CAPM) (Sharpe, 1964; Lintner, 1965) and Fama-French models (Fama and French, 1993, 2015, 2016) relating the relationship between risk and return do a poor performance in the neoclassical paradigm to explain the variations in the expected stock returns. Since the expected stock returns of a long ex ante period vary over time and is very sensitive to the assumptions based on a Fama-French model in asset pricing (Fama and French, 2016), computing the implied cost of equity capital is of prime importance. To help alleviate these arguments concerned with the most interesting question of how to compute the cost of equity capital for investment opportunities, we perform the implied cost of equity capital using earnings-performance approach following Easton (2004) and Ohlson and Juettner-Nauroth (2005). Based on this insight, we use the realised data (ex-post) instead of analysts' forecast data expressed in terms of ex ante.[52]

While some studies have successfully used analysts' forecast data because it captures other factors of interests, the difficulty of estimating the cost of equity capital lies in the fact that analysts' forecast is not often available, even ex-post. We argue that using realised earnings (ex-post) for the estimated cost of equity capital implied in stock prices is more appropriate and accurate. Adam (2009) suggests that the managers' market views on hedging policies partially derive the sensitivity of the firm's share price to rise significantly. These findings indicate that hedging for financial risk exposures has raised several questions with respect to the cost of equity capital. However, our understanding as to when firms announce the use of derivative instruments and underline contracts is limited. Therefore, whether or not hedging financial risk exposures related to market conditions can offer directly marginal effects on the firm's abnormal performance or excess returns. A market premium rate related to the financial risk is an important rational of a firm's cost of equity capital in the asset pricing model (Modigliani and Miller, 1958).

[52] See for instance, Bonaimé *et al.* (2014b) use realised earnings when estimating equity misevaluation by the residual income model (RIM).

While the above arguments in literature on the firms' inherent financial risk exposures is the concentration of the cost of equity capital and its determinants, this chapter investigates an empirical question, which tests the influence of corporate hedging on stock returns variability. This study fills this gap in the literature by answering two important questions: (1) *Does hedging reduce stock return volatility and the cost of equity capital?* (2) *Do hedging decisions alleviate the impact of information asymmetry on the cost of equity capital?* (3) *If so, whether derivative users have a lower cost of equity capital than non-users in the presence of business risks?*

This research is important because equity-financing is a major capital source for a firm's operations in market imperfections. The data on hedging activities are hand-collected from firms' annual reports downloaded from their official websites, while we obtain the remaining data from the Bloomberg database. This sample includes 250 UK nonfinancial firms that have publicly-traded on the London Stock Exchange over a period of 2005-2012. We exclude financial firms because of using derivative instruments for speculations, consequently, we are able to examine the impact of the use of foreign currency (FX), interest rate (IR), and commodity price (CM) derivatives on the stock returns volatility and implied cost of equity capital. This data set also allows us to examine the extent to which hedgers, in comparison to nonhedgers, have a lower cost of capital.

The findings of this study contribute to literature showing that corporate hedging decisions related to financial risk exposures mitigate the stock returns volatility and reduce the cost of equity capital. Furthermore, the interaction of corporate hedging decisions with asymmetric information provides strong evidence of the economic values of hedging to a firm's performance. To our best knowledge, this study is the first to provide a distinct advantage over other studies in the existing literature and focuses on the relationship between corporate hedging decisions and the cost of equity capital, not having to rely upon the capital asset pricing model (CAPM) or Fama-French five factors models (Fama and French, 2015, 2016) estimates for the cost of equity calculations. Thus, this chapter documents important risk factors and variables and precisely estimates the implied cost of equity capital mean on realised data set which is based on earnings-performance approaches of the firms' valuation model. The remainder of this chapter is organised as follows. Section 2 describes the literature review. Section 3 shows the methodology. Section 4 reports the empirical findings. Section 5 documents the results of additional robustness tests. Section 6 concludes.

4.2. Related literature and hypothesis development

A well-known result in the risk management literature is the apparent strong valuable benefits between corporate hedging activities and firm equity volatility. There had been an early success in linking hedging financial risks, as part of the firm's financing decisions (Smith and Stulz, 1985), and stock prices (Bartram and Bodnar, 2007). Prior empirical results in finance literature (e.g., , (Bartram *et al.*, 2011), (Gay *et al.*, 2011), (Chen and King, 2014); among others) suggest that the regression coefficients of corporate hedging financial risk exposures on stock return volatility and the cost of capital are significantly negative. Smith and Stulz (1985) document why some firms hedge their accounting risk while others hedge their economic value. In addition, any estimates of time-varying corporate hedging decisions will be a common share issue in methodologies. Thus, regressing estimates of corporate hedging decisions on stock return volatility and the cost of equity capital will involve considerable common measurement control and self-selection bias.

4.2.1. Stock return volatility

Empirical evidence documents that firms associated with the use of derivatives would be consistent with lower stock return volatility (Bartram *et al.*, 2011). Pincus and Rajgopal

(2002) use the standard deviation of the firm's monthly returns over the fiscal year (σ_E) as a proxy for the cost of capital associated with cash flow volatility, and predict that derivative users have a lower stock return volatility. Consistent with this notion, Bartram *et al.* (2015) document the determinants of stock return volatility of nonfinancial firms using a large U.S. data, in context to which risk management policies, firm size, profit volatility and capital expenditures are the most influential factors on the cost of capital. The above discussion leads to the following predictions:

H1. When firms hedge financial risk exposures, more hedging decisions reduce stock return volatility.

4.2.2. Hedging decisions and cost of equity capital

The capital asset pricing model (CAPM) pioneered by Sharpe (1964) and Lintner (1965) has initially structure a fundamental basis for estimating the firm's cost of equity capital in several directions in the literature. However, the increasing arguments (e.g., Choi and Richardson (2016), among others) on the capital asset pricing model (CAPM), Fama-French models (Fama and French, 1993, 2015, 2016), among others, focus on alternative risk factors (e.g., Walkshäusl and Lobe (2014)) lead us to investigate the cost of equity capital implied in stock prices from earnings-performance perspectives (Ohlson, 1995; Ohlson and Juettner-Nauroth, 2005). In contrast to the lack of studies about the impact of corporate hedging activities on the implied cost of equity, several studies examine hedging strategies related to the cost of capital. Tufano (1996) shows that corporate hedging decisions have a marginal effect on firms' stock price sensitivity in the gold mining industry.

Nevertheless, hedging decisions for financial instruments use are correlated with a firm's equity securities price. The theoretical literature on corporate hedging relaxes on the classical assumptions of Modigliani and Miller (1958) as to whether corporate hedging is a value adding strategy. For example, Nelson *et al.* (2005) shows that corporate hedging activities can influence the cost of equity capital and find explicitly abnormal returns for large firms hedging currency exposures. The over-performance for firms that are more likely to hedge foreign currency risk exposures is due to firms that hold portfolio securities in global equity markets. The link between expected excess returns of holding equity securities and risk uncertainty remains a puzzle. This belief assumes that individual investors, in market imperfections or frictions, may justify optimal derivatives use to alleviate risk uncertainty for expected economic value (Smith and Stulz, 1985). While most models on corporate hedging focus on the optimal capital structure given the financing decisions (Froot *et al.*, 1993; Allayannis *et al.*, 2003), a few approaches argue that hedging may also have an impact on the cost of equity capital when external financing is costly (Bartram *et al.*, 2011). Similarly, Chen and King (2014) investigate whether hedging financial risks is associated with a lower cost of capital and find a negative impact consistently across various industries. This leads to our second hypothesis:

H2. When firms hedge financial risk exposures, more hedging decisions reduce the cost of equity capital.

4.2.3. Hedging decisions and information asymmetry

In this section, we aim to provide evidence on the relative importance of information asymmetry on the cost of equity capital. The link between information asymmetry and the cost of equity capital is one of the most fundamental issues in asset pricing. We build our models structure on two streams of research that consider the effects of corporate hedging decisions and information asymmetry on the cost of equity capital, and the relation between those factors in the interaction term on the market outcome. One of the motivations for this study: the growing debate about whether information asymmetry, in some circumstances, affects the cost of equity capital through its effects of implications in the market outcome.

It is necessary to point out which type of information asymmetry that perfectly increases the cost of equity capital in the market imperfection or friction because it has casual effects when its source defined. Prior studies investigate the determinants of a firm's cost of equity, and information asymmetry broadly has various forms of risk that affects the implied cost of equity capital. Our measures of the information asymmetry follow prior research. Among the generally used proxies for the information asymmetry, analysts' forecast dispersion and long-term growth rate are the most closely associated empirically with future earnings and realised growth (Dhaliwal *et al.*, 2016). A plausible measure is needed to reflect the information risk implied in the cost of equity (Bhattacharya *et al.*, 2011).

Given this friction of information asymmetry, the analyst forecast dispersion and the analyst forecast of the long-term earnings growth rate are selected. An extension of our arguments is that we expect hedging decisions to play more economic benefits to mitigate the effect of information asymmetry on the cost of equity. Information asymmetry can increase the cost of equity capital. Prior studies show that corporate hedging arises in response to information asymmetries, and it can lower the positive consequences of information asymmetry for the cost of equity. For example, Bartram and Bodnar (2007) find that the percentage of firms with significant stock price exposures increases with the forecast horizon. Similarly, Dierkens (1991) finds in time-series study that information asymmetry is an important variable determinant in market imperfections, in which the cost of equity significantly fluctuates. Consistently with further research on stock returns volatility, Neuhierl *et al.* (2013) document that stock returns volatility is more likely to increase to a higher level following greater information asymmetry releases. Therefore, we confirm earlier findings (e.g.,Guo and Whitelaw (2006); Bartram *et al.* (2011); Gay *et al.* (2011)) on the reactions to stock returns volatility, and the cost of equity capital, when firms hedge financial risks exposures. This leads to our third hypothesis:

H3. More hedging decisions reduce the cost of equity capital in firms associated with greater information asymmetry.

4.3. Methodology

4.3.1. Model framework

To examine the impact of hedging decisions on stock return volatility and the cost of equity capital, our general methodology is to estimate the following OLS panel regression model:

$$Y_{it} = \beta_0 + \beta_1 Hderiv_{it} + \gamma X'_{it} + \alpha_t + \alpha_i + \varepsilon_{it} \quad (1)$$

where Y_{it} represents the outcome variable of both dependent variables - stock volatility and cost of equity capital – for firm *i* and year *t*. First, following Li *et al.* (2011) and Chen *et al.* (2013b), we use two proxies of firm-level stock return volatility: the logarithm of squared daily returns and the standard deviation of daily stock returns. Appendix A presents the calculations of stock return volatility. Second, building on the theoretical background in finance literature, we now present a method for estimating the cost of equity capital for UK non-financial firms listed in the FTSE-All share index, such as firms use derivative instruments for hedging purposes. The method expresses the implied cost of equity capital, following the earnings-performance approach by (Easton, 2004; Ohlson and Juettner-Nauroth, 2005), thus enabling us to compute the cost of equity capital that is implied in current stock prices. We empirically estimate the cost of equity capital with two specific models. Both models introduced by Easton (2004) and Ohlson and Juettner-Nauroth (2005) are based on abnormal earnings growth valuation model. Appendix A. provides a detailed description of the cost of equity calculation. The main variable of interest in this study is

$Hderiv_{it}$ that representing the hedging activities with financial risk exposures that including hedging overall (H), foreign currency (FX) risk, interest rate (IR) risk or commodity price (CM) risk in which it takes a dummy variable of 1 if a firm reports any type of risk hedging or specific risk exposure, respectively, and zero otherwise. X'_{it} is a set of firm-level control variables that consists of all variables of interests employed in all regression models. In our methodology, we use a comprehensive set of control variables relating 4 groups: firms' characteristics, information asymmetry, risk and financial distress proxies.[53]

Control variables are the market value of equity (log), book-to-market (B/M), return on assets (ROA) represents the firm profitability, capital expenditure and research and development that both of them divided by total assets represent proxies for investment factor, momentum, analysts' forecast dispersion, long-term growth rate, beta value-weighted, and book leverage. Table 1 reports all variables definition for our research models. In our tests, we include year fixed effects (α_t) to control for some factors such as momentum, analyst forecast dispersion and long-term growth rate. We also include firm fixed effects (α_i) in all our regression estimations to control for time-invariant omitted firm characteristics that could differ across firms. In all our regressions estimation, we use robust standard errors under the different regression methods (OLS, IV-GMM, treatment effects-control function, and propensity-score matching) to control for within-firm level error term correlations over time (Wooldridge, 2012). We use Eq. (1) to test H1 and H2 relating the effects of hedging decisions on stock return volatility and the cost of equity capital, respectively.

To test H3, we extend the previous analysis to investigate whether corporate hedging activities ($Hderiv_{it}$) relating to hedging overall (H) or financial risk exposures (FX, IR and

[53] As control variables, we comprehensively use several proxies in all our models estimation to avoid as much of omitted-variable bias.

