UNIVERSITÉ DU QUÉBEC À MONTRÉAL

TROIS ESSAIS SUR LA GESTION DES RISQUES FINANCIERS: CAS DE L'INDUSTRIE PÉTROLIÈRE AMÉRICAINE

THÉSE

PRÉSENTÉE COMME EXIGENCE PARTIELLE

DU DOCTORAT EN ADMINISTRATION

PAR

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MAI 2014

UNIVERSITÉ DU QUÉBEC À MONTRÉAL

THREE ESSAYS ON CORPORATE RISK MANAGEMENT: THE CASE OF U.S OIL AND GAS INDUSTRY

DISSERTATION

PRESENTED IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE DEGREE OF DOCTOR OF PHILOSOPHY IN ADMINISTRATION

BY

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MAY 2014

REMERCIEMENTS

Louange à Allah Le Tout Miséricordieux Le Très Miséricordieux

Au terme de cette thèse, je souhaite tout d'abord remercier chaleureusement, M. Jean-Pierre Gueyie et M. Georges Dionne, mes directeurs de thèse pour la qualité de leur encadrement, leurs conseils avisés, et leurs qualités humaines d'écoute et de compréhension. J'éprouve une sincère gratitude envers vous mes chers professeurs.

Par ailleurs, j'exprime ma gratitude à M. Tim Rene Adam, M. Hatem Ben Ameur, et M. Sedzro Komlan qui m'ont fait l'honneur de participer à l'évaluation de ma thèse.

Mes vifs remerciements vont également à mes amis et compagnons des années au doctorat: Abdelmajid, Wejdi, et Salma. Je n'oublierai toutefois pas monsieur Maher Kooli ainsi que tout le personnel du Département de finance de l'UQAM.

Je garde mes remerciements amoureux pour mon épouse Khaoula qui m'a soutenu au quotidien durant toutes ces années. À mon très cher petit prince Mounib, je te demande pardon pour mon absence durant tes débuts dans la vie. Mes remerciements amoureux s'adressent aussi à mes parents et à mon cher oncle Cheikh Borni pour leur soutien moral qui a favorisé l'aboutissement de ce projet. Qu'ils trouvent tous dans cette thèse le témoignage de mon amour et ma profonde reconnaissance.

TABLE DES MATIÈRES

LISTE DES FIGURES vii

LISTE DES TABLEAUX viii

RÉSUMÉ x

ABSTRACT xii

INTRODUCTION GÉNÉRALE 1

CHAPITRE I
ARTICLE 1 12

ABSTRACT 14

1.1 Introduction 15

1.2 Related Literature and Hypotheses 19

1.2.1 Correlation between Internal Cash Flows and Investment Opportunities 19

1.2.2 Production Function Characteristics 20

1.2.3 Overinvestment Problem 22

1.2.4 Compensation Policy and Ownership Structure 22

1.2.5 Tax Incentives 23

1.2.6 Control Variables 24

1.3 Data and Dependent Variables 32

1.3.1 Data Construction 32

1.3.2 Dependent Variables: Construction and Characteristics 33

1.3.3 Econometric Methodologies 37

1.3.4 Dynamic Generalized Ordered Specification for Hedging Instrument Choice 38

1.3.5 Dynamic Multinomial Specification for Hedging Portfolio Choice 39

1.4 Results and Discussion 40

1.4.1 Descriptive Statistics: Independent Variables 42

1.4.2 Multivariate Results 46

1.5 Concluding remarks 68

APPENDIX 1.1
HOW DO FIRMS HEDGE RISKS? EMPIRICAL EVIDENCE FROM US OIL AND GAS PRODUCERS 70

APPENDIX 1.2
UNIVARIATE ANALYSIS 73

REFERENCES 87

CHAPITRE II
ARTICLE 2 91

ABSTRACT 93

2.1 Introduction 94

2.2 Hypotheses 97

2.2.1 Financial distress 97

2.2.2 Market conditions 98

2.2.3 Hedging contract features 100

2.2.4 Underinvestment costs 101

2.2.5 Production characteristics 102

2.2.6 Other control variables 103

2.3 Sample construction and characteristics 104

2.3.1 Sample construction 104

2.3.2 Sample characteristics 108

2.4 Econometric methodology 112

2.5 Univariate results 112

2.6 Maturity structure of corporate risk management 119

2.7 Robustness checks 129

2.7.1 Maturity choice at the inception of the hedging contract 129

2.7.2 Determinants of the early termination decision of hedging contracts 132

2.8 Real implications of hedging maturity choice 136

2.8.1 Effects of hedging maturity on stock return sensitivity 137

2.8.2 Effects of hedging maturity on stock volatility sensitivity 140

2.9 Concluding Remarks 141

APPENDIX 2.1
FIRST STEP OF THE TWO-STEP HECKMAN REGRESSIONS WITH SAMPLE SELECTION: DETERMINANTS OF THE OIL OR GAS HEDGING DECISION 143

APPENDIX 2.2
SUMMARY OF OUR PREDICTIONS AND FINDINGS 145

REFERENCES 149

CHAPITRE III
ARTICLE 3 153

ABSTRACT 155

3.1 Introduction 156

3.2 Real implications of corporate risk management: a review 160

3.2.1 Risk management, firm value and risk 160

3.2.2 Risk management and firm cost of capital 161

3.3 Sample construction and characteristics 163

3.3.1 Data collection 163

3.3.2 Descriptive statistics: Firms and loans' characteristics 163

3.3.3 Descriptive statistics: Oil and gas hedging activities 168

3.4 Empirical results 171

3.4.1 Univariate analysis 172

3.4.2 Risk management and firm performance 173

3.4.3 Risk management and firm risk 179

3.4.4 Risk management and external financing 186

3.5 Concluding Remarks 193

APPENDIX 3.1
VARIABLES' DEFINITIONS, CONSTRUCTION AND DATA SOURCES 194

APPENDIX 3.2
SIMULTANEOUS EQUATION ANALYSIS OF HEDGING EXTENT AND THE RETURN ON EQUITY 198

REFERENCES 201

CONCLUSION 204

RÉFÉRENCES 207

LISTE DES FIGURES

Figure Page

1.1 Frequency of use by hedging strategy over 1998-2010 for gas hedging 36

1.2 Frequency of use by hedging strategy over 1998-2010 for oil hedging 36

2.1 Non-monotonic relationship between hedging maturity and leverage for gas hedgers 123

2.2 Non-monotonic relationship between hedging maturity and leverage for oil hedgers..124

2.3 Non-monotonic relationship between hedging maturity and gas spot prices for gas hedgers 126

2.4 Non-monotonic relationship between hedging maturity and oil spot prices for oil hedgers..127

LISTE DES TABLEAUX

Table Page

1.1 Variables definitions, construction and data sources 29
1.2 Distribution of hedging decisions by firm–quarter 33
1.3 Hedging instruments used by oil and gas producers 34
1.4 Hedging strategies adopted by oil and gas producers 35
1.5 Summary statistics for firm financial and operational characteristics 43
1.6 Hedging instrument choice by gas hedgers 47
1.7 Hedging instrument choice by oil hedgers 49
1.8 Hedging portfolio choice by gas hedgers 55
1.9 Hedging portfolio choice by oil hedgers 57
1.10 Hedging intensity by derivative by gas hedgers 62
1.11 Hedging intensity by derivative by oil hedgers 64
2.1 Variable definitions and construction, and data sources 106
2.2 Weighted-average maturity by hedging instrument (in years) 109
2.3 Summary statistics for sample firms financial and operational characteristics 111
2.4 Characteristics of oil and gas producers and market conditions by hedging maturity 115
2.5 Contract features by hedging maturity...118
2.6 Maturity structure by gas hedgers 120
2.7 Maturity structure by oil hedgers...121
2.8 Maturity choice at the inception of hedging contracts by gas hedgers 130
2.9 Maturity choice at the inception of hedging contracts by oil hedgers 131
2.10 Determinants of early termination of hedging contracts by gas hedgers 133
2.11 Determinants of early termination of hedging contracts by oil hedgers 135
2.12 Effect of hedging maturity on stock return and volatility sensitivity 139
3.1 Summary statistics for sample firms..165

3.2 Summary statistics for loan characteristics 168
3.3 Distribution of hedging decisions by firm–quarter...169
3.4 Hedging instruments used by oil and gas producers...169
3.5 Summary statistics of hedging ratios by horizon..170
3.6 Univariate tests..173
3.7 Simultaneous equation analysis of hedging extent and realized selling prices 175
3.8 Simultaneous equation analysis of hedging extent and the return on asset.............178
3.9 Simultaneous equation analysis of hedging extent and firm idiosyncratic risk........181
3.10 Simultaneous equation analysis of hedging extent and firm systematic risk 185
3.11 Simultaneous equation analysis of hedging extent and firm leverage 188
3.12 Simultaneous equation analysis of hedging extent and loan spread 191

RÉSUMÉ

La présente thèse se compose de trois chapitres qui portent sur la gestion des risques financiers dans les entreprises non-financières. Les différents tests empiriques que nous y effectuons sont basés sur un large panel de 6,326 observations trimestrielles. Ce panel comporte des données détaillées concernant les positions de couverture d'un échantillon de 150 compagnies pétrolières américaines et ce, entre 1998 et 2010.

Le premier chapitre contribue à la littérature en apportant des réponses à la question relative aux déterminants du choix des stratégies de couverture. Une telle question qui a été relativement abordée sur le plan théorique mais peu d'évidences empiriques sont fournies vu le manque de données détaillées sur la structure des stratégies de couverture ou les difficultés de les avoir. Dans l'ensemble, les résultats obtenus prouvent que le choix de la stratégie de couverture est influencé par les dépenses d'investissement et la corrélation entre ces dépenses et les flux monétaires générés par l'entreprise.

Le choix de la stratégie est aussi très relié aux prix au comptant (*spot*), à leur volatilité, ainsi qu'aux prix anticipés. De surcroit, les contraintes financières jouent un rôle important dans la détermination de la nature de la couverture. Finalement, les caractéristiques de la production, telles que la diversification géographique et l'incertitude dans la production, influencent aussi le choix de la stratégie de la couverture.

Le deuxième chapitre contribue à la littérature en donnant des premiers constats empiriques au regard du choix de la structure de maturité des positions de couverture. Les résultats montrent une relation non-monotone entre la maturité de la couverture et la probabilité de la détresse financière. Cette non-monotonicité existe aussi entre la maturité et les prix au comptant.

Les résultats indiquent aussi que la maturité de la couverture est positivement reliée à l'incertitude dans la production, à la corrélation entre les prix de ventes et les quantités produites, et à la volatilité des prix au comptant du pétrole et du gaz. Les entreprises semblent encore aligner la maturité de leurs positions de couverture avec celles de leurs actifs (réserves de pétrole et de gaz) et dettes.

L'aversion au risque du gestionnaire n'a pas un effet significatif sur le choix de la maturité. Finalement, le deuxième chapitre présente une première évidence empirique concernant l'impact de la maturité sur les rendements de l'action de l'entreprise.

Le troisième chapitre réexamine l'hypothèse de la prime liée à la gestion des risques financiers. Une estimation en équations simultanées par la méthode des triples moindres carrés est utilisée pour pallier le problème d'endogénéité entre la décision de couverture et d'autres décisions financières de l'entreprise. Les résultats montrent que les entreprises, qui se couvrent contre les fluctuations des prix du pétrole et du gaz, réalisent des prix de vente sensiblement plus élevés qui vont rehausser les résultats comptables. De surcroit, la couverture est associée à une réduction du risque total et du risque spécifique de l'entreprise. Finalement, les entreprises qui gèrent leurs risques financiers accèdent à plus de financement externe mais non pas à moindre coût.

Mots clés: Gestion des risques financiers, choix des instruments dérivés, stratégie de couverture, maturité, résiliation prématurée, implications réelles, création de valeur, réduction de risque, industrie pétrolière et gazière.

ABSTRACT

This thesis consists of three essays on corporate risk management. It uses a new hand-collected dataset on the hedging activities of 150 US oil and gas producers during the period 1998-2010.

The first chapter examines the determinants of hedging strategy choice. Several theoretical studies investigate this issue; however, little empirical evidence is given. In this regard, this chapter adds to the hedging literature by exploring the implications of some theoretical predictions related to derivative choice that have not been explored yet. We use different dynamic discrete choice frameworks with random effects to mitigate unobserved heterogeneity and state dependence. Our evidences suggest that hedging strategy is strongly influenced by investment opportunities, the correlation between generated cash flows and investment expenditures, oil and gas market conditions, financial constraints, production specificities (i.e., production uncertainty, production flexibility, and price-quantity correlation), and managerial risk aversion.

The second chapter investigates how firms design the maturity of their hedging programs, and the real effects of maturity choice on firm value and risk. This chapter contributes to the literature by providing first empirical evidences on the determinants of the hedging maturity structure. We then study the determinants of the maturity choice at the inception of hedging contracts and the motivations of the early termination of outstanding contracts. We find that hedging maturity is influenced by investment opportunities, the correlation between generated cash flows and investment expenditures, oil and gas market conditions, production specificities (i.e., production uncertainty and price-quantity correlation), and hedging contract features (i.e., strike price and remaining maturity).

Our results also indicate an interesting non-monotonic relationship between hedging maturity and measures of financial distress. Oil and gas producers tend to align their hedging maturity with expected life duration of oil and reserves and weighted-average maturity of debt. Finally, we show that longer hedging maturities could attenuate the sensitivity of stock returns to oil and gas price fluctuations.

In the third chapter, we examine whether derivative use has real implications on firm value and risk. Previous hedging literature leads to fairly mixed and controversial results. Therefore, we revisit the hedging premium question for non-financial firms after controlling for potential shortcoming sources detected in previous studies. Particularly, we control for the endogeneity problem between derivative use decision and other firm's financial policies. We also control for sample selection bias by selecting firms within the same industry. Other forms of non-financial hedging are further considered (i.e., operational hedging).