CM) contribute the reduction of the cost of equity capital in settings where information asymmetry ($InfoAsym$) proxy is represented by the long-term growth rate.

$$Y_{it} = \beta_0 + \beta_1 Hderiv_{it} + \beta_2 InfoAsym_{it} + \beta_3 Hderiv_{it} * InfoAsym_{it} + \gamma X'_{it} + \alpha_t + \alpha_i + \varepsilon_{it} \quad (2)$$

where Y_{it} represents the outcome variable of the dependent variable – the cost of equity capital mean – for firm *i* and year *t*. The mean of the cost of equity capital (R_{AVG}) implied in stock prices is calculated by taking the mean of the two individual estimates of R_{OJ} and R_{MPEG} and is in excess of the UK yield on 10-year Treasury bonds. Consistent with theoretical research, information asymmetry increases the cost of equity capital, therefore we predict coefficient β_2 to be positive and significant. The coefficients of interest in Eq.(2) is β_3. We do expect the hedging decisions to reduce the effects of information asymmetry on the cost of equity capital. Therefore, under our hypothesis H3, when firms use derivative financial instruments for hedging purposes (i.e., $Hderiv = 1$), we expect β_3 to be negative and significant, indicating that hedging decisions are more likely to mitigate the cost of equity capital in settings where information asymmetry between managers and the providers of finance are increasingly pronounced.

4.3.2. Endogeneity issues in estimation

To account for potential endogeneity and econometrics concerns, we employ multiple approaches: instrumental variable (IV-GMM) and treatment effects control function (TE-GMM). Our approach demonstrates the importance of economic significance of hedging decisions on the stock return volatility and the cost of equity capital. The first is instrumental variable (IV-GMM) approach to capture the extent to which a firm's stock return volatility and cost of equity capital might be endogenously determined and driven by omitted variables bias. This method has the advantage of controlling endogeneity issues caused by unobserved heterogeneities and the possibility of hedging decisions variable that might be endogenous to our model estimation. The IV-GMM estimator involves the use of probit regression estimation in the first stage of the hedging decisions estimation, where the fitted value from the first stage is to be transformed to the second stage regression estimation on the outcome model of stock return volatility or cost of equity capital. The IV-GMM approach also is robust to the consistency on the use of valid instruments in the first and second stage regression estimations.

Consistent with prior studies (e.g., Allayannis *et al.* (2012); Chen and King (2014)), we implement instrumental variables (IVs) approach where hedging decisions are more likely determined by relating variables for risk exposures. Instrumental variables include: foreign sales ratio, foreign expenditures, and geographical diversification that are more strongly related to hedge FX risk; interest rate float and fixed rate are more likely to be associated with IR risk hedge; and commodity raw material purchase and commodity oil & gas are more likely to considerably affect CM price risk.[54] We observe in the firms' annual reports that these selected instrumental variables are most commonly rational for hedging financial risk exposures in UK nonfinancial firms. A full description of instrumental variables is defined in Table 1.

Second, we use treatment effects control function (TE-GMM) approach, which has attracted significant attention in recent studies dealing with the issues of endogeneity (e.g., Florens *et al.* (2008)). In our regression model, the treatment is a having the hedging

[54] See for example, Allayannis *et al.* (2012) document a selection of instrument variables which seem to be relative and positively associated with FX or IR risk exposures, such as a floating or fixed currency dummy variable indicating whether a country of study has a floating or fixed currency regime. Similarly, Bartram and Bodnar (2007) summarise what motives the use of financial derivatives by corporations. Aabo and Ploeen (2014) highlight the importance of the new accounting standard for segment information section in firms' annual reports that gives direct motives for hedging FX risk, such as foreign sales ratios, foreign debt, and geographical diversification. For related instrumental variables with CM risk hedge, Carter *et al.* (2006) investigate jet fuel hedging behaviour of firms in the US airline industry and find that commodity purchase for operations is one of the most important determinants of hedging CM volatility price.

decisions (hedging overall, FX, IR, and CM risk) and the outcome variables are measures of stock return volatility and the implied cost of equity capital mean. The treatment effects control function (TE-GMM) estimator also has the advantages of controlling for self-selection bias.

4.3.3. Propensity-score matching approach

Next, we test the robustness of our results by using propensity-score matching (PSM) estimation approach. Based on theoretical literature on matching methods (Rosenbaum and Rubin, 1983; Heckman *et al.*, 1997; Rosenbaum, 2002; Imbens, 2004; Abadie and Imbens, 2006, 2011, 2012; Wooldridge, 2012), PSM method allows us to estimate the average effect for hedging decisions (control groups) with derivative users on the model outcomes (stock return volatility and the cost of equity capital) using heteroskedastic-robust variance estimation. The key characteristics of PSM method is that it belongs to a class of matching methods, which proceeds kernel and other specific functions to identify a control sample of firms that do hedging decisions but are otherwise similar in characteristics to the firms that do not hedge. Once these matching peers are identified, PSM method calculates the difference between two groups. This dynamic procedure reflects the comparison set of treatment group (hedgers) with non-hedgers, which reports the effects of hedging decisions on the expected outcome in our models estimation (stock return volatility and the cost of equity capital).

$$\tau = E[Y|\, W = 1] - E[E[Y|\boldsymbol{X}, W = 0]|\, W = 1\,] \qquad (3)$$

where τ is the average treatment effect on the derivative users (treated) under unconfoundeness assumptions (Abadie and Imbens, 2012), $\boldsymbol{X}$ represent a vector of variables in our model specification described in Eq.(1), W =1 represent derivative users (treated groups), W =0 is non-hedgers (untreated groups), and Y is the model outcomes (stock return volatility and the cost of equity capital) in matching procedures.

Hedging decisions in corporate risk management theories draw on the relations between hedging financial risks and economic benefits to the firm performance. These relations may be endogenous or cause heterogeneity concerns. A firm's decision to hedge a specific risk exposure is to a certain extent determined over time-varying, which in turn is likely to be related to observed firm characteristics such firm size, value, total and systematic risk, financial distress, agency costs, and opportunity growth (Smith and Stulz, 1985; Froot *et al.*, 1993; Bartram, 2000; Morellec and Smith, 2007; Aretz and Bartram, 2010). Ideally, one would like to run an experiment with pairs of matched firms that are identical in all firm characteristics with derivative users and nonusers to account for the difference of performance measures.

4.4. Data and descriptive statistics

4.4.1. Sample and data sources

This section introduces the sample and data sources employed in this study. Following the data structure of Bartram *et al.* (2011), we obtain our sample of derivative use for hedging financial risks (FX, IR, and CM) from firms' annual reports. The sample includes nonfinancial firms that have publicly incorporated in the UK and listed in the FTSE All-Share index for the period 2005 to 2012, and has non-missing data form the main variables of interest[55]. Further, in order to ensure that derivative use disclosures that are primarily used for collecting data on hedging policies and type of derivative instruments for particular risk exposures, we combine these datasets with detailed hedge accounting in firms' financial statements.

[55] Prior year 2005, reporting financial derivative instruments in firms' annual reports is inconsistent with detailed information on hedging activities and hedge accounting standards.

We classify a firm as a hedger or derivative user if there is a detailed hedge accounting and financial disclosures reporting the type of risk exposures (FX, IR, or CM), the type of derivative instruments implemented in firm strategy within the fiscal year and the notional amount of derivative contract if available in financial statements. [56] We precisely consider quantile descriptive statistics with 25th, 75th and 90th percentile. To test for potential sample outliers, all control variables are winsorised at 1st and 99th percentile values of the sample. A hand-collected data collection for derivatives use from the firms' annual reports is obtained to estimate the effects of corporate hedging decisions on the cost of equity capital. Continuous variables are mainly collected from the Bloomberg database over the time *t-2* and *t+1* of 2005-2012 period to calculate the cost of equity estimates implied in stock prices. Delisted firms are eliminated from the sample firm-year observations when collecting the data over time *t-2* and *t+1* periods. Because of investigating corporate financial risks for hedging purposes only, we exclude financial and utilities firms from this sample. The full sample counts 2,000 observations for 250 nonfinancial firms that have been used in stock return volatility regression estimation. Table 1 describes the variable definitions as follows.

[56] Hedge accounting has been recently developed under the International Financial Reporting Standards (IFRS) by early 2005 in context to which firms obviously have to acknowledge more details on hedge accounting and hedging policies.

Table 1. Description of variables

Variable	Definition	Data Source
Derivatives use:		
Hedging decisions	Dummy variable with value 1 if firms use derivative securities for hedging FX, IR or CM (H) risks, and 0 otherwise.	Annual report
Foreign currency hedge	Dummy variable with value 1 if firms use derivative securities for hedging foreign currency (FX) risk, and 0 otherwise.	Annual report
Interest rate hedge	Dummy variable with value 1 if firms use derivative securities for hedging interest rate (IR) risk, and 0 otherwise.	Annual report
Commodity price hedge	Dummy variable with value 1 if firms use derivative securities for hedging commodity price (CM) risk, and 0 otherwise.	Annual report
Firm characteristics:		
Beta value-weighted	The average company's beta for the year at time t, which is estimated by regressing daily individual stock returns over the fiscal year that based on CAPM asset pricing model provided by Bloomberg's analysts.	Bloomberg
Market value of equity	The share price of the company's stock at its fiscal year end multiplied by the number of common shares outstanding.	Bloomberg
Book-to-market	Book value of equity from the most recent available financial statements divided by market value of equity at time *t*.	Bloomberg
Profitability (ROA)	Return on assets (earnings before finance costs and tax/ book value of total assets).	Bloomberg
Capex/assets	Capital expenditures divided by book value of assets.	Bloomberg
R&D/assets	Research and development expense divided by book value of assets.	Bloomberg
Momentum	Percentage change over the last 6 months in the one month moving average of the share price (P^*) relative to a benchmark of FTSE-All share index.	Bloomberg
Analyst forecast dispersion	A ratio measure that is calculated by the natural log of the standard deviation of return on equity divided by the average of each of the analysts' current recommendations which takes a rank number between 1 -5.	Bloomberg
Long-term growth rate	Represents a forecast of the expected annual increase in operating earnings (OP) per share over the firm's next 3-5 years period.	Bloomberg
Leverage	Book value of total debt, including short and long debt / book value of total assets.	Bloomberg
Foreign sales ratio	The ratio of foreign sales to revenues (or net sales).	Annual report
Foreign expenditures	Dummy variable with value 1 if firms have foreign expenditures abroad and 0 otherwise.	Annual report
Geographical diversification	Dummy variable with value 1 if firms have subsidiaries outside the UK, and 0 otherwise.	Annual report
Floating rate debt	Dummy variable with value 1 if firm has borrowings debt in floating interest rate.	Annual report
Fixed rate debt	Dummy variable with value 1 if firm has borrowings debt in fixed interest rate.	Annual report
Commodity purchases	Dummy variable with value 1 if firms buy commodity for use in operations, and 0 otherwise.	Annual report
Commodity oil & gas	Dummy variable with value 1 if firms sell or produce oil, gas or mining related commodities, and 0 otherwise.	Annual report
Stock volatility	Two measures used to reflect stock volatility: the logarithm of squared daily returns (*VOL*) and The standard deviation of daily stock returns (σ_E).	
Cost of equity (R_{AV})	Average cost of equity capital based on two models: Ohlson and Juettner-Nauroth (2005) R_{OJ} ratio model and Easton (2004) R_{MPEG} ratio model.	Bloomberg

4.4.2. Dependent variables

Following (Bartram *et al.*, 2011; Li *et al.*, 2011; Chen *et al.*, 2013b; Cosset *et al.*, 2016), we use two proxies for estimating stock return volatility. The first is the logarithm of squared daily returns, where trading on the London Stock Exchange for a fiscal year is approximately 261 days. We use stock market data from Datastream Thomson Reuters to collect daily stock returns (R_i) for the sample. To enter the sample, a firm must have 261 days of returns in the fiscal year. We count 2000 firm-year observations over the time period of study 2005-2012. The second is the standard deviation of daily stock returns (σ_E), that is systematic volatility risk (Cosset *et al.*, 2016), therefore we calculate the stock return volatility in a fiscal year by annualising the total volatility for each stock *i.* Appendix A represents the mathematical models structure. For the implied cost of equity capital calculations, we follow the methodology of Easton (2004) and Ohlson and Juettner-Nauroth (2005). Many studies in the cost of equity estimates use the mean from different models to avoid one single model estimation errors. We use the mean of the cost of equity capital implied in stock prices from two models of estimation: Easton's earnings-performance model and Ohlson and Juettner-Nauroth's firm-valuation model (Appendix A).

4.4.3. Control variables

The widespread use of the capital asset pricing model (CAPM) in cross-sectional studies represents a fundamental basis for the important factors in describing important factors relating to asset returns. These fundamental risk factors and most influential variables allow us to map out our control variables in our models estimation. Drawing on prior studies, (e.g., Chen *et al.* (2013c); Dhaliwal *et al.* (2016)), we employ three groups of control variables: firm characteristics, asymmetric information, risk and financial distress measures.

Table 1 shows detailed variable definitions. We use the natural log of firm market equity as a proxy for firm size factor, book-to-market equity as a proxy for value factor, return on assets as a proxy for profitability factor, both capital expenditure and research and development divided by total assets as proxies for investment factor, momentum factor that defined as Percentage change over the last 6 months in one month the moving average of the share price (P^*) relative to a benchmark of the FTSE-All share index, analyst forecast dispersion and long-term growth rate as proxies for asymmetric information, beta-value weighted as a proxy for risk factor, and book leverage as a proxy for firm financial distress.