We find that oil and gas hedging allows firms to realize higher selling prices and higher accounting performance. More importantly, results show that firm's total and idiosyncratic risks are significantly reduced by oil and gas hedging. Finally, results indicate that hedging eases access to higher debt financing, however with no real effects on debt cost. In sum, these real effects of hedging should lead to valuation gains for shareholders.

Keywords: Risk management, derivative choice, hedging strategy, maturity choice, early termination, real implications, value creation, risk reduction, oil and gas industry.

INTRODUCTION

Dans le monde sans friction de Modigliani et Miller (1958), la gestion des risques financiers s'avère infructueuse car elle ne génère pas une augmentation de la valeur pour l'entreprise. Toutefois, dans le monde réel imparfait, la gestion des risques au moyen d'instruments financiers dérivés devient de plus en plus répandue. En juin 2013, la Banque des Règlements Internationaux (BRI) a publié des statistiques révélatrices qui montrent que les entreprises non-financières détenaient des montants notionnels de 10.6 trillions de dollars et de 35.8 trillions de dollars de produits financiers dérivés sur les devises et les taux d'intérêt, respectivement. À cette même date, les contrats de gré à gré sur les matières premières avaient un encours notionnel d'environ 2 trillions de dollars, l'or non compris. Au début du millénaire, ces chiffres étaient d'environ 2.8 trillions, 5.5 trillions et 0.3 trillions de dollars pour les produits financiers dérivés sur les devises, les taux d'intérêt et les matières premières.

De surcroit, les études empiriques révèlent que les entreprises non-financières recourent davantage aux produits financiers dérivés pour couvrir leurs expositions aux différents risques financiers (voir par exemple, Haushalter, 2000; Jin et Jorion, 2006 et Kumar et Rabinovitch, 2013 pour l'industrie pétrolière). Dans une perspective internationale, Bartram, Brown, et Fehle (2009) trouvent que 60% des 7,319 firmes étudiées, issues de 50 pays différents, utilisent des instruments financiers dérivés sur des devises, des taux d'intérêt ou des matières premières.

La présente thèse répond à deux questions relatives à la gestion des risques financiers par les entreprises non-financières. La première question portera sur l'architecture des programmes de couverture des risques financiers et plus spécifiquement sur (i) les déterminants du choix de la stratégie de couverture et (ii) les déterminants du choix de l'horizon de la couverture. Le premier volet relatif au choix des stratégies sera traité dans le premier chapitre. Le deuxième volet portant sur le choix de l'horizon de la couverture sera abordé dans le deuxième chapitre. La deuxième question qui fera l'objet du troisième chapitre portera sur les implications réelles de la gestion des risques financiers sur la valeur et le risque de l'entreprise. Pour ce faire, les différents tests empiriques dans cette thèse sont basés sur des données détaillées concernant les positions de couverture d'un échantillon de 150 compagnies pétrolières américaines durant la période allant de 1998 à 2010.

1- Les déterminants de la gestion des risques financiers[1]

Il importe, à ce niveau, de rappeler les déterminants et les motivations de la gestion des risques financiers au sein des entreprises non-financières pour mieux situer la thèse dans son contexte. La littérature financière se base sur l'existence des frictions (taxes, coûts d'agence, coûts de la détresse financière, l'asymétrie de l'information, …) dans le monde réel pour bâtir un cadre théorique des motivations de la gestion des risques financiers. Ces motivations pourront être classées en deux grandes catégories. La première catégorie considère la gestion des risques financiers comme étant un moyen de création et de maximisation de la valeur de l'entreprise, et la deuxième catégorie relie la gestion des risques à la maximisation de l'utilité des gestionnaires des entreprises.

Les motivations liées à la maximisation de la valeur stipulent que la gestion des risques réduit la variabilité des flux monétaires et plus particulièrement elle évite les grandes pertes. Par conséquent, la gestion des risques réduit les coûts anticipés de la détresse financière (Mayers et Smith, 1982; Stulz, 1984; Smith and Stulz, 1985; Stulz, 1996). La réduction de la probabilité de la détresse financière et des coûts qui lui sont rattachés permettra à l'entreprise d'accéder à un financement extérieur plus élevé et moins coûteux. L'augmentation de la capacité d'endettement de l'entreprise se traduira par une augmentation de la valeur de celle-ci et ce à travers : (i) Les économies d'impôts liées à la déductibilité des intérêts financiers (Smith et Stulz, 1985; Leland, 1998; Ross, 1996; Graham et Rogers, 2002). (ii) Une meilleure coordination entre le financement et l'investissement ce qui permettrait d'éviter le problème du sous-investissement (Bessembinder, 1991; Froot, Scharfstein et Stein, 1993).

[1] Voir Aretz et Bartram (2010).

La réduction de la variabilité des flux monétaires aidera encore l'entreprise à avoir les fonds internes nécessaires pour le financement des projets ayant des retombées financières positives. Les effets bénéfiques de la gestion des risques s'accentuent davantage dans le cas des entreprises ayant des opportunités d'investissement substantielles et faisant face à un coût de financement externe élevé (Smith et Stulz, 1985; Froot, Scharfstein et Stein, 1993; Gay et Nam; 1998).

La gestion des risques permet aussi de réduire les coûts reliés au problème d'agence. En effet, le gestionnaire avec des flux monétaires plus stables est moins enclin de se comporter d'une manière opportuniste par le biais d'un transfert des risques (*risk-shifting*) qui va à l'encontre des intérêts des créanciers de l'entreprise.

De même, la gestion des risques augmente la valeur de l'entreprise en diminuant ses dettes sous forme de taxes à payer. Smith et Stulz (1985) démontrent qu'une entreprise, assujettie à un taux de taxation qui croît avec l'augmentation de ses résultats comptables (fonction de taxation convexe), pourra diminuer les taxes à payer par le biais de la gestion des risques financiers. En effet, la gestion des risques atténuera la variabilité des résultats comptables avant impôts diminuant ainsi les taxes dues. Par conséquent, l'allégement du fardeau fiscal à long terme permettra de rehausser la valeur de l'entreprise. Cet argument a été validé empiriquement dans les études subséquentes (Nance, Smith et Smithson, 1993; Graham et Smith, 1999; Graham et Rogers, 2002).

Un deuxième courant, dans la littérature, relie la gestion des risques financiers au comportement des gestionnaires qui ont un penchant pour la maximisation de leur utilité. Les arguments avancés s'insèrent dans le cadre du problème principal-agent entre les gestionnaires et les actionnaires (Jensen et Meckling, 1976). En effet, l'ancienneté dans le travail, la réputation, l'expertise (ces facteurs représentent le capital humain du gestionnaire) et encore la détention directe des actions de l'entreprise font en sorte que la richesse personnelle du gestionnaire soit étroitement reliée à la valeur de l'entreprise. Tous ces facteurs combinés à l'incapacité du gestionnaire à diversifier sa richesse personnelle (carrière dans l'entreprise) l'incitent à entreprendre des activités de gestion des risques financiers pour couvrir sa propre richesse et non pas pour maximiser celle des actionnaires. Pour pallier à ce problème Stulz (1984) et Smith et Stulz (1985) suggèrent l'inclusion des options d'achat des actions de l'entreprise comme composante de la rémunération des gestionnaires. Les résultats empiriques concernant cet argument sont controversés. Par exemple, Tufano (1996) confirme cette hypothèse alors que Haushalter (2000) ne trouve pas une relation directe entre la gestion des risques et la valeur des actions détenues par le gestionnaire.