4.4.4. Descriptive statistics

Table 2, Panel A reports the hedging behaviour across the time period of 2005- 2012. Statistics show that the trend of hedging activities relating to overall hedge financial risks (FX, IR or CH) has been increasing from 80.0% to 86.0% over the time period of 2005-2012 while the majority of corporate hedging decisions have the highest activities percentage with regard to foreign currency (73.2%) risk and interest rate (64.0%) risk in comparison with commodity price (15.2%) hedge risk, respectively, by year 2012. In terms of sample frequency, a small percentage of sample observations relating to hedging the commodity price risk comes from firms in oil & gas industry or purchase commodity raw materials for intra operational activities (e.g., transportation). Panel B of Table 2, which details the firm level variables of sample observations, presents the descriptive statistics for the regression variables in this study. The means (medians) of market value of equity (log), book-to-market, profitability, capital expenditures and R&D ratios, momentum, analysts' forecast dispersion, long term growth rate, and book leverage are 2.880 (2.830), 0.628 (0.455), 0.058 (0.056), 0.047 (0.034), 0.016 (0.000), -0.002 (0.010), 0.122 (0.119), 0.107 (0.089), 0.223 (0.205), respectively. Since this study investigates the effects of corporate hedging decisions on risk measures and the cost of equity capital, Panel C of Table 2 presents means (medians) of beta value-weighted, stock volatility (VOL), standard deviation of stock returns (σ_{Ei}), and the implied cost of equity mean (R_{AVG}) are 0.859 (0.841), -3.070 (-2.810), 0.361 (0.318), 0.204 (0.171), respectively.

Table 2

Summary Statistics

This table reports summary statistics for variables of interest for UK-nonfinancial firms listed in the FTSE-All share index from 2005 to 2012. Panel A reports hedging decisions behaviour for the full sample of 250 firms, over time period, with related to hedging financial risks overall (H), foreign currency (FX), interest rate (IR) and commodity price (CM) risks. Panel B. reports firms' characteristics and other control variables for the full sample. Panel C reports risk and value measures for the dependent variables at firm levels. Full sample uses Bloomberg data sets for all firms' characteristics, while dummy variables of hedging decisions are hand-collected precisely from firms' annual reports for the period 2005-2012. Prior to 2005, the availability of information relating to hedge accounting according to financial standards was inconsistent. Continuous control variables, in Panel B, are winsorised at their 1^{th} and 99^{th} percentiles for omitting outliers. Hedging decisions, foreign currency, interest rate and commodity price risk set to a dummy variable with one if the firm reports using derivative instruments for hedging overall or any types of risk exposures, respectively, and zero otherwise. Motivated by Fama and French (2016) and firm-valuation models, the control variables include firm size, value, profitability, investment, firm growth, and other factors to the market. The natural logarithm of market value of equity calculated at the end of fiscal year is a proxy for firm size. Book-to-market is the book value of equity divided by market value of equity at time *t*. Profitability relates to return on assets calculated as earnings before finance costs and tax divided by book value of total assets. We use the ratio of capital expenditure to total assets and the ratio of research and development to total assets as proxies for investment risk factor. Momentum relating stock return is the percentage change over the last 6 months in the one month moving average of the share price (P^*) relative to a benchmark index in UK. Analyst forecast dispersion is the natural logarithm of the std. deviation of the analysts' estimate for the next period's return on equity divided by the consensus forecast rank set to 1-5. Long-term growth rate is the forecast of the expected annual increase in operating earnings (*OP*) per share over the firm's next 3 years period. Beta value-weighted is estimated by regressing daily individual stock returns over the fiscal year based on CAPM asset pricing model. Leverage is the Book value of total debt, including short and long debt divided by book value of total assets. All other variable definitions are in Table 1.

Panel A: Hedging behaviour across time

Time periods	Total	Hedging (any)		Foreign currency hedging		Interest rate hedging		Commodity hedging	
		N	%	N	%	N	%	N	%
2005	250	200	80.0%	156	62.4%	154	61.6%	32	12.8%
2006	250	204	81.6%	163	65.2%	155	62.0%	35	14.0%
2007	250	213	85.2%	171	68.4%	161	64.4%	33	13.2%
2008	250	216	86.4%	173	69.2%	164	65.6%	38	15.2%
2009	250	218	87.2%	176	70.4%	168	67.2%	36	14.4%
2010	250	219	87.6%	178	71.2%	168	67.2%	37	14.8%
2011	250	217	86.8%	183	73.2%	167	66.8%	39	15.6%
2012	250	215	86.0%	183	73.2%	160	64.0%	38	15.2%
Total	250	1702	85.1%	1383	69.2%	1297	64.9%	288	14.4%

Panel B. summary statistics of firm level variables

Variable	N	Mean	Median	Std.	25th	75th	90th
Hedging decisions	2000	0.851	1.000	0.356	1.000	1.000	1.000
Foreign currency hedge	2000	0.692	1.000	0.462	0.000	1.000	1.000
Interest rate hedge	2000	0.648	1.000	0.478	0.000	1.000	1.000
Commodity hedge	2000	0.144	0.000	0.351	0.000	0.000	1.000
Market value of equity (log)	2000	2.880	2.830	0.771	2.340	3.340	3.900
Book-to-market (B/M)	2000	0.628	0.455	0.602	0.258	0.806	1.260
Profitability (ROA)	2000	0.058	0.056	0.092	0.028	0.094	0.143
Capex/assets	2000	0.047	0.034	0.047	0.015	0.063	0.105
R&D/assets	2000	0.016	0.000	0.053	0.000	0.004	0.047
Momentum	2000	-0.002	0.010	0.203	-0.058	0.018	0.196
Analyst forecast dispersion	2000	0.122	0.119	0.165	0.038	0.204	0.299
Long-term growth rate	2000	0.107	0.089	0.119	0.056	0.130	0.200
Leverage	2000	0.223	0.205	0.177	0.077	0.323	0.461
Foreign sales ratio	2000	0.498	0.563	0.388	0.038	0.876	0.990
Foreign expenditures	2000	0.851	1.000	0.357	1.000	1.000	1.000
Geographical diversification	2000	0.792	1.000	0.406	1.000	1.000	1.000
Floating rate debt	2000	0.900	1.000	0.300	1.000	1.000	1.000
Fixed rate debt	2000	0.716	1.000	0.451	0.000	1.000	1.000
Commodity purchases	2000	0.186	0.000	0.389	0.000	0.000	1.000
Commodity oil & gas	2000	0.092	0.000	0.289	0.000	0.000	0.000
Earnings per share (EPS)	2000	0.518	0.245	1.180	0.105	0.522	1.140
Dividends per share (DPS)	2000	0.157	0.092	0.227	0.033	0.184	0.366

Panel C. summary statistics of risk measures at firm-level

Variable	N	Mean	Median	Std.	25th pctl	75th	90th
Risk and Value Measures							
Beta value-weighted	2000	0.859	0.841	0.285	0.661	1.040	1.220
Std. deviation of ROE (log)	2000	0.456	0.477	0.577	0.154	0.778	1.080
stock volatility (*VOL*)	2000	-3.070	-2.810	2.190	-4.180	-1.580	-0.627
Std. deviation of stock returns	2000	0.361	0.318	0.171	0.247	0.426	0.578
Cost of equity R_{OJ}	1136	0.205	0.172	0.148	0.119	0.256	0.362
Cost of equity R_{MPEG}	1151	0.201	0.167	0.147	0.114	0.253	0.359
Cost of equity mean R_{AVG}	1135	0.204	0.171	0.147	0.118	0.255	0.363
Capital Markets Data							
Stock return (*Ri*)	2000	0.036	0.102	0.486	-0.168	0.296	0.508
Market return (*Rm*)	2000	0.077	0.070	0.025	0.054	0.100	0.121

4.5. Empirical results

4.5.1. Univariate results

We begin our empirical analysis by the univariate results in Table 3 reporting the mean difference between hedgers vs. nonhedgers and Wilcoxon median difference test statistics. The descriptive statistics of our sample, reported in Table 3, indicate that firms with derivatives use are typically much larger in size, they also have higher value, slightly a less level of profitability, and invest less. We perform several diagnostic tests in the univariate analysis section to evaluate our sample for the successfulness of PSM matching procedures relating hedging decisions, control variables, and the model outcomes (stock returns volatility and the cost of equity capital).

The univariate test results are only suggestive of underlying relations for matched sample characteristics because other unobserved variables are not controlled. Across all firms and time period, we classify the variables to risk measures and firm characteristics to provide a distinguished view for the matched sample that accounts for 2,000 firm-year observations. When we are unable to calculate the implied cost of equity capital measured by R_{OJ} *and* R_{MPEG} because the conditional structure of the model specification requiring $EPS_{t+2} > EPS_{t+1} > 0$, we drop the observations resulting in 1135 firm-year observations for the implied cost of equity capital mean (R_{AVG}). As shown in Panel A of Table 3, firms with derivative use have a lower stock returns volatility by 3.8% in our matched sample, and statistically significant in mean and median difference. By contrast, Bartram *et al.* (2011) document that stock returns volatility for derivatives users is on average, 18% lower than nonusers, based on a large sample of nonfinancial firms from 47 countries. Evidence on whether derivatives use can alleviate the stock returns volatility and the cost of equity implied in stock prices over time for some firms, at least in part, due to the inclusion of a greater market value in our matched sample as shown of Panel B of Table 3.

Table 3

Univariate Tests of Risk factors and Derivatives Use

This table presents the number of observations (N), mean, median and difference in mean of risk factors and firms' characteristics for the PSM matched sample of hedgers and nonhedgers firms. The sample covers 2,000 firm-year observations based on 250 firms from 2005 to 2012. For each cost of equity estimate (R_{OJ} ,R_{MPEG} and R_{AVG}) we require the estimate to be positive to enter the sample, resulting in sample sizes ranging from 1135 to 1151 firm-year observations. The univariate tests report the difference in distribution between two samples whether is statistically significance. The last column presents *p*-value of Wilcoxon rank sum tests between hedgers vs. nonhedgers, where ***, **, and * denote significance at the 1%, 5%, and 10% level, respectively. The variable definitions are in Table 1.

	Full sample			Hedgers			Nonhedgers			Mean Diff.	Wilcoxon
variable name	N	Mean	Median	N	Mean	Median	N	Mean	Median		*p*-value
Panel A. risk measures											
Beta value-weighted	2000	0.859	0.841	1702	0.870	0.849	298	0.799	0.787	0.071***	0.000
stock volatility (*VOL*)	2000	-3.070	-2.810	1702	-3.090	-2.840	298	-2.940	-2.530	-0.153	0.075
Std. deviation of stock returns	2000	0.361	0.318	1702	0.355	0.314	298	0.394	0.348	-0.038***	0.000
Stock return (*Ri*)	2000	0.036	0.102	1702	0.032	0.100	298	0.058	0.127	-0.026	0.257
Cost of equity R_{OJ}	1136	0.205	0.172	965	0.206	0.174	171	0.199	0.156	0.007	0.234
Cost of equity R_{MPEG}	1151	0.201	0.167	978	0.202	0.170	173	0.195	0.151	0.007	0.230
Cost of equity mean R_{AVG}	1135	0.204	0.171	964	0.205	0.172	171	0.198	0.154	0.007	0.213
Panel B. Firm characteristics											
Market value of equity	2000	2.880	2.830	1702	2.940	2.880	298	2.550	2.590	0.394***	0.000
Book-to-market (B/M)	2000	0.628	0.455	1702	0.632	0.467	298	0.608	0.379	0.023	0.003
Profitability (ROA)	2000	0.058	0.056	1702	0.056	0.054	298	0.064	0.069	-0.008	0.005
Capex/assets	2000	0.047	0.034	1702	0.047	0.035	298	0.049	0.023	-0.002	0.004
R&D/assets	2000	0.016	0.000	1702	0.015	0.000	298	0.022	0.000	-0.008**	0.003
Momentum	2000	-0.002	0.010	1702	-0.001	0.010	298	-0.009	0.010	0.008	0.346
Analyst forecast dispersion	2000	0.122	0.119	1702	0.122	0.117	298	0.123	0.126	-0.002	0.696
Long-term growth rate	2000	0.107	0.089	1702	0.102	0.087	298	0.132	0.100	-0.030***	0.000
Leverage	2000	0.223	0.205	1702	0.239	0.225	298	0.128	0.070	0.112***	0.000
Foreign sales ratio	2000	0.498	0.563	1702	0.485	0.539	298	0.574	0.696	-0.089***	0.000
Foreign expenditures	2000	0.851	1.000	1702	0.866	1.000	298	0.762	1.000	0.104***	0.000
Geographical diversification	2000	0.792	1.000	1702	0.789	1.000	298	0.809	1.000	-0.020	0.441
Floating rate debt	2000	0.900	1.000	1702	0.942	1.000	298	0.661	1.000	0.281***	0.000
Fixed rate debt	2000	0.716	1.000	1702	0.783	1.000	298	0.336	0.000	0.447***	0.000
Commodity purchases	2000	0.186	0.000	1702	0.209	0.000	298	0.057	0.000	0.152***	0.000
Commodity oil & gas	2000	0.092	0.000	1702	0.081	0.000	298	0.158	0.000	-0.077***	0.000

Table 4 reports correlation coefficients among the variables used in this study. The results show that there is no multicollinearity problem in the regression models where variables of interests are used. We find that hedging decisions (H) is negatively correlated with the standard deviation of stock returns (σ_{Ei}) with a magnitude of -0.080, and statistically significant at 1%. Specifically, hedging FX risk, hedging IR risk, and hedging CM risk are also negatively correlated with the standard deviation of stock returns (σ_{Ei}), suggesting that hedging financial risks can provide a source of economic benefits to alleviate total and systematic risk.

Table 4

Correlation Matrix

This table provides a correlation matrix between risk measures, including stock volatility (*VOL*) and standard deviation of stock returns (σ_E), implied cost of equity mean (R_{AVG}) and the variables used in regressions analyses, respectively. We provide the Pearson correlation coefficients for all variables which are defined in Table 1. The results presented in bold mean that the coefficients are statistically significant at 1% level.

Variable	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)
1. Stock volatility (*VOL*)	1.000															
2. Std. deviation of stock returns (σ_E)	**0.307**	1.000														
3. Cost of equity mean R_{AVG}	**0.079**	**0.148**	1.000													
4. Hedging decisions	-0.025	**-0.080**	0.018	1.000												
5. Foreign currency hedge	0.042	**-0.085**	**-0.088**	**0.627**	1.000											
6. Interest rate hedge	0.017	**-0.074**	**0.085**	**0.568**	**0.216**	1.000										
7. Commodity price hedge	0.009	-0.041	-0.005	**0.168**	**0.160**	**0.171**	1.000									
8. Market value of equity	**0.210**	**-0.216**	**-0.126**	**0.182**	**0.172**	**0.193**	**0.210**	1.000								
9. Book-to-market (B/M)	**0.196**	**0.247**	**0.365**	0.014	**-0.119**	**0.074**	**-0.100**	**0.305**	1.000							
10. Profitability (ROA)	**-0.127**	**-0.269**	**-0.189**	-0.031	0.057	**-0.113**	0.000	**0.167**	**-0.235**	1.000						
11. Capex/assets	0.005	-0.010	-0.025	-0.016	-0.046	0.005	**0.175**	**0.074**	**-0.089**	**0.103**	1.000					
12. R&D/assets	0.014	**0.077**	**-0.086**	-0.051	0.040	**-0.214**	**-0.078**	**-0.076**	**-0.095**	-0.057	**-0.076**	1.000				
13. Momentum	**-0.078**	**-0.185**	**-0.171**	0.013	0.022	-0.040	0.036	**0.128**	**-0.225**	**0.157**	-0.038	**0.078**	1.000			
14. Analyst forecast dispersion	0.043	0.029	-0.016	-0.004	0.007	-0.026	-0.001	**0.128**	**-0.225**	**0.157**	-0.038	0.078	1.000	1.000		
15. Long-term growth rate	0.007	-0.008	-0.028	**-0.089**	**-0.081**	**-0.088**	0.007	0.009	**-0.098**	**0.062**	0.052	0.009	0.015	0.000	1.000	
16. Leverage	**0.067**	0.020	**0.165**	**0.224**	-0.012	**0.466**	0.047	**0.073**	**0.094**	**-0.170**	**0.170**	**-0.219**	**-0.086**	**0.012**	**0.086**	1.000
17. Beta value-weighted	**0.106**	**0.133**	0.012	**0.089**	0.042	**0.151**	**0.151**	**0.372**	**0.077**	-0.047	0.044	0.014	0.002	-0.083	0.028	**0.100**

4.5.2. Multivariate results

In this section, we explore the relationship between hedging decisions and stock return volatility, as well as the impact of hedging financial risks on the cost of equity capital. We control firm characteristics such as firm size, value, profitability, investment and growth. Based on prior research, our proxies for firm characteristics capture the most influential factors on the stock return volatility and the cost of equity capital implied in stock prices. We investigate the effects of corporate hedging decisions overall on our models outcomes by constructing a dummy variable that equals one when a firm reports derivative instruments use for hedging purposes with any financial risks exposures (FX, IR or CM), and equals zero otherwise. Therefore, we also construct a dummy variable that equals one when a firm reports derivative instruments use for each type of financial risk exposure (FX, IR and CM) respectively, and equals zero otherwise.

We start with regressions that show the effects of corporate hedging decisions on the stock return volatility. Table 5 reports our results of OLS regressions with time and industry fixed effects; standard errors are robust. The dependent variable in Panel A of Table 5 is stock return volatility proxied by the logarithm of squared daily returns. Panel B of Table 5 reports the regression estimation of stock return volatility using an alternative measurement of volatility which is the standard deviation of daily stock returns (σ_E). The explanatory variable of interest in all our models is hedging decisions, including hedging overall (H), foreign currency (FX), interest rate (IR) and commodity price (CM) risk hedge. We also control for a number of firm characteristics previously defined in Eq. (1). The coefficients estimation results in Panel B of Table 5 are statistically negative and strongly significant, which means that firms with hedging decisions overall (H), FX risk, IR risk and CM risk have a 3.7%, 1.7%, 2.8% and 2.6% lower stock return volatility (σ_E), respectively.

Table 5

OLS Regressions: The Effect of Hedging Activities on Stock Return Volatility

This table reports results from OLS regressions relating the stock return volatility to corporate hedging decisions and control variables for non-financial firms listed in the FTSE-All share index in London Stock Exchange (LSE) from 2005 to 2012. The dependent variables are the stock return volatility using two proxies. The first, in Panel A, is calculated using the logarithm of squared daily returns, and the second, in Panel B, is the standard deviation of daily stock returns. More specifically, columns (1) and (5) report the results for the effect of corporate hedging (overall) activities on stock return volatility proxies, respectively. Columns 2-4 and 6-8 report the results for the effect of hedging the FX, IR and CM risks on stock volatility (*VOL*) and standard deviation of stock returns (σ_E), respectively. Robust standard errors are in between parentheses. ***, **, and * denote significance at the 1%, 5%, and 10% level, respectively. All variables are defined in Table 1.

Explanatory variables	Pred. sign	Panel A. Stock Volatility (*VOL*)				Panel B. Std. Deviation of Stock Returns (σ_E)			
		H	FX	IR	CM	H	FX	IR	CM
		(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Hedging decisions	-	-0.041	0.036	0.093	0.068	-0.037***	-0.017**	-0.028***	-0.026***
		(0.150)	(0.107)	(0.116)	(0.143)	(0.010)	(0.007)	(0.007)	(0.007)
Market value of equity	-	-0.618***	-0.626***	-0.631***	-0.626***	-0.038***	-0.040***	-0.039***	-0.040***
		(0.078)	(0.077)	(0.078)	(0.077)	(0.005)	(0.005)	(0.005)	(0.005)
Book-to-market (B/M)	+	0.341***	0.342***	0.336***	0.343***	0.004	0.002	0.004	0.002
		(0.080)	(0.081)	(0.081)	(0.081)	(0.008)	(0.008)	(0.008)	(0.008)
Profitability (ROA)	-	-0.976*	-0.978*	-0.949	-0.962*	-0.311***	-0.307***	-0.317***	-0.314***
		(0.580)	(0.579)	(0.583)	(0.582)	(0.061)	(0.062)	(0.062)	(0.063)
Capex/assets	-	0.509	0.516	0.548	0.471	0.089	0.085	0.076	0.102
		(0.979)	(0.979)	(0.979)	(0.989)	(0.062)	(0.062)	(0.062)	(0.063)
R&D/assets	-	0.440	0.439	0.536	0.467	0.226***	0.227***	0.198***	0.217***
		(0.992)	(0.990)	(0.992)	(0.992)	(0.075)	(0.076)	(0.075)	(0.077)
Momentum	-	0.078	0.078	0.076	0.075	-0.050**	-0.052**	-0.051**	-0.051**
		(0.238)	(0.238)	(0.238)	(0.238)	(0.023)	(0.023)	(0.023)	(0.023)
Analyst forecast dispersion	+	0.769**	0.765**	0.771**	0.764**	0.063***	0.062***	0.060***	0.063***
		(0.309)	(0.308)	(0.308)	(0.309)	(0.019)	(0.019)	(0.019)	(0.019)
Long-term growth rate	+	0.539	0.555	0.554	0.553	0.027	0.026	0.028	0.028
		(0.390)	(0.391)	(0.390)	(0.390)	(0.025)	(0.025)	(0.025)	(0.025)
Beta value-weighted	+	1.413***	1.413***	1.406***	1.407***	0.099***	0.100***	0.102***	0.102***
		(0.177)	(0.177)	(0.177)	(0.178)	(0.013)	(0.013)	(0.013)	(0.013)
Leverage	+	0.596**	0.581**	0.479	0.577**	-0.028	-0.042	- 0.011	-0.041
		(0.288)	(0.283)	(0.306)	(0.282)	(0.021)	(0.022)	(0.023)	(0.021)
Intercept		-1.816***	-1.873***	-1.853***	-1.833***	0.620***	0.608***	0.597***	0.590***
		(0.325)	(0.318)	(0.308)	(0.307)	(0.025)	(0.024)	(0.023)	(0.024)
Year & industry FE		Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Adjusted R^2		0.134	0.134	0.134	0.134	0.476	0.473	0.476	0.473
Observations		2000	2000	2000	2000	2000	2000	2000	2000

Table 6 represents the effect of hedging decisions overall risks and financial risk exposures (FX, IR, and CM) on the cost of equity capital implied in stock prices. Models 1-4 are OLS regressions with time and industry fixed effects; robust standard errors. Similarly, the explanatory variable of interest is hedging decisions and firms' characteristics defined in Eq.(1). The coefficients in model 1-4 for hedging decisions are negative and consistent with prior research (e.g., Gay *et al.* (2011)), but insignificant. Because we use a panel data set, all of our estimation involving robust standard errors specification are corrected for industry and year fixed effects. For model 1 in Table 6, we see that hedging decisions overall (H) indicator variable is negatively related to the cost of equity. The estimated coefficient of -0.008 indicates that corporate hedging decisions reduce the cost of equity implied in stock price. Similar results are found in model 2-4 for hedging risks (FX, IR, and CM). The estimated coefficients in models 2-4 indicate a decrease in the cost of equity of -0.010, -0.005, and -0.002, respectively.

With respect to the theoretical predicted sign, we observe firms associated with greater financial distress are strongly associated with a higher cost of equity in the market imperfections. We find that firm leverage in models 1-4 of Table 6 is positively correlated with the cost of equity while having greater profitability is negatively related. Consistent with previous findings in prior research (e.g., Dhaliwal *et al.* (2016)), we predict the signs in Table 6 on the estimated coefficients on the control variables, which showing that the cost of equity capital is positively related to the book-to-market ratio, analysts forecast dispersion, long-term growth rate, beta value-weighted, leverage. Further, the implied cost of equity capital is expected to be negatively correlated with the logarithm of market value of equity, profitability, capital expenditure divided by book value of total assets, research and development divided by book value of total assets, and price momentum. We define industries at the two-digit SIC level. We include industry and year fixed effects controls for omitted industry characteristics within the two-digit SIC code in a given year. Thus, the industry and year fixed effects account for potential industry effects on hedgers' cost of equity capital in any particular year. The estimated standard errors in all regressions are robust and clustered at the firm level to correct for serial correlation within groups. However, these results do not account for the endogeneity concerns and the self-selection of firms into having a hedging activity relating to specific risk exposures. To address this concern, we employ in the following section instrumental variables and treatment effects approaches with the GMM system model which attracted significant attention in the recently developed studies dealing with issues of endogeneity in corporate hedging.

Table 6

OLS Regressions: The Effect of Hedging Activities on Implied Cost of Equity Capital

This table reports results from OLS regressions relating the impact of corporate hedging decisions on the implied cost of equity capital for nonfinancial firms based in UK and listed in the FTSE-All share index from 2005 to 2012. The dependent variable in columns 1-4 is the implied cost of equity calculated by taking the mean of the two individual estimates of R_{OJ} and R_{MPEG} and is in excess of the UK yield on 10-year Treasury bonds. Corporate hedging decisions in column (1) relating hedging risks overall (H) is an indicator dummy variable set to one if a firm does hedging decisions for any types of financial risks, and zero otherwise. Columns 2-4 relating foreign currency, interest rate and commodity price risk is an indicator dummy variable set to one, respectively, if a firm uses derivative instruments (i.e., future, forward, options and swaps) on time *t*, and zero otherwise. Robust standard errors are in between parentheses. ***, **, and * denote significance at the 1%, 5%, and 10% level, respectively. All variables are defined in Table 1.