2- Les déterminants du choix de la stratégie de couverture

Comme déjà mentionné, une riche littérature a permis de mieux comprendre les motivations de la gestion des risques et ses vertus pour les entreprises non-financières. Cependant, une moindre attention a été accordée à la manière dont on doit gérer les risques financiers. En effet, à part les quelques travaux théoriques en rapport avec les déterminants du choix de la stratégie de couverture, on distingue une seule étude empirique menée par Adam (2009) pour le secteur de l'or. Encore, les constats empiriques révèlent que les entreprises, dans le même secteur d'activité, adoptent des stratégies de couverture différentes alors qu'elles font face à la même source de risque. Ainsi, le premier chapitre de cette thèse aura comme objectif de combler le manque d'études empiriques en rapport avec les déterminants du choix de la stratégie de couverture. Plus particulièrement, nous vérifierons la validité empirique de certaines prédictions émanant des travaux théoriques.

La littérature financière classifie les instruments financiers dérivés en deux grandes catégories: (i) les instruments dérivés qui ont un profil de gain (*payoff*) ayant une relation linéaire avec le prix de l'actif sous-jacent. Les contrats swap et les contrats à terme (de gré à gré ou les contrats futures) font partie de cette catégorie. L'initiation de ce genre d'instruments ne génère pas de paiement. La deuxième catégorie englobe les instruments financiers dérivés dont le profil de gain a une relation non-linéaire avec le prix de l'actif sous-jacent. Ces instruments non-linéaires englobent les options d'achat, les options de vente et d'autres produits avec une structure relativement plus complexes (les *collars*, les *strangles*, ...). Les instruments non-linéaires génèrent le paiement d'une prime à l'initiation.

L'analyse de la dynamique des stratégies de couverture adoptées par les entreprises dans notre échantillon révèle un constat très important relatif à la persistance dans les choix effectués par les gestionnaires. En effet, ces derniers maintiennent leurs stratégies de couverture pour des périodes relativement longues. Ceci pose un défi au niveau de l'approche économétrique à adopter. Nous avons ainsi opté pour des méthodologies économétriques dynamiques dérivées des modèles appliqués aux choix discrets à savoir le modèle probit ordonné et le modèle logit multinomial.

Nos tests empiriques révèlent que les stratégies non-linéaires sont positivement corrélées avec les opportunités d'investissement. En effet, les entreprises ayant des dépenses élevées en termes d'exploration et de développement des réserves de gaz et de pétrole font recours à plus de stratégies non-linaires. Ce constat corrobore la prédiction théorique de Froot, Stein, et Scharfstein (1993) et les résultats d'Adam (2009) pour le secteur de l'or. Dans ce même contexte, les résultats montrent qu'une corrélation positive entre les dépenses en capital et les flux monétaires générés incitera les entreprises à utiliser davantage les produits linéaires (les contrats swap). Les résultats démontrent aussi que les stratégies linéaires sont positivement corrélées avec les prix au comptant (*spot*) du pétrole et du gaz alors que les stratégies non-linéaires sont plus liées au niveau de la volatilité de ces prix au comptant et aux prix anticipés dans le futur.

Les producteurs de pétrole et de gaz qui ont une plus grande diversification géographique dans leurs opérations de production font plus recours aux stratégies non-linéaires. Ce résultat est conforme à l'argument de la flexibilité de la production avancé par Moschini et Lapan (1992). La flexibilité dans la production est considérée comme étant une option réelle avec un *payoff* non-linéaire (convexe) nécessitant une stratégie non-linéaire pour la couvrir. Une corrélation positive entre les prix de vente et les quantités produites encourage le recours aux stratégies linéaires comme stipulé dans la littérature (Brown et Toft, 2002; Gay, Nam, et Turac, 2002). De plus, une plus grande incertitude dans les quantités produites motive le recours aux stratégies non-linéaires. L'incertitude dans la production accentue la convexité de l'exposition globale de l'entreprise, ce qui nécessite le recours aux stratégies avec un *payoff* convexe tel que suggéré par Moschini et Lapan (1995) et Brown et Toft (2002).

Les résultats donnent une première évidence empirique de l'impact du problème de surinvestissement, tel que identifié par Morellec et Smith (2007), sur le choix de la stratégie de couverture. Lorsque la variabilité des flux monétaires générés par l'entreprise est grande, les stratégies linéaires permettront de mieux les stabiliser et réduire ainsi les flux monétaires disponibles aux gestionnaires. En concordance avec les prédictions de Smith et Stulz (1985), nos résultats démontrent qu'un gestionnaire détenant une plus grande part d'actions de l'entreprise a tendance à recourir aux contrats swap. Au contraire, si le gestionnaire détenait plus d'options d'achat d'actions de l'entreprise, il aurait plus d'incitation à utiliser des stratégies non-linéaires. Les entreprises qui ont un ratio d'endettement plus élevé, mais pas encore en détresse financière, ont tendance à utiliser les stratégies linéaires. Ces entreprises cherchent plus à stabiliser leurs revenus pour faire face aux paiements induits par leur endettement élevé. Par contre, les entreprises qui sont déjà en situation de détresse financière recourent davantage aux stratégies non-linéaires en guise de comportement de transfert de risque (*risk-shifting*) tel que identifié dans la littérature (Jensen et Meckling, 1976; Adler et Detemple, 1988).

3- Les déterminants de l'horizon de la couverture

Un autre volet de l'architecture ou du *design* de la stratégie de gestion des risques financiers a été largement ignoré dans la littérature qui se focalise plus sur les explications de l'étendue de la couverture et ses implications. Il s'agit du choix de l'horizon lors de l'initiation du programme de couverture, des ajustements à apporter par la suite, de la résiliation prématurée des contrats de couverture en place et le remplacement de ceux déjà expirés. La littérature théorique a ignoré tous ces aspects car elle traite des modèles statiques qui sont préconisés souvent sur une seule période de temps et qui assument que la décision de couverture est irréversible et sans coûts.[2] Les études empiriques ont aussi ignoré ce volet vu l'indigence des données pertinentes et les difficultés d'y accéder.

[2] Par exemple les modèles développés par Smith et Stulz (1985), Froot, Scharfstein, et Stein (1993) et Adam (2002).

Récemment, Fehle et Tsyplakov (2005) ont comblé le manque de prédictions théoriques concernant la structure de maturité de la couverture. Ils ont bâti un modèle dynamique en temps continu dans lequel l'entreprise pourrait ajuster son ratio de couverture ainsi que la maturité des instruments qu'elle utilise en réponse aux fluctuations des prix de son produit. Leur modèle produit un certain nombre de nouvelles prédictions théoriques concernant le choix de la maturité à l'initiation de la couverture et les ajustements à apporter par la suite tels que la résiliation prématurée et le remplacement des positions expirées.

Le deuxième chapitre de la thèse a pour objectif de combler le manque d'études empiriques relatives aux déterminants du choix de la maturité à l'initiation de la couverture ainsi que son évolution dans le temps. De surcroit, ce chapitre examine les implications réelles de la maturité de la couverture sur la valeur et le risque de l'entreprise. Pour ce faire, nous retiendrons les différentes prédictions théoriques émanant du modèle de Fehle et Tsyplakov (2005), ci-dessus mentionné, et nous les supplémentons par d'autres hypothèses relatives aux caractéristiques du programme d'investissement de l'entreprise, la maturité de ses actifs et dettes, les taxes, et l'aversion au risque du gestionnaire.

Les résultats révèlent des effets opposés des caractéristiques du programme d'investissement sur la maturité de la couverture. En effet, les entreprises avec des grandes opportunités d'investissement font recours à des positions de couverture avec des longues maturités pour avoir une meilleure harmonisation entre les dépenses en capital et les flux monétaires générés à l'interne. Cependant, une corrélation positive entre les dépenses d'investissement et les flux monétaires muni les entreprises d'une diversification naturelle qui diminuera la probabilité d'un sous-financement et donc favorisera l'utilisation des positions de couverture plus courtes.

Les tests empiriques démontrent aussi un constat très révélateur. Il s'agit de la relation non-monotone (concave) entre la maturité de la couverture et la probabilité de la détresse financière. Ce constat corrobore la prédiction théorique de Fehle et Tsyplakov (2005) qui stipule que les entreprises qui sont loin de la détresse financière et celles qui sont proches de la détresse financière adopteront des stratégies de couverture de courte durée. Cependant, nous avons trouvé que les entreprises, qui sont déjà en détresse financière et qui encourent des grandes pertes en termes de flux monétaires, font davantage recours aux options de vente avec des maturités plus longues pour se couvrir. Ce résultat contredit la prédiction théorique de Fehle et Tsyplakov (2005) mais il est justifié par un comportement de transfert de risque (*risk-shifting*).

De surcroit, nos résultats indiquent qu'une plus grande incertitude dans la production incite les entreprises à utiliser des couvertures de longue maturité. Ce constat infirme la prédiction théorique de Brown et Toft (2002) affirmant que l'incertitude dans la production rend les entreprises réticentes à couvrir leurs expositions les plus lointaines. Comme attendu, une corrélation positive entre les prix au comptant et les quantités produites, favorise l'implémentation de couvertures avec de longues durées pour éviter les variations dans les flux monétaires. La maturité de la couverture semble aussi avoir une relation non-monotone avec les prix au comptant du pétrole et du gaz et elle est positivement corrélée avec la volatilité de ces prix au comptant. Ces deux derniers constats corroborent avec les prédictions de Fehle et Tsyplakov (2005).

Les résultats indiquent encore que les entreprises ayant une plus grande convexité dans leur fonction de taxation utilisent davantage des couvertures de longue durée afin de profiter des économies d'impôts liées à la gestion des risques tel que stipulé dans la littérature (Graham et Smith, 1999; Graham et Rogers, 2002). Les résultats prouvent aussi que les entreprises alignent la maturité de leurs positions de couverture avec celles de leurs actifs (les réserves de pétrole et de gaz) et dettes. Finalement, ce deuxième chapitre documente une première évidence empirique de l'impact de la structure de maturité de la couverture sur la valeur et le risque de l'entreprise. À cet égard, nos résultats montrent que les couvertures avec de longues échéances sont capables d'atténuer la sensibilité des rendements des actions aux fluctuations des prix du pétrole et du gaz. Cependant, l'effet sur la volatilité des rendements est statistiquement insignifiant.

4- Les implications réelles de la gestion des risques financiers

Partant des imperfections qui entachent le monde réel, une large littérature s'est donné pour objectif de mettre en évidence les vertus et les bienfaits de la gestion des risques financiers pour les entreprises non-financières et, par conséquent, pour leurs actionnaires. Selon cette littérature, la gestion des risques contribue à la création de valeur, entre autres, en réduisant la probabilité de la détresse financière, en évitant le problème de sous-investissement, en diminuant les taxes à payer, et en empêchant les problèmes d'agence. Toutefois, les résultats et constats empiriques restent largement controversés et non concluants. Par exemple, Allayannis et Weston (2001), Graham et Rogers (2002), Carter, Rogers, et Simkins (2006), Adam et Fernando (2006), et Bartram, Brown, et Conrad (2011) font partie d'un courant qui, dans la littérature, confirme l'hypothèse selon laquelle la gestion des risques est créatrice de valeur pour l'entreprise. Par contre, les résultats d'autres études empiriques menées par Hentschel et Kothari (2001), Guay et Kothari (2003), Jin et Jorion (2006), et Fauver et Naranjo (2010) n'appuient pas cette hypothèse.

Aretz et Bartram (2010) font une revue exhaustive de cette littérature et ils renvoient la contradiction entre les résultats empiriques, principalement, à un problème d'endogénéité entre la décision d'utiliser les instruments financiers dérivés en vue de faire de la couverture et autres décisions financières dans l'entreprise. De surcroit, selon ces auteurs, ce problème d'endogénéité se trouve aggravé par un autre problème fondamental d'identification où les déterminants de la décision de couverture sont en même temps des déterminants d'autres décisions financières. Encore, la gestion des risques est une stratégie multidimensionnelle qui incorpore d'autres aspects outre l'usage des instruments dérivés. En effet, la gestion opérationnelle des risques (*operational hedge*) est vue comme un moyen complémentaire de couverture qui pourrait expliquer les effets faibles de la gestion des risques par les instruments financiers dérivés (Guay et Kothari, 2003). Finalement, Aretz et Bartarm (2010) mettent de l'avant une source supplémentaire de divergence et d'ambigüité dans les résultats empiriques. Il s'agit de la difficulté à identifier avec précision l'étendue de la couverture. Ceci est dû essentiellement au fait que les entreprises utilisent plutôt des portefeuilles d'instruments différents (*hedging mix*) que des instruments individuels.

Partant de tous ces constats, le troisième chapitre vise à revisiter la question de la prime liée à la gestion des risques financiers tout en prenant en compte les différentes sources de divergence susmentionnées. Pour surmonter le problème d'endogénéité, nous considérons les effets de rétroaction mutuelle entre la décision de couverture et les autres décisions financières dans l'entreprise. Nous utiliserons ainsi l'approche des triples moindres carrés (*Three-Stage Least Squares, 3-SLS*) pour l'estimation des équations simultanées. La méthode des triples moindres carrés a l'avantage essentiel de considérer la corrélation entre les résidus des équations estimées, par conséquent, elle conduit à des estimations plus efficientes. De surcroit, le biais de sélection est minimisé dans nos tests empiriques car les entreprises, dans notre échantillon, appartiennent à la même industrie, elles sont exposées à la même source de risque (les prix du pétrole et du gaz) et elles diffèrent considérablement en termes de comportements de couverture tel que suggéré par Jin et Jorion (2006). Encore, nous prenons en considération l'existence de la gestion d'autres risques financiers (le taux d'intérêt et le taux de change) et la diversification géographique comme moyen de couverture opérationnelle. Finalement, les tests sont réalisés en utilisant l'étendue global du portefeuille de couverture ainsi que par instrument (contrats swap, options de vente, et les *costless collars*).