Explanatory variables	Pred. sign	Hedging Decisions			
		H	FX	IR	CM
		(1)	(2)	(3)	(4)
Hedging decisions	-	-0.008 (0.014)	-0.010 (0.009)	-0.005 (0.009)	-0.002 (0.010)
Market value of equity (log)	-	0.002 (0.007)	0.002 (0.007)	0.002 (0.007)	0.002 (0.007)
Book-to-market (B/M)	+	0.088*** (0.020)	0.087*** (0.020)	0.088*** (0.020)	0.088*** (0.020)
Profitability (ROA)	-	-0.118*** (0.045)	-0.116** (0.046)	-0.118*** (0.045)	-0.116** (0.046)
Capex/assets	-	-0.057 (0.100)	-0.056 (0.099)	-0.059 (0.100)	-0.056 (0.101)
R&D/assets	-	-0.062 (0.053)	-0.063 (0.053)	-0.066 (0.053)	-0.062 (0.053)
Momentum	-	-0.033 (0.024)	-0.033 (0.024)	-0.033 (0.024)	-0.033 (0.024)
Analyst forecast dispersion	+	0.033 (0.025)	0.033 (0.025)	0.032 (0.025)	0.033 (0.025)
Long-term growth rate	+	0.023 (0.033)	0.021 (0.033)	0.024 (0.033)	0.024 (0.033)
Beta value-weighted	+	-0.010 (0.020)	-0.010 (0.020)	-0.010 (0.020)	-0.010 (0.020)
Leverage	+	0.114*** (0.033)	0.110*** (0.033)	0.117*** (0.036)	0.111*** (0.033)
Intercept		0.135*** (0.032)	0.137*** (0.030)	0.130*** (0.029)	0.129*** (0.029)
Year & industry FE		YES	YES	YES	YES
Adjusted R^2		0.175	0.176	0.175	0.175
Observations		1135	1135	1135	1135

4.5.3. Endogeneity issues and control function approach

Our previous analysis shows that effects of hedging financial risks alleviate the stock return volatility and also reduce the cost of equity capital. The extended multivariate models including IV-GMM, treatment effects control function, and propensity score-matching approach provide strong support that the relationship between corporate hedging and the stock return volatility as well as the implied cost of equity capital is not driven by the possibility of model misspecification, time-varying firm characteristics, and endogeneity issues.

However, it is still possible in our models specification that endogeneity concerns arising from unobserved omitted variables remains. For example, we are unable to observe: (1) hedging decisions are time-varying and affecting the stock return volatility and the cost of equity capital, and (2) the determinants of hedging decisions may be correlated with other variables of firms' characteristics and could result in bias findings. Therefore, we use the instruments variables approach utilising a feasible generalised method of moments (IV-GMM) estimator. It is well-known that in the econometric literature that IV-GMM estimator is more efficient than other estimators when employing related instruments variables to the endogenous variable of interest. It consistently generates efficient coefficients estimation in case of heteroscedastic error terms (Wooldridge, 2001). Thus, we examine the robustness of our model IV-GMM testing the validity of the instruments used for hedging determinants.

Specifically, consistently with prior research (e.g., Allayannis *et al.* (2012)), we select the number of instrumental variables associated with hedging determinants, implying that the instruments are exogenous with respect to the firm's cost of equity capital. The instruments include: (1) foreign sales ratio, foreign expenditures, and geographic diversification with regards to hedging FX risk; (2) the floating and fixed rate debt with regards to IR risk; and (3) commodity operational purchases and commodity oil & gas producers for CM risk. The instrumental variable (IV-GMM) approach performs a first stage regression estimation, in which each model entirely (1-4) regresses the hedging decision relating to either overall hedge (H) or any specific risk hedge (FX, IR, and CM) on the hedging determents, respectively.[57] This approach relies on specific robustness tests that confirm the instrumental variables used in our models are jointly valid and strong. We test instrumental variables in four ways, including endogeneity, weak instruments, and overidentification tests.

First, *Wu-Hasman* test statistics for endogeneity concerns show that models 1 and 2 count for endogeneity issues and statistically significant at 5%, but model 3 and 4 the *p-value* is insignificant. Second, we perform several tests for the null hypothesis of weak instruments that the *Kleibergen-Paap rank LM* and rank *Wald F* statistics developed recently by Kleibergen and Paap (2006) using the robust GMM estimates. Third, *Stock and Yogo* test measures how strong the identification is in our sample if errors are not assumed to be independently and identically distributed, which the measure is greater than the critical value in all models 1-4 of Table 7. Forth, the results of *Hansen J statistics* for overidentification test show that *p-value* is insignificant, which means that we are unable to reject the null hypothesis that our selected instruments are uncorrelated with error term, implying that the overidentification restrictions are accepted and the instruments used are jointly valid and strong in all our models.

The main dependent variable of interest in our models is the cost of equity capital mean. First, Table 7 Panel A reports the instrumental variables IV-GMM approach showing that hedging decisions, including hedging overall (H), foreign currency (FX), interest rate (IR) and commodity price (CM) risk alleviate the cost of equity capital. Therefore, columns 1-4 report the regressions analysis estimation of IV-GMM method; and the coefficients are -0.122, -0.044, -0.016, and -0.010 for hedging overall (H), FX, IR, and CM hedge risk,

[57] First stage regression estimation is not reported for brevity, but it is available upon request.

respectively. The results in model 1 and 2 are statistically negative and significant. The results are consistent with prior research. For example, Gay *et al.* (2011) document findings, which employ Fama-French risk factors model to investigate the relation between derivative use and the cost of equity, showing that the use of derivative instruments reduces firms' financial distress and the cost of equity. Their study to the extent that the instrumental variables employed in our models are strongly valid, the results of Panel A of Table 7 suggest that greater hedging activities relating to hedging financial risks causally decreases a firm's cost of equity capital implied in stock prices.

In order to estimate the average treatment effects (ATEs) of hedging decisions on the outcome variable (the implied cost of equity capital), we use the treatment effects approach with control function GMM estimator when the outcome variable model may not be conditionally independent of hedging effects.[58]

When firms with hedging decisions (treatment group) suffer from the endogeneity concerns relating the interaction of hedging decision with unobserved heterogeneity conditional on exogenous variables in our models, the control function method implemented recently in ATEs approach can be valuable and provides consistent estimation (Wooldridge, 2008). Panel B of Table 7 reports treatment effects control function (GMM) approach to investigate a potential self-selection bias in our models. Standard error is robust to some kind of misspecification. In the first stage regression, we run a probit regression with relating instrumental variables using GMM estimator to get the predicted value of hedging decisions for financial risk exposures. In the second stage, we use these predicted values as independent variables in regression to predict the implied cost of equity capital (outcome).

[58] The control function approach developed by Heckman and Navarro-Lozano (2004) is asymptotically more efficient in discrete models than an alternative two-stage estimation approach and more robust to omitted variables (Blundell and Powell, 2004).

Table 7

Multivariate Regressions Models of Implied Cost of Equity Capital on hedging risks and other determinants.

This table reports an analysis of the effect of hedging financial risks and other factors on the implied cost of equity. The dependent variable in all regressions estimates is the implied cost of equity calculated by taking the mean of the two individual estimates of R_{OJ} and R_{MPEG} and is in excess of the UK yield on 10-year Treasury bonds. The regressions pertain to our sample of 250 firms representing 1135 firm-year observations. We use a hand-collected data set on the firms' usage of financial derivative instruments for corporate hedging decisions relating to hedging overall (H), foreign currency (FX), interest rate (IR) and commodity price risk (CM), respectively. Panel A reports IV-GMM estimates on the impact of hedging decisions, in columns (1-4) and other determinants on the implied cost of equity. The fitted values from the first stage regressions are used in running regressions of (IV-GMM) in the second stage. For the IV-GMM estimation, instrumental variables including: foreign sales, foreign expenditures, and geographical diversification are used column (1-2); floating rate and fixed rate are used in column (3); and commodity raw material purchase and commodity oil and gas are used in column (4). The 'Hansen J statistic' is a test of the validity of instruments used under the null hypothesis that instruments are endogenous and weak. Rejecting the null hypothesis suggests that the instruments used are jointly strongly valid. Panel B reports the results of a Treatment Effects model with control function GMM system. Columns 5-8 report the impact of hedging overall and types of financial risk exposures (FX, IR and CM), respectively. The treatment effects model differs from the IV-GMM estimation model, in Panel A, in terms of assumptions of the error term where are assumed to have a bivariate distribution with correlation ρ. Continuous variables, in all regressions specification above, are winsorised at 1% and 99% levels. The regressions are includes controls for the two-digit SIC code of the industry. Robust standard errors are in between parentheses; ***, **, and * denote significance at the 1%, 5%, and 10% level, respectively. All variables are defined in Table 1.

		Panel A. IV-GMM model				Panel B. Treatment effects model			
Explanatory variables	Pred. sign	H	FX	IR	CM	H	FX	IR	CM
		(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Hedging decisions	-	-0.122**	-0.044***	-0.016	-0.010	-0.150***	-0.044***	-0.033*	-0.012
		(0.052)	(0.017)	(0.018)	(0.016)	(0.054)	(0.017)	(0.020)	(0.015)
Market value of equity	-	0.012	0.005	0.001	0.002	0.002	0.002	0.003	0.002
		(0.009)	(0.007)	(0.007)	(0.007)	(0.007)	(0.007)	(0.007)	(0.007)
Book-to-market (B/M)	+	0.086***	0.082***	0.082***	0.087***	0.089***	0.088***	0.089***	0.087***
		(0.020)	(0.018)	(0.019)	(0.019)	(0.019)	(0.019)	(0.020)	(0.019)
Profitability (ROA)	-	-0.146***	-0.119***	-0.120***	-0.120***	-0.122***	-0.107**	-0.118***	-0.118***
		(0.048)	(0.045)	(0.044)	(0.045)	(0.044)	(0.045)	(0.044)	(0.045)
Capex/assets	-	-0.055	-0.049	-0.066	-0.048	-0.052	-0.065	-0.062	-0.056
		(0.105)	(0.098)	(0.100)	(0.100)	(0.097)	(0.097)	(0.099)	(0.100)
R&D/assets	-	-0.094	-0.074	-0.094*	-0.065	-0.040	-0.049	-0.079	-0.066
		(0.064)	(0.053)	(0.050)	(0.052)	(0.055)	(0.053)	(0.051)	(0.052)
Momentum	-	-0.037	-0.037	-0.038	-0.034	-0.036	-0.036	-0.032	-0.033
		(0.025)	(0.024)	(0.024)	(0.024)	(0.024)	(0.024)	(0.024)	(0.024)
Analyst forecast dispersion	+	0.032	0.035	0.023	0.033	0.034	0.036	0.033	0.033
		(0.028)	(0.025)	(0.024)	(0.025)	(0.025)	(0.025)	(0.025)	(0.025)
Long-term growth rate	+	0.010	0.011	0.024	0.022	0.023	0.026	0.023	0.024
		(0.034)	(0.034)	(0.033)	(0.033)	(0.033)	(0.033)	(0.033)	(0.033)
Beta value-weighted	+	-0.018	-0.007	-0.015	-0.010	-0.015	-0.014	-0.009	-0.010
		(0.020)	(0.020)	(0.019)	(0.020)	(0.020)	(0.020)	(0.020)	(0.020)
Leverage	+	0.149***	0.105***	0.117***	0.110***	0.110***	0.104***	0.156***	0.111***
		(0.045)	(0.032)	(0.042)	(0.032)	(0.032)	(0.031)	(0.049)	(0.032)
Intercept		0.227***	0.168***	0.165***	0.146***	0.276***	0.177***	0.153***	0.148***
		(0.041)	(0.031)	(0.030)	(0.033)	(0.048)	(0.031)	(0.033)	(0.033)
Year & industry FE		Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Kleibergen–Paap rk LM statistic (p-value)		0.000	0.000	0.000	0.000				
Kleibergen–Paap rk Wald F statistic		16.585	264.408	178.509	143.613				
Stock-Yogo test		13.910	13.910	19.930	19.930				
Hansen J statistic (p-value)		0.486	0.832	0.206	0.606				
Wu-Hausman test (p-vlaue)		0.029	0.011	0.489	0.540				
Wald test - Chi-squared statistic						4.490	5.070	3.730	0.720
Wald test (p-value)						(0.034)	(0.024)	(0.053)	(0.397)
Adjusted R^2		0.105	0.165	0.173	0.175				
Observations		1135	1135	1135	1135	1135	1135	1135	1135

Our results in Panel B of Table 7 show that hedging decisions overall (H), FX hedge, IR hedge, and CM hedge risk, are negatively and significantly related to the cost of equity capital implied in stock prices, suggesting that firms making corporate hedging decisions have contributions of a lower cost of equity capital. The coefficient of hedging decisions overall (H) is -0.150 and statistically significant at 1% level, which suggests that on average the implied cost of equity with derivative users is lower than non-users. Similarly, column 6 to 8 present the impact of hedging decisions relating specific risk exposures (FX, IR, and CM) on the cost of equity capital, where the coefficients are -0.044, -0.033, and -0.012, respectively, which consistently show that hedging decisions alleviate the cost of equity capital. Wald test of independent equations ($\rho = 0$) shows that models 5 to 7 have a self-selection bias, which has been considered in treatment effects models at the 5% significance level. The results in ATE control function with GMM estimator reject the null hypothesis of independent equations ($\rho = 0$) at the 5% level. Interestingly, our results in Table 7 suggest that corporate hedging has a source of economic benefits to a firm's cost of equity capital.