Dans l'ensemble, les résultats obtenus montrent que la couverture a des effets positifs sur les prix de vente, ce qui se traduira par une amélioration dans les rendements des actifs (*return on asset*) et des capitaux propres (*return on equity*). En outre, la couverture réduit sensiblement le risque total et le risque idiosyncratique de l'entreprise. Ces résultats corroborent ceux rapportés par Guay (1999) et Bartram, Fehle, et Conrad (2011). À l'instar d'Adam (2009), la couverture n'entraîne pas une augmentation du coût des capitaux propres car elle n'augmente pas le risque systématique (coefficient beta) de l'entreprise. Finalement, la couverture semble augmenter la capacité d'endettement de l'entreprise tel que prôné par la littérature (Stulz, 1984; Smith et Stulz, 1985; Stulz, 1996; Garham et Rogers, 2002). Cependant, dans notre échantillon, la couverture s'avère sans impact réel sur le coût de la dette pour les entreprises. Ceci contredit les récents résultats rapportés par Campello, Lin, Ma, et Zou (2011) pour le cas de la couverture des taux d'intérêt et des taux de change, et Kumar et Rabonovitch (2013) pour la couverture des prix du pétrole et du gaz. Kumar et

Rabonovitch (2013) n'ont pas pris en considération le problème d'endogénéité dans leur régression.

Le reste de la thèse est divisé de la façon suivante: un premier chapitre qui explore les déterminants du choix de la stratégie de couverture. Le second examine les déterminants du choix de la maturité de la couverture ainsi que ses implications réelles sur la valeur et le risque de l'entreprise. Le troisième chapitre revisite la question de la prime associée à la gestion des risques financiers pour les entreprises non-financières. Finalement, une dernière partie est consacrée à la synthèse des résultats et à la conclusion.

CHAPITRE I

ARTICLE 1

HOW DO FIRMS HEDGE RISKS?

EMPIRICAL EVIDENCE FROM US OIL AND GAS PRODUCERS

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ABSTRACT

This paper investigates the determinants of hedging strategy choice. We introduce different dynamic discrete choice frameworks with random effects to mitigate unobserved heterogeneity and state dependence. Using a new dataset on the hedging activities of 150 US oil and gas producers, we find strong evidence that hedging strategy is influenced by investment opportunities, the correlation between generated cash flows and investment expenditure, oil and gas market conditions, financial constraints, and oil and gas production specificities (i.e., production uncertainty, production flexibility, and price-quantity correlation).

Keywords: Risk management, derivative choice, hedging strategy, oil and gas industry.

JEL classification: D8, G32.

1.1 Introduction

To date, scant empirical research has attempted to explore how hedging programs are structured by non-financial firms (e.g., Tufano, 1996; Géczy, Minton, and Schrand, 1997; Brown, 2001; Adam, 2009). The goal of this study is to add to the literature by shedding light on how firms hedge risks. We also study the determinants and consequences of their choices. We answer the following question: What are the determinants of hedging strategy choice? It is important to understand why firms within the same industry and with the same risk exposure vastly differ in terms of their hedging strategy. Differences in firms' hedging practices seem to come from differences in firm-specific characteristics rather than differences in their underlying risk exposures. Therefore, explaining how firms structure their hedging portfolios and measuring their related economic effects should provide a better understanding of how hedging affects corporate risk and value.

This study contributes to the literature on corporate hedging in several ways. We use an extensive and new hand-collected dataset on the risk management activities of 150 US oil and gas producers with quarterly observations over the period 1998 to 2010. Our data, collected from publicly disclosed information, avoid the non-response bias associated with questionnaires and provide detailed information about hedging activities. Moreover, unlike previous studies on risk management in the oil and gas industry, our dataset is quarterly rather than annual and covers a far longer period. In addition, we study the hedging activities of both commodities, oil and gas, separately, which gives deeper insight into oil and gas producers' hedging dynamics. Finally, our study period coincides with the application of the new derivative accounting standard (Financial Accounting Standards Board 133) in the United States, which is expected to influence corporate risk management starting from 1998: Bodnar, Hayt, and Marston (1998) find that 80% of the Wharton Survey respondents expressed concern regarding the accounting treatment of derivatives.

In addition, we innovate in terms of the econometric methodology to better capture hedging dynamism and improve the reliability of the statistical inference of our findings. We consider derivative choice as a multi-state process and examine the effects of firm-specific characteristics and oil and gas market conditions on the choice of hedging strategy. To alleviate the effects of unobserved individual heterogeneity and state dependence[3], we use dynamic discrete choice methodologies with random effects that account for the initial condition problem. We thus distinguish the effects of past hedging strategy choice and observable and unobservable firm characteristics on current hedging behavior. We use a dynamic generalized random effects ordered probit model to analyze why firms chose linear or non-linear instruments. This model explores the determinants of hedging strategies based on one instrument only (i.e., swap contracts only, put options only, costless collars only). In addition, we use a dynamic random effects mixed multinomial logit (MMNL) to explore the determinants of hedging strategies based on a combination of two or more instruments (i.e., hedging portfolios). For the multinomial mixed logit, we chose swap contracts as our base outcome, which allows us to determine why firms chose hedging portfolios with payoffs departing from strict linearity.

Our comprehensive dataset allows us to reliably test the empirical relevance of some theoretical arguments and predictions related to derivative choice that have not been explored yet. In particular, we test the implications of the prediction of Froot, Scharfstein, and Stein (1993) related to the impact of the correlation between internally generated cash flows and investment opportunities. Further, our dataset allows us to verify the implications of production characteristics (i.e., production flexibility and quantity–price correlation) as suggested by Moschini and Lapan (1992), Brown and Toft (2002) and Gay, Nam, and Turac (2002, 2003). We also test the empirical relevance of the overinvestment problem (i.e., free cash flow agency problem) as theorized by Morellec and Smith (2007) and identified empirically by Bartram, Brown, and Fehle (2009), namely that large profitable firms with few investment opportunities face overinvestment problems. We test the real implication of managerial risk aversion and tax function convexity on derivative choice. We revisit other predictions explored by Adam (2009). In particular, we investigate the effects of production

[3] The current state depends on last period's state, even after controlling for unobserved heterogeneity.

uncertainty, financial constraints, oil and gas market conditions, and industrial diversification on derivative choice. Finally, we investigate the impacts of the existence of other hedgeable risks—that is, interest rate (IR), foreign exchange (FX) and basis risks.

Our results reveal significant state dependence effects in the hedging strategy that should be accounted for when studying firms' risk management behaviors. Accounting for this state dependence allows us to better distinguish the effects of observable and unobservable characteristics on hedging preferences. Consistent with the theoretical predictions of Froot, Scharfstein, and Stein (1993), we find that positive correlation between internally generated cash flows and investment expenditures motivates oil and gas producers to rely more on hedging strategies with linear-like payoffs (i.e., swap contracts only, costless collars only or a mixture of swaps and collars) and to avoid put options. This positive correlation provides oil and gas producers with a natural hedge (i.e., natural diversification) and linear strategies could provide value-maximizing hedges.

Results further indicate that oil and gas producers with higher geographical dispersion in their production activities tend to use put options only or sometimes a mixture of swaps and collars, and to avoid swap contracts only. This finding corroborates the production flexibility argument of Moschini and Lapan (1992), in that the firm is able to alter its production parameters after observing the future price of the output. The geographical dispersion allows producers to shift their production operations between different locations with different cost structure and operational characteristics. This operational flexibility could be seen as a real option with convex payoffs requiring non-linear hedging strategies. Results further show that when gas production and gas spot prices are positively correlated, gas producers tend to hedge more with swaps only to stabilize firm's cash flows because quantities and prices are moving in the same direction. This empirical evidence supports the theoretical prediction by Brown and Toft (2002) and Gay, Nam, and Turac (2002, 2003).

Multivariate results also give empirical evidence of the role of the overinvestment problem arising from the free cash flow agency theory (e.g., Jensen, 1986). Overinvestment is positively related to the use of swap contracts only or collars only and negatively related to put options only. This finding is consistent with the theoretical prediction of Morellec and

Smith (2007). More linear instruments stabilize generated cash flows and prevent the managerial affinity to overinvest. However, the impact of overinvestment problem on put options combined with swaps is mixed. In sum, these results give the first direct evidence of the real implications of the overinvestment problem on hedging behavior.

Regarding managerial risk aversion, we find that managerial option-holding is positively related to the use of put options (only or in combination with swaps), and managerial stockholding is positively associated with swap contracts. These latter findings corroborate the theoretical predictions (e.g., Smith and Stulz, 1985) and show that a manager with higher stockholding seeks complete insulation of firm value from the source of risk. On the contrary, higher option-holding motivates managers to accept more variability in firm value. Interestingly, we find that costless collars are positively related to both managerial stockholding and option-holding. Results pertaining to tax function convexity are mixed. As predicted, oil and gas producers with more tax loss carryforwards tend to use put options only or collars only and to avoid swaps only. Tax loss carryforwards seem to motivate firms to tolerate more variability in their pre-tax incomes because they could use this tax shield to decrease their future tax liabilities.

Oil and gas producers that are more leveraged but not yet close to financial distress tend to use more swap contracts to ensure predetermined revenues. More solvent producers generally use collars only and avoid swaps only. In line with the risk-shifting theory, producers close to financial distress use put options only or hedging portfolios with non-linear payoffs (swaps in combination with put and/or collars). We also find that investment opportunities are positively related to hedging strategies with non-linear payoffs. This result is consistent with the argument of Froot, Scharfstein, and Stein (1993) and the empirical finding of Adam (2009) that firms with larger investment programs tend to use non-linear strategies to preserve any upside potential and ensure sufficient internal financing of future investment expenditures. The results further emphasize the real implications of market conditions on derivative choice and show that put options and costless collars are positively related to price volatility and anticipated prices, and swap contracts are positively related to spot prices.

As predicted, our results suggest that production uncertainty is positively related to the use of non-linear hedging strategies because this uncertainty adds more convexity to the firm's total exposure (e.g., Moschini and Lapan, 1995; Brown and Toft, 2002). Results related to the variability in production costs are significant and mixed. With regard to the existence of additional hedgeable risks, we find that FX risk is significantly related to the use of put options only or collars in combination with swaps. Basis risk is more related to swaps only. Interest rate risk has significant but mixed impacts. Consistent with Adam (2009), we find that more focused oil and gas producers tend to use more non-linear strategies. Finally, we test the robustness of the results using continuous measures of instrument intensity (i.e., derivative notional position scaled by the aggregate hedging portfolio) and find similar results.

The remainder of the paper is divided into five sections. Section I reviews the existing theoretical and empirical studies and states our hypotheses. Section II describes our data and dependent variables. Section III presents the retained econometric methodologies. Section IV reports our results, discussions, and robustness checks. Section V concludes the paper.

1.2 Related Literature and Hypotheses

In this section, we review the related literature, develop our testable hypotheses, and discuss the construction of independent variables.

1.2.1 Sensitivity of Firm's Revenues and Investment Costs to the Risk Exposure

Froot, Scharfstein, and Stein (1993) argue that when revenues and investment costs have similar sensitivities to changes in the underlying risk factor, linear strategies alone can provide value-maximizing hedges. Otherwise, firms should use non-linear strategies to achieve more optimal hedging strategies. In the oil and gas industry, contemporaneous oil and gas prices determine the cash flows generated from operations. These prices also dictate future rents associated with the exploration, development, and acquisition of oil and gas reserves. We therefore posit:

HYPOTHESIS 1: *When revenues and investment costs have equal sensitivities to commodity price movements, oil and gas producers are more likely to use linear hedging strategies. Otherwise, non-linear strategies may be required to achieve optimal hedge.*

To test the empirical relevance of this hypothesis, we simply calculate the correlation coefficients between firm's revenues and investment costs[4]. Firm's revenues are measured by free cash flow before capital expenditures, as in Lehn and Poulsen (1989)[5]. These free cash flows are not contaminated by the monetary effects of hedging because these effects are reported in comprehensive income as suggested by the new derivative accounting standard FASB 133 effective since 1998. Investment costs are measured by the ratio of the cost incurred over net property, plant, and equipment at the beginning of the quarter. In the oil and gas industry, the cost incurred includes the total costs of oil and gas property acquisition, exploration, and development. For each firm, these correlation coefficients are calculated by taking all the observations available until the current quarter.

1.2.2 Production Function Characteristics

Moschini and Lapan (1992) conclude that when the firm has sufficient production flexibility (in the sense that it is able to change its production parameters after observing the future price of the output, and assuming that this future price is unbiased), it should make use of options by shorting a put and call option with the same strike price and maturity (i.e., shorting a straddle position). In contrast, when all the production parameters are fixed ex-ante (before observing the future price of the output), there is no production flexibility and options will be useless. Generally, oil and gas firms operate in different regions of the world, with operating costs varying significantly between regions due to variations in domestic factors costs (i.e., salary, royalties, taxes, transportation costs...). This geographical dispersion of oil and gas reserves could be seen as production flexibility because firms can adjust their

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[4] As robustness checks, we follow Tufano (1996) and estimate these sensitivities in a more direct manner that will be discussed later.