4.5.4. Asymmetric information interaction

Information asymmetry between firms and outside capital providers can increase the stock price volatility and cost of equity capital (Wang, 1993). In this section, we estimate the effects of hedging decisions on the cost of equity capital using interaction terms that have been emphasised recently in previous studies on asymmetric information. We do expect in hypothesis H3 that hedging decisions are expected to mitigate such unfavourable effects on the cost of equity capital. In terms of magnitude, our alternative theoretical analysis in this section focuses on perfectly economic benefits of corporate hedging decisions on the cost of equity capital, in which we test hypothesis H3 through interaction term mechanism.

According to our model in Eq.(3), the relationship between information asymmetric and hedging decisions for financial risks suggest that hedgers with more information asymmetry have a lower cost of equity than nonhedgers. Consistent with prior research (e.g.,Froot *et al.* (1993); MacKay and Moeller (2007); Choi *et al.* (2013)) the interrelation between information asymmetry and corporate risk management seems to be relevant and reasonable. In order to test the extent to which the economic benefits of corporate hedging decisions alleviate the cost of equity capital in the presence of greater information asymmetry, we use the long-term growth rate as a proxy for information asymmetry between managers and investors. We then interact with the information asymmetry proxy in our analysis, and examine the coefficients of the interaction term in the cost of equity capital regressions.

Depending on the specification in Eq.(2), Table 8 represents the results of the effects of the interaction term of hedging decisions with the long-term growth rate on the cost of equity capital. We obtain estimates of the hedging decisions in the interaction term through two approaches: OLS and treatment effects control function (GMM) methods, which may also influence robustness checks on potential endogeneity concerns. We perform treatment effects control function (GMM) approach to overcome the self-selection bias estimation of the effect of hedging decision in interaction term approach (Heckman *et al.*, 1997). Specifically, the average treatment effects (ATE) control function approach with GMM estimator gives unbiased estimate when firms are prone in settings to receive treatment (hedging decisions). Therefore, throughout the TE control function approach with GMM estimator, the first stage explanatory variables include: foreign sales ratio, foreign expenditures, and geographical diversification for hedging decisions overall (H) and FX risk model; floating rate debt, fixed rate debt, and leverage for IR risk hedge model; and commodity operational purchase, commodity production oil & gas, and geographical diversification for CM risk hedge model, in the panel B of Table 8, respectively. For robustness checks, the results in ATE control function with GMM estimator reject the null hypothesis of independent equations ($\rho = 0$) at the 5% level for exogeneity tests; ρ is statistically significant in columns 5 to 7, indicating that the OLS estimates for the effect of hedging decision on the cost of equity capital are strongly biased toward zero. Accounting for self-selection in Panel B of Table 8 represents the results regressions estimation based on this approach. In column 1 of Table 8, the coefficient of the effect of overall hedging decisions (H) in interaction term with information asymmetry proxy is -0.141, indicating that more hedging decisions reduce the cost of equity capital in firms are more pronounced in settings by greater information asymmetry. The estimated coefficient of hedging decisions (H) is negative and significant at 10% level. However, the results in Panel A of Table 8 (OLS regressions) do not account for the self-selection of firms.

Table 8

The effects of Long Term Growth Rate and hedging decisions interaction on the Implied Cost of Equity Capital

This table reports results from OLS and treatment effects with control function (GMM system) regression estimations relating the implied cost of equity capital mean (R_{AVG}) and corporate hedging decision in an interaction term with long-term growth rate. Given that the estimations of the dependent variable of interest require a positive difference of earnings (i.e., $EPS_{t+2} > EPS_{t+1} > 0$.), resulting in a sample size of 1,135 firm-year observations based on 250 firms from 2005 to 2012. In both Panel A and B, hedging overall (H) or hedging financial risk exposures (FX, IR and CM), respectively, is an indicator variable set to one if the firm discloses use of derivative instruments for hedging financial risks purposes only within the fiscal year on time *t* for hedging overall or a specific risk exposure. All models specifications include year and industry fixed effects. Industries are defined at two-digit SCI level. Continuous variables are winsorised at 1% and 99% levels to reduce the influence of outliers. Robust standard errors are in between parentheses; ***, **, and * denote significance at the 1%, 5%, and 10% level, respectively. All variables are defined in Table 1.

Explanatory variables	Pred. sign	Panel A. OLS model				Panel B. Treatment effects model			
		H	FX	IR	CM	H	FX	IR	CM
		(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Hedging decisions	-	0.010	-0.011	-0.001	0.016	-0.132**	-0.044**	-0.028	0.004
		(0.015)	(0.012)	(0.011)	(0.013)	(0.056)	(0.019)	(0.020)	(0.016)
Long-term growth rate	+	0.146**	0.017	0.054	0.048	0.144**	0.028	0.054	0.049
		(0.066)	(0.050)	(0.056)	(0.036)	(0.065)	(0.048)	(0.056)	(0.036)
Hedging × Long-term growth rate	-	-0.141*	0.006	-0.044	-0.173**	-0.139*	-0.002	-0.045	-0.183***
		(0.074)	(0.066)	(0.069)	(0.068)	(0.073)	(0.065)	(0.069)	(0.068)
Market value of equity	-	0.002	0.003	0.002	0.002	0.002	0.002	0.003	0.003
		(0.007)	(0.007)	(0.007)	(0.007)	(0.007)	(0.007)	(0.007)	(0.007)
Book-to-market (B/M)	+	0.088***	0.087***	0.088***	0.088***	0.089***	0.088***	0.089***	0.087***
		(0.020)	(0.020)	(0.020)	(0.020)	(0.020)	(0.019)	(0.020)	(0.019)
Profitability (ROA)	-	-0.118***	-0.116**	-0.118***	-0.119***	-0.121***	-0.107**	-0.118***	-0.120***
		(0.045)	(0.046)	(0.045)	(0.046)	(0.044)	(0.045)	(0.045)	(0.045)
Capex/assets	-	-0.061	-0.056	-0.064	-0.046	-0.057	-0.065	-0.067	-0.045
		(0.099)	(0.099)	(0.100)	(0.101)	(0.097)	(0.096)	(0.099)	(0.100)
R&D/assets	-	-0.053	-0.063	-0.066	-0.061	-0.030	-0.049	-0.079	-0.067
		(0.053)	(0.053)	(0.053)	(0.053)	(0.055)	(0.053)	(0.051)	(0.052)
Momentum	-	-0.032	-0.034	-0.033	-0.034	-0.035	-0.036	-0.032	-0.034
		(0.024)	(0.024)	(0.024)	(0.024)	(0.024)	(0.024)	(0.024)	(0.024)
Analyst forecast dispersion	+	0.034	0.033	0.033	0.032	0.035	0.036	0.033	0.032
		(0.025)	(0.025)	(0.025)	(0.025)	(0.025)	(0.025)	(0.025)	(0.025)
Beta value-weighted	+	-0.011	-0.010	-0.010	-0.012	-0.016	-0.013	-0.009	-0.013
		(0.021)	(0.020)	(0.020)	(0.021)	(0.020)	(0.019)	(0.020)	(0.020)
Leverage	+	0.112***	0.110***	0.116***	0.110***	0.108***	0.104***	0.155***	0.110***
		(0.033)	(0.033)	(0.036)	(0.033)	(0.032)	(0.031)	(0.049)	(0.032)
Intercept		0.137***	0.152***	0.145***	0.143***	0.261***	0.177***	0.149***	0.144***
		(0.036)	(0.034)	(0.033)	(0.033)	(0.048)	(0.031)	(0.033)	(0.033)
Year & industry FE		YES	YES	YES	YES	YES	YES	YES	YES
Wald test-Chi-squared statistic						4.450	5.140	3.740	1.180
Wald test (p-value)						0.035	0.023	0.053	0.277
Adjusted R^2		0.176	0.175	0.175	0.176				
Observations		1135	1135	1135	1135	1135	1135	1135	1135

To address this concern, we obtain, columns 5-8 in Panel B of Table 8, the coefficients on the interaction term are -0.139, -0.002, 0.045 and -0.183 for hedging decisions, specifically, relating to H, FX, IR, and CM price risk, respectively. The coefficient of hedging decisions (overall) in model 5 of Table 8, in the interaction term with the long-term growth rate, is negative and strongly significant. The results imply that firms in settings prone for hedging decisions overall (H) are more attracted to outside investors with the increasing detailed information asymmetry and resulting in a reduction on the cost of equity capital. Interestingly, the results support a strong evidence for our hypothesis H3 that hedging decisions are the source of economic benefits for such firms practising hedging activities using derivative instruments.

4.5.5. Matched sample

For further robustness, we employ a propensity score matching approach driven by Rosenbaum and Rubin (1983). This method identifies a control sample of firms that do not hedge, but are otherwise similar in characteristics of the firms experiencing hedging decisions. Once these matching procedures are identified in settings, we can compare differences in our model outcomes (stock return volatility and the cost of equity capital). To implement this approach, we match derivative instruments users with nonusers on the basis of their propensity score, which has an advantage of treating potential endogeneity concerns and the standard errors may be severely downward biased (Rosenbaum and Rubin, 1983; Abadie and Imbens, 2012). In particular, propensity score-matching (PSM) method estimation is robust in our models estimation with regards to a potential of endogeneity concerns on the relationship between corporate hedging decisions, any omitted variables and the model outcomes. Therefore, using a conditional logistic regression model, PSM method regresses hedging decisions (indicator variable) for whether the propensity score (probability) estimation on the hedging determinants are driven by specific related factors.

Next, we match each observation where a firm reports a derivative use for hedging risk on specific treatment resulting in estimation of the effects of hedging decisions on the model outcomes (stock return volatility and cost of equity capital) with other control variables defined in Eq (1). This propensity score is estimated as a function of observed firm characteristics (firm size, value, profitability, investment growth, and leverage) and risk measures. We also include instrumental variables related to risk hedging decisions in our models.

Consistent with earlier findings in IV-GMM and treatment effects control function models, the results in the matched sample approach show that predicted signs of the results on the effects of corporate hedging decision, whether overall hedging or for a specific risk exposure, on the stock return volatility and the cost of equity capital remain negative and statistically significant. In untabulated tests, we employ additional specifications in our regressions estimation: nearest-neighbor, caliper, and pstolerance. First, the "*nearest-neighbor"* option picks a firm control according to the closest propensity score in matched sample procedures, where we use an integer 2, 3, 4, or 5 to specify the number of matches per each observation in order to obtain a robustness results in each model, while the default is one. The second option "*caliper"*, where we use small (alternatively, large at 10%), calipers of 0.01 to identify sets of matches and specify the maximum distance for which two observations are likely potential neighbours. Finally, we include "*pstolerance"* option with integer (1e-5) or more until potential overlap to be settled in the matching sample procedures. The complicity of propensity score matching procedures, the standard derivative-based standard-error estimators cannot be used by ATE-PSM method because these matching estimators are not differentiable. For each regression estimations, we generate a single variable containing numbers of observations of the nearest neighbours to calculate the coefficients in difference. We employ robust *Abadie-Imbens* standard errors and number matches for robustness results (Abadie and Imbens, 2006, 2011, 2012).

Table 9

Matched Sample Tests: Propensity Score Matching

This table presents the differential effects of hedging decisions on the outcome (i.e., stock return volatility and implied cost of equity capital mean) variables by comparing the non-users with the users of derivative instruments during the period from 2005 to 2012. Last two columns report difference between the coefficients pertaining to the two groups and the corresponding standard errors, respectively. The dependent variables in Panel A and B are the stock return volatility using two proxies. The first, in Panel A, is calculated using the logarithm of squared daily returns, and the second, in Panel B, is the standard deviation of daily stock returns. The dependent variable, in Panel C, is the implied cost of equity capital mean (R_{AVG}) calculated by taking the mean of the two individual estimates of R_{OJ} and R_{MPEG} and is in excess of the UK yield on 10-year Treasury bonds. Panel A, B and C show the results for corporate hedging decisions H, FX, IR and CM risk, respectively, using derivative instrument contracts and taking the difference between users vs. nonusers. All estimations use robust *Abadie and Imbens* standard errors. Regressions in the pre-treatment variables modelling hedging are based on *Probit* model with determinants of derivatives. We also control for industry effects by using industry dummies based on two-digit SIC codes and control for time effects by using year dummies. All variables are defined in Table 1. ***, **, and * denote significance at the 1%, 5%, and 10% level, respectively.

Variables	Users Sample	Non-users Sample	Difference	*Robust* S.E.
Panel A. Stock Volatility (*VOL*) No. of obs. (2000)				
Hedging decisions overall (H)	-3.045	-2.877	-0.168	0.233
Foreign currency hedge (FX)	-3.097	-3.007	-0.091	0.171
Interest rate hedge (IR)	-3.133	-3.136	0.003	0.191
Commodity price hedge (CM)	-3.163	-3.086	-0.078	0.247
Panel B. Std. Deviation of Stock Return (σ_E) No. of obs. (2000)				
Hedging decisions overall (H)	0.357	0.395	-0.038**	0.019
Foreign currency hedge (FX)	0.353	0.390	-0.037***	0.009
Interest rate hedge (IR)	0.349	0.361	-0.013**	0.006
Commodity price hedge (CM)	0.311	0.362	-0.051*	0.029
Panel C. Implied Cost of Equity Capital Mean (R_{AVG}) No. of obs. (1135)				
Hedging decisions overall (H)	0.202	0.213	-0.011	0.012
Foreign currency hedge (FX)	0.198	0.239	-0.041***	0.015
Interest rate hedge (IR)	0.188	0.201	-0.013	0.013
Commodity price hedge (CM)	0.051	0.141	-0.039*	0.022

Table 9 provides the average treatment effects estimation of PSM approach, for control samples matched to derivative users on stock return volatility measures (Panel A and B) and the cost of equity capital (Panel C). In Panel A, the average stock returns volatility (*VOL*) of the derivative users (treated) sample is -3.045 which is statistically lower than nonusers (control) sample based on *nearest-neighbor* (5) and small calipers, giving the difference -0.168 for hedging decisions (H) but statistically insignificant. The results in Panel B show alternative measure of stock returns volatility (σ_{Ei}) and the average treatment effects PSM estimations in difference are -0.038, -0.037, -0.013, and -0.051 for hedging decisions (H), FX hedge, IR hedge, and CM hedge risk, respectively, which are significantly negatively associated with the stock return volatility (σ_{Ei}). Interestingly, these results confirm the prediction of our hypothesis H1, that in context to which firms exercising hedging decisions have lower levels of stock return volatility.

Finally, the results in Panel C of Table 9, consistently provides the average treatment effects PSM estimates of the treated sample (users) in hedging overall (H), FX hedge, IR hedge, and CM hedge risk are -0.011, -0.041, -0.013, and -0.039, respectively, indicating that firms do hedging financial risks have a lower cost of equity capital than nonhedgers. The results for FX hedge and CM hedge risk are negative and statistically significant. Overall, these results add robustness to our previous results and provide further support for the empirical research that UK nonfinancial firms exercising derivative instruments for hedging financial risk exposures have a lower cost of equity capital in volatility market conditions.

4.6. Conclusion

This study examines the effect of hedging decisions relating financial risk exposures on the stock returns volatility and the cost of equity capital in UK nonfinancial firms over the years 2005-2012. In line with theoretical predictions, we find corporate hedging to be an important determinant of the implied cost of equity capital and a source of economic benefits to the firms which are increasingly exercising derivative instruments. Interestingly, compared with the prior literature as an unanswered question, our results provide empirical evidence that hypothesised hedging decisions in information asymmetry due to frequent interaction between managers and providers of finance are at least partly reflected in the cost of equity capital implied in stock prices.

Accounting for endogeneity concerns of corporate hedging to have interrelations effects, we demonstrate that our results become much economically stronger and significant to show that corporate hedging decisions mitigate the stock returns volatility in market imperfections and reduce a firm's cost of equity capital implied in stock prices. In addition, examining firm characteristics in matched sample (hedgers), our results contribute to the literature that stock returns volatility and the implied cost of equity capital of firms with derivative instruments use in hedging decisions overall scenario or detailed specific financial risks is lower than nonusers. Specifically, firms with derivative use capture a noticeable decline in their stock returns volatility and the implied cost of equity capital.

We estimate that the stock returns volatility, on average, is lower when firms exercise hedging decisions overall which accounts for 3.8% in difference for derivative users, while a decline in the cost of equity capital implied in the firms' stock prices are 4.1% and 3.9%, respectively, for firms with derivative instruments use for hedging foreign currency (FX) and commodity price (CM) risk exposures. Thus, our results indicate that when global markets become more volatile in foreign currency and commodity price fluctuations, hedging decisions comes from what in essence is an important source of economic benefits for the firm's implied cost of equity.

CHAPTER 5

Conclusion

5.1. Introduction

In this study, we explore investment inefficiency as an important determinant of corporate hedging decisions. Investment inefficiency is predicted along two dimensions of underinvestment or overinvestment, which reflects the difference between real investment and optimal investment level, developed by Richardson's (2006) accountancy-basis model. We analyse not just one aspect of corporate hedging, but focus the impact of different types of financial risk exposures and most common derivative instruments on firm value and performance. Our analyses are constructed for the three financial risks: foreign currency (FX) rates, interest rates (IR), and commodity price (CM). The Aretz and Bartram (2010) framework comprehensively summarises the theoretical background of the hedging determinants and links key factors related to corporate hedging decisions. Nevertheless, the existing empirical findings of these theories remain limited, because of endogeneity concerns related to corporate hedging decisions.

As data on corporate risk hedging are not often readily available before 2005 or inconsistent, we manually collect hedging information from firms' annual reports for UK nonfinancial firms listed in the FTSE-All share index between 2005 and 2012. We considered any comments reported under the derivative instruments disclosures and hedge accounting that explain in detail corporate hedging activities for the most common derivative contracts: futures, forwards, options, and swaps. Corporate governance, risk measures, and other financial data were collected from various sources, which include Bloomberg, Thomson Reuters Datastream, and Thomson One banker, in order to construct the best possible reliable dataset at firm-level. On the basis of this information, we develop our models in this research to stream three different dimensions of corporate risk hedging: 1) the effect of under- or over-investment on the propensity of hedging decisions 2) the impact of use derivatives on firm value and performance, and 3) the effect of corporate hedging on stock return volatility and the implied cost of equity capital. Furthermore, we shed light on how corporate hedging draws inferences on time-varying effects. For example, pre- and post-financial crisis (2008-2009), it can easily distinguish differences of effects on the firm value and performance. Furthermore, our analyses provide robustness tests to control for potential endogeneity concerns with corporate hedging. In particular, the changes of firm value and performance may not be driven by the use of derivatives only, but also by the same other explanatory variables or omitted variables bias in our models. However, it makes intuitive sense that the need for the use of derivatives may increase due to large firm size, foreign operations, or increasing levels of financial distress. Such firms' characteristics also facilitate the potential existence of relationship between corporate risk hedging and firm value.

This research extends the literature by documenting how corporate risk hedging mitigates the firms' returns variability and reduces the implied cost of equity. Therefore, in market imperfections, corporate risk hedging has economic significance and positively associated with firm value.

5.2. Summary and findings

This study examines corporate hedging motives associated with agency costs, and the impact of risk hedging with derivatives on firm value, performance, and the cost of equity capital. We use panel data techniques to control for time-invariant unobserved firm's characteristics that may be correlated with the motivations for using derivative financial instruments. We summarise our findings in this research as follows.

First, we find strong evidence that the underinvestment problems influence the likelihood of corporate hedging decisions to increase; supporting that it plays an important factor in risk management. The empirical results show that underinvestment is likely to induce the corporate hedging for firms that have more financial distress and a high investment opportunity. The explanation of underinvestment problems is that, in these firms, managers with risk aversion are more likely to accept projects, which may not contribute to firm value. This finding is consistent with the view (e.g., Bartram *et al.* (2009)) that corporate hedging is positively associated with underinvestment to alleviate agency costs. Interestingly, our findings show that overinvestment, in the presence of strong corporate governance, are more likely to influence those firms with a high investment capacity to increase corporate risk hedging with derivatives to alleviate agency costs, in which managers are more likely to impose a lower return or negative NPV projects to increase their utility functions. Our findings are consistent with the theoretical background of Morellec and Smith (2007) on the association between corporate risk hedging and firms in setting prone to under- or overinvest. We also find that corporate risk hedging can lead to a reduction of information asymmetry costs. Our interpretation of less information asymmetry costs that associated with hedging activities is strongly consistent with the literature (e.g., DeMarzo and Duffie (1995); Géczy *et al.* (1997); DaDalt *et al.* (2002); Kumar and Rabinovitch (2013)), where board independence, and analysts following the firm are proxies for information asymmetries in our models.

To ensure that our findings are robust, we control for potential endogeneity issues in the propensity of hedging determinants. Therefore, we employ a recent developed method called "special regressor" in binary outcome model developed by Dong and Lewbel (2015), which can efficiently provide coefficients estimation, when one or more endogenous control variables are discrete (i.e., under- or over-investment problems). Our results, for example, show that the marginal effects for FX hedging decisions is 0.350, which suggests that a firm in settings prone to underinvest may lead to a marginal change in the probability of FX hedging by 35.0% when a 1-unit increases in underinvestment from 0 to 1, and statistically significant at 1% level, in the presence of information asymmetry. This study provides strong empirical support for the growing number of research that corporate risk hedging with derivatives is an important financial strategy that leads to a significant reduction in asymmetric information costs, mitigation of investment inefficiency, and therefore increases firm value.

Our model, in which we use the special regressor based estimator to link the hedging determinants with agency costs and information asymmetry, provides us with specific predictions as to the existing theoretical studies. Without this recent developed approach in binary models, it is difficult to consistently report significant results and interpret the links between corporate hedging decisions and investment inefficiency.

Our findings suggest that investment inefficiency is indeed related to agency problems, but in a more sophisticated framework than has been explored in the existing literature. In equilibrium, firms in which underinvestment problems undertake an increase will have managers with greater incentives to avoid investment opportunities. When we link the agency costs with corporate hedging benefits, our results suggest that hedging decisions related to FX, IR, and CM risk exposure can lead to the optimum level of investment and rule out the managerial risk aversion when opportunity growth is applicable, it is sharply sympathetic with the shareholder value maximisation view.

Second, when we examine the value implications of corporate risk hedging, we find strong evidence that foreign currency risk hedging positively influences firm value and performance, while there is no significant result of interest rate risk hedging associated with firm value creation. This result is in line with Allayannis and Weston (2001) and Allayannis *et al.* (2012), who report that interest rate risk hedging generate no abnormal returns to the firms in market imperfections. Our interpretation is that the interest rate risk hedging might be driven by speculations when political risk policy potentially arises, and is not necessary to increase firm value and performance. Our findings also show that there is a positive association between the commodity price (CM) risk and firm value and performance. For example, the gold mining industry represents an excellent sample for studying corporate commodity derivatives. [59] However, the empirical findings regarding the effect of commodity price (CM) hedge on firm value and performance is mixed. Jin and Jorion (2006) provide evidence that CM risk hedging mitigates firms' returns variability, but not necessarily affects firms' market value.

Our analysis based on propensity score matching (PSM) approach provides strong evidence that hedgers with different types of derivative instruments may potentially harm firm value and performance if risk management activities are not adequately monitored. Using the PSM method with the nearest-neighbour estimation, it successfully allows us to limit the number of firms matched in certain characteristics. The estimation of the treatment groups (hedgers) helps to control for various forms of unobservable and time-invariant, thereby reducing unobservable variables that may be correlated with corporate hedging decisions when estimating the average effects of hedging on firm value and performance.

Not surprisingly, the results based on this approach provides strong evidence that the major common derivative contracts (e.g., forwards and swaps) for FX risk hedge are positively associated with firm value over time period, but there is weak evidence that IR risk hedge with some derivative contracts (e.g., options and swaps) may lead to shareholder value-maximization. Géczy *et al.* (1997) document that corporate risk management with particular instrument choices is associated with payoffs of costs, including liquidity costs, transaction costs, and other counterparty default risk, in context to which forward contracts provide a relatively low-cost strategy. Consistent with the existing empirical studies, Adam

[59] See for example, Adam (2009) analysed why gold mining firms use options contracts instead of linear strategies, such as forwards. Carter *et al.* (2006) investigate the relation between hedging and value in the airline industry and find strong evidence that commodity derivative users have, in average, a higher 5.0% value increase than do not hedge fuel price fluctuations in operations.

(2009) find that market conditions are correlated with firms' hedging instrument choices, but firms associated with financial constraints are highly motivated to use options contracts. However, these findings are to guide the economic benefits of corporate risk hedging with derivative choices; this should be interpreted with caution.

Despite considerable evidence in the difference-in-differences treatment (DDM) approach, which estimates the average effects of hedging with derivatives on the firm outcome in time-variant (e.g., pre-crisis and post-crisis), the results suggest that incremental benefits of the FX risk hedging with derivative contracts overall is 3.7 percentage points higher in post-crisis and statistically significant at 1%. We find no evidence that firms hedge the uncertainty of IR risk exposure overall within pre-crisis and post-crisis are correlated with the value-maximisation hedge. Consistent with our expectations on the firms' hedging instrument choices to draw inferences on its motives, theoretical literature documents that the optimal hedging strategy requires nonlinear derivative instruments (e.g., options).[60] For example, firms often use nonlinear derivative contracts (e.g., options), in some circumstances, in contrast to linear contracts (e.g., forwards) which are not necessarily to be related to hedging purposes (Bessembinder (1991); Adam and Fernando (2006); Adam (2009); Allayannis *et al.* (2012)). Thereby, the results are mixed in literature with regards to the uncertainty of the risk hedging with specific contracts, rather than others.

Third, our results show that the effects of corporate hedging decisions overall are negatively associated with both stock return variability and the cost of equity capital. We perform propensity score matching estimation to compare derivative users (treatment groups) with nonusers(controls) that are similar to a set of important observable characteristics such as firm size, value, profitability, investment expenditure, leverage, and risk factors (including firm beta, momentum price, and forecast earnings dispersion).

[60] Moschini and Lapan (1992, 1995) show that when managers are risk aversion, they prefer hedging with options.

The propensity score matching analysis yields that firms with derivative use, in risk hedging overall, are obviously associated with a decline in stock returns volatility that on average 3.8% and statistically significant at 5% level. On the other hand, firms associated with the risk hedging overall, the implied cost of equity capital is lower by 1.1%, and statistically insignificant. Our findings also show that a decline in the cost of equity capital for those associated with FX and CM risk hedging are 4.1% and 3.9%, respectively.

These results suggest that the largest firms associated with greater investment expenditures and more operations abroad are more likely to face FX currency price fluctuations in foreign income and expenses as well as those with commodity producers. In terms of the effects of IR risk hedging, there is not much difference between derivative users and nonusers for the stock return volatility, which shows that it is less by 1.3%, and statistically significant, while there is no evidence related to the cost of equity capital. The results suggest that interest rate (IR) risk hedging is compulsory for firms, and not necessary to cause a significant fluctuation on the stock return volatility on a regular basis. Evidence on whether the IR risk hedging with derivative in the cost of equity model must be interpreted with caution, since we do not account for market conditions of treasures and time-varying of monetary policy changes.

5.3. Contributions of the study

Our evidence strongly adds to a growing number of studies that demonstrate hedging determinants and the effects of the use of derivatives on firm value and performance. These effects of corporate risk hedging are more pronounced in the presence of financial distress and information asymmetries. This research distinguishes itself from existing studies and contributes to the literature on three important aspects.

First, how do agency costs presented in investment inefficiency (under- or over-investment) affect corporate risk hedging at the firm level? Prior research shows that corporate risk hedging can mitigate underinvestment problems when those firms have growth opportunities and costly external financing (Froot *et al.*, 1993; Jin and Jorion, 2006; Bartram *et al.*, 2009). Although an underinvestment problem is one part of investment inefficiency, managers may also induce firms to an overinvestment scenario because of potential self-interest or increasingly their entrenchment power since they derive substantial benefits. Therefore, we extend the evidence on the role of agency costs in mitigating the overinvestment problems documents in (Morellec and Smith, 2007). We show that the role of strong corporate governance mechanisms is expected to positively affect the propensity of corporate risk FX and CM hedging, that is, for those firms in settings prone to overinvestment problems. Our findings complement the work of Lin *et al.* (2008), who shows that corporate hedging, financing and investment inefficient are jointly determined. Hence, we also expand the existing empirical studies on potential endogeneity concerns in addressing corporate hedging determinants by implementing the recent developed approach "*special regressor*" in binary models outcome, which supports consistent and efficient estimations results.

Second, streaming other dimensions of the effects of the use of derivatives on firm value and performance adds valuable contributions to the growing literature in risk management. The existence gap in the literature related to the use of derivatives is also associated with which derivative should the firm use? Whether all derivative contracts are often associated with shareholders' value creation? These predictions lead us to two further investigations about the time-varying in exploring the effects of different risk exposures and types of instruments choice on firm value and performance. Our key contribution is that the differential effects of various types of contracts on firm value and performance are subject to what type of risk, time-varying (pre- or post-financial crisis), and the magnitude of contracts in risk management policy.

When addressing potential self-selection bias in our models with various risk exposures and types of instruments, we show that FX risk hedging is positively associated with firm performance, but there is weak evidence associated IR and CM risk hedging. We also show that hedging FX risk with forwards and swaps are positively linked to ROA. Using forwards or swaps (options) enhances (reduces) value when they are used for FX hedging and if forwards (options or swaps) are used for the IR risks this increases (decreases) value. Our findings complement the work of existing studies (e.g., Allayannis *et al.* (2012); Panaretou (2014)), who support evidence on the effects of overall corporate risk exposures.

Third, this study also contributes to the stream literature on the links between corporate risk hedging and the cost of equity capital (e.g., Nelson *et al.* (2005)) and stock return volatility risk (e.g., Bartram *et al.* (2011); Chen and King (2014)). Prior work shows that corporate risk hedging can lead to a lower cost of equity capital (e.g., Gay *et al.* (2011)). We also expand the evidence on the economic benefits of the use of derivatives in reducing the cost of equity capital implied in firms' stock prices. We also add to their findings that, where information asymmetry is costly to the firms' implied cost of equity capital, the intervention of the use of derivatives can help to mitigate such unfavourable effects for those firms associated with financial distress and extremely monitored by outsider investors.

5.4. Recommendations

Inappropriate use of derivative choices not only can lead to a reduction of firm value, but also increases asymmetric information that might threaten a firm's existence. We note that the use of derivative contracts has a double sword of effects if risk management strategies not frequently being reviewed and evaluated in terms of the optimal weight of derivative choices. This study sheds light on the various effects of the most common favourable derivative contracts available in the derivatives market. Though the majority of existing research focuses only on overall corporate risk hedging, it is an important aspect the role of board independence and other corporate governance mechanisms to monitor managers' incentives for those firms in settings prone to underinvestment or overinvestment scenarios.

Agency costs are generally considered to be well-known value destroying actions and typically corporate risk hedging has implications to the shareholders' perspectives. We also note that strong corporate governance mechanisms can help to facilitate the effects of corporate risk management policies. We suggest a higher role of board independence in facilitating risk shifting and monitor frequently growth opportunities, for those firms may have underinvestment or overinvestment problem. Our recommendations are important to those firms that are associated with frequent fluctuations in stock prices and implied cost of equity capital in the financial markets when the outsiders monitoring the firm and consider the absence of a suitable corporate risk hedging.

5.5. Research scope and limitations

In this study, we use a sample of UK nonfinancial firms to comprehensively investigate the effects of different types of derivative financial instruments and financial risk exposures on firm value and performance. While our findings provide a useful insight in corporate hedging determinants and value implications of using different types of derivative instruments in risk hedging, foreign currency price risk often has a volatile relationship with firm value. For example, it would be interesting to explore the sources of the hedging benefits from the optimal levels of some favourable derivative contracts. The widespread use of derivative instruments in the global markets and increasingly hedging activities of financial and nonfinancial firms open a new question whether there is differential benefits of risk hedging on time-varying in whether hedging or speculation. Our limitations in this study rely on the availability of notional amounts of derivative instruments in each fiscal year, and announcements of detailed information on corporate hedging activities. Future research should focus on out of specific samples or industry, either at firm-level or country-level, in order to assess the optimal levels of foreign currency derivatives that could lead to maximising value creation.

Our key findings are likely to be a fruitful area for further research on the foreign currency risk hedging and the links between managerial incentives and detailed information on corporate risk management practices in the UK to investigate the value implications of specific instrument choices. For example, considering a firm aggressively use selective derivative contracts without caution to the downside risk. So, it important to ask: how does the portfolio risk management design its policy to maximise the firm value and performance? How is the magnitude of firms' instrument choices in corporate hedging portfolio in market imperfections? Relatedly, we shed light on valuable contributions for future research in corporate risk management.

5.6. Implications for future research

The implications of this study bring new insights for future research. In particular, we shed light in the following ways.

First, a further examination of the relationship between FX risk hedge and the sensitivity of firm performance (e.g., stock returns) in the presence of political policy changes, regards to a currency devaluation, would be an interesting future research in the country level. In fact, there have already been some efforts try to explore the relations between exchange rate fluctuations and political risks (e.g., Bailey and Chung (1995)) that affect the sensitivity of equity market in emerging markets. When political uncertainty arises, hedging FX risk strategy becomes effective disciplines on management through the use of derivative instruments and optimal hedging levels. Recently, for example, in the event of UK Brexit from the EU, there is an obvious variation in firms' performance between FX derivatives users and those of nonusers.

Second, in the absence of firm going-concern value, we delegate a further investigation of the relationship between corporate hedging and the probability of bankruptcy as a result of exchange rate fluctuations.

Third, our empirical evidence sheds light on the importance of optimal hedging positions in instrument choices in time-variant to take shareholders' value maximisation perspective as a goal of achievement in the long run of the business model. In exploring the optimal hedging, further study should focus on firms' motives to use derivatives and exploiting the insight that managerial characteristics associated with overconfidence may behave differently when their activities are not well-monitored and for their self-interest. We expect monitoring of managerial activities and find appropriate measures have an important impact on firms' use of derivatives. Firms associated with strong corporate governance mechanisms and intervention of board independence is expected to reduce managerial activities of self-interest and overcome agency costs. Finally, this study clearly suggests that academics should not only focus on a sample selection bias but what the psychological factors that influence the managerial behaviour to foster hedging activities or being against the use of derivative instruments.

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APPENDIX

Appendix A

(1) Estimation of stock volatility

Consistent with prior research risk measures and stock volatility, we use two proxies of firm-level stock return volatility. The first is the logarithm of squared daily returns, calculated as follow:

$$VOL_i = \frac{1}{n}\sum_{t=1}^{n} ln\left(R_{i,t}{}^2\right) \quad (1)$$

where $R_{i,t}$ is the daily stock return, and n is the number of trading days in ith year at time t. The average trading days in UK FTSE index is 261 days. The daily stock return data is from Bloomberg. σ_E

The other measurement of volatility is the standard deviation of daily stock returns (σ_E), calculated as follows:

$$\sigma_{Ei} = \sqrt{\frac{1}{n-1}\sum_{t=1}^{n} (R_{i,t} - MEAN_{i,t})^2} \quad (2)$$

where $MEAN_{i,t}$ is the annual average rate of stock return.

(2) Measurement of the implied cost of equity capital: the earnings-performance approach

In order to test the implied cost of equity capital and its determinants at firm-level, we follow prior research in the finance literature by adopting earnings-performance approach. We construct two implied cost of equity capital (ICE) from Ohlson and Juettner-Nauroth growth model and Easton model that based on future realised earnings. To ease the discussion, we first define the variables used in the following two models of earnings growth estimation.

P_t = Implied market price of a firm's common stock at time t. We use the price at month +3 after the last fiscal year-end (source: Bloomberg).[61]

EPS_{t+i} = Realised earnings per share (EPS) for the next ith year at time t.

[61] Chen *et al.* (2011) use the price at month +4 after the last fiscal year, while Dhaliwal *et al.* (2016) use the price in June following the latest fiscal year-end to compute P^*_t. According to analysts' recommendations from Bloomberg data source, we use the price at month +3 after the last fiscal year.

DPS_{t+i} = Realised dividend per share (DPS) for the next *i*th year at time *t*.

$POUT$ = Dividends payout ratio. We use the ratio of the actual dividends per share (DPS_{t+i}) divided by the actual earnings per share (EPS_{t+i}) for the fiscal year at time *t* to measure the realised payout ratio. If EPS_{t+i} is negative, we assume a return on assets of 6.0% to calculate earnings (source: Bloomberg). POUT is winsorised to be within 0 and 1 (Frank and Shen, 2016).

g_{st} = The short-term earnings growth rate implied in EPS_{t+1} and EPS_{t+2}.

g_{lt} = The long-term *abnormal* earnings growth rate is calculated using the contemporaneous risk-free rate (the interest rate on the yield on 10-year Treasury bonds in UK measured in June of the given year) minus 3%. Treasury yield data are from the Bank of England (Statistical Interactive Database source).

(i) R_{OJ} ratio model by Ohlson and Juettner-Nauroth (2005) and implemented by Gode and Mohanram (2003)

$$P_t = \frac{\mathrm{E}_t(EPS_{t+1})}{R_{OJ}} + \frac{\mathrm{E}_t(EPS_{t+1})\,\mathrm{E}_t[g_{st} - R_{OJ} \times (1 - POUT)]}{R_{OJ}(R_{OJ} - g_{lt})} \tag{3}$$

from Eq. (3), R_{OJ} ratio can be solved as follows:

$$R_{OJ} = A + \sqrt{A^2 + \frac{\mathrm{E}_t(EPS_{t+1})}{P_t} \times (g_{st} - g_{lt})} \tag{4}$$

where $A = 0.5\left(g_{lt} + \frac{DPS_{t+1}}{P_t}\right)$,

and where EPS_{t+1} and EPS_{t+2} are the one and two-year ahead realised EPS to derive a measure of the short-term earnings growth rate. This model requires that $EPS_{t+1} > 0$ and $EPS_{t+2} > 0$. The R_{OJ} is implied cost of equity capital from Ohlson and Juettner-Nauroth growth model.

(ii) The modified price-earnings growth ratio (R_{MPEG}) model by Easton (2004)

$$P_t = \frac{\mathrm{E}_t(EPS_{t+1})}{R_{MPEG}} + \frac{\mathrm{E}_t(EPS_{t+1})\,\mathrm{E}_t[g_{st} - R_{MPEG} \times (1 - POUT)]}{(R_{MPEG})^2} \tag{5}$$

from Eq. (5), R_{MPEG} ratio can be solved as follows:

$$R_{MPEG} = A + \sqrt{A^2 + \frac{\mathrm{E}_t(EPS_{t+2}) - \mathrm{E}_t(EPS_{t+1})}{P_t}} \tag{6}$$

where $A = 0.5\left(\frac{DPS_{t+1}}{P_t}\right)$,

and where R_{MPEG} is implied cost of equity capital from Easton growth model. This model requires that $EPS_{t+2} > EPS_{t+1} > 0$.