[5] Lehn and Poulsen (1989) calculate free cash flow before investment expenditures as operating income before depreciation less total income taxes plus changes in the deferred taxes from the previous quarter to the current quarter less gross interest expenses on short- and long-term debt less the total amount of preferred dividends less the total dollar amount of dividends declared on common stock.

production capacity in each geographic location with different production costs in relation to the anticipated commodity prices to preserve their profit margins. This operative flexibility is thus a real option that has a convex payoff by definition and requires non-linear instruments to be hedged. Hence we propose:

HYPOTHESIS 2: *Oil and gas producers with higher production flexibility (i.e., geographical diversification of oil and* gas *production) are more likely to use non-linear instruments.*

We measure the geographical diversity of oil or gas production as one minus the Herfindahl index. A higher value implies that the oil or gas production has greater geographical dispersion and hence the firm has more production flexibility (see Table 1.1 for more details).

Moreover, the theoretical works of Brown and Toft (2002) and Gay, Nam, and Turac (2002, 2003) emphasize that the impact of price risk and production uncertainty on derivative choice is closely related to the level of the correlation between the output quantities and current prices. In fact, a positive correlation will increase the volatility of revenues because quantities and prices are moving in the same direction. A negative correlation will reduce variability in revenues and produce a natural hedge for the firm, but overhedging (i.e., when the sold quantities under forward/futures contracts are higher than produced quantities, and prices are rising) is then more likely to happen and hence non-linear instruments are more advantageous.

HYPOTHESIS 3: *Oil and gas* producers *with a negative quantity–price correlation are more likely to use non-linear instruments because overhedging is more likely. Conversely, firms with a positive quantity–price correlation are more likely to use linear instruments to reduce the volatility of their revenues.*

We calculate the correlation coefficient between quantities of daily oil (gas) production and oil (gas) spot prices. For each firm, the correlation coefficients are constructed with all the observations of daily production and spot prices available until the current quarter.

1.2.3 Overinvestment Problem

Morellec and Smith (2007) show that the firm's hedging policy is derived not only by the underinvestment incentives arising from shareholder–debtholder conflict but also by the overinvestment incentives arising from shareholder–manager conflict. The overinvestment problem is due to the managerial tendency to overinvest because managers derive private benefits from the investment. This problem is more observable in the case of firms with larger free cash flows and fewer investment opportunities. Morellec and Smith's (2007) argument is consistent with the empirical evidence reported by Bartram, Brown, and Fehle (2009), that large profitable firms with fewer growth options tend to hedge more, a finding that runs counter to the financial distress and underinvestment hypotheses. To reduce the costs of both overinvestment and underinvestment, Morellec and Smith (2007) suggest that the optimal hedging policy must reduce free cash flow volatility. Hence we posit:

HYPOTHESIS 4: *Oil and gas producers with large free cash flows and fewer investment opportunities are more likely to* use *linear instruments because of their capability to decrease free cash flow volatility to avoid the overinvestment problem.*

The overinvestment problem is measured by a binary variable that takes the value of one when the ratio of free cash flows scaled by the book value of total assets and investment opportunities are, respectively, above and below the industry's median and zero otherwise.

1.2.4 Compensation Policy and Ownership Structure

In a value-maximizing framework, Stulz (1984) points out the crucial role of managerial compensation contracts in optimal hedging policies. In a subsequent seminal work, Smith and Stulz (1985) show that if the manager's end-of-period utility is a concave function of the firm's end-of-period value, the optimal hedging policy involves complete insulation of the firm's value from underlying risks (if feasible). Accordingly, a risk-averse manager owning a significant fraction of the firm's shares is unlikely to hold a well-diversified portfolio and hence has more incentives to use linear hedging strategies. Linear strategies can better eliminate the volatilities of the firm's payoffs that directly affect the manager's wealth.

Smith and Stulz (1985) contend that if a manager's end-of-period utility is a convex function of a firm's end-of-period value, the manager has less incentive to completely eliminate underlying risks. The more a compensation package includes stock option grants, the more a manager's utility tends to be a convex function of firm value and hence the manager has more motivation to use non-linear instruments that reduce rather than eliminate the volatility of the firm's payoffs.

HYPOTHESIS 5: *Oil and gas producers with large manager shareholding are more likely to use linear instruments. Conversely, oil and gas producers with large stock option compensation are more likely to use non-linear instruments.*

We focus on chief executive officer (CEO) compensation packages because the CEO plays a crucial role in corporate hedging decisions. We measure the manager's firm-specific wealth by the logarithm of one plus the market value of common shares held by the CEO at the end of each quarter. Following Tufano (1996), we use the logarithm specification to reflect the idea that managerial risk aversion should decrease as firm-specific wealth increases. We also use the number of options held by the firm's CEO at the end of each quarter. To check whether the hedging strategy choice is due to poorly diversified risk-averse managers, Tufano (1996) controls for the existence of outside blockholders and argues that they should be well-diversified investors less interested in risk hedging. We subsequently control for the existence of outside blockholders by using the percentage of common shares held by institutional investors.

1.2.5 Tax Incentives

The tax argument for corporate hedging was analyzed by Mayers and Smith (1982), Smith and Stulz (1985), and Graham and Smith (1999) among others. The latter show that, in the presence of a convex tax function, hedging reduces the variability of pre-tax firm values and reduces the expected corporate tax liability. As for the choice of what derivative instruments to use, we expect firms with a convex tax function to use linear instruments because of their ability to eliminate the volatility of pre-tax incomes and we predict:

HYPOTHESIS 6: *Oil and* gas *producers in the convex tax region are more likely to use linear instruments and those with more tax loss carryforwards are likely to use non-linear instruments more often.*

Because the sample consists of US firms, we compute a proxy for tax function convexity based on the simulation procedure proposed by Graham and Smith (1999) to measure the expected percentage of tax savings arising from a 5% reduction in the volatility of pre-tax income. This measure is already applied in some empirical research, as in the work of Campello et al. (2011) and Dionne and Triki (2013). We also use the book value of tax loss carryforwards scaled by the book value of total assets to control for any disincentive to stabilize the pre-tax income because firms could use this tax shield to minimize their future tax liabilities. Graham and Rogers (2002) argue that tax loss carryforwards are uncorrelated with tax function convexity. We therefore predict that firms with higher tax loss carryforwards tend to use non-linear hedging strategies.

1.2.6 Control Variables

We include the following control variables, as in Adam (2009).

1.2.6.1 Financial Constraints

In Jensen and Meckling's (1976) risk shifting (or asset substitution) approach, the convexity of shareholders' utility motivates them to increase risk when the firm nears bankruptcy. It is then expected that highly distressed firms have more incentives to use non-linear hedging strategies that increase rather than eliminate the firm's payoff volatility. Adam (2002) extends the work of Froot, Scharfstein, and Stein (1993) to an inter-temporal setting and argues that hedging strategy depends on the firm's credit risk premium. When this premium is relatively low, the firm buys put options to avert a shortfall in future cash flows to fund its future investment programs. Firms with large credit risk premiums tend to hedge with concave strategies that involve selling call options. In intermediate cases between those two situations, Adam (2002) confirms that hedging portfolios will contain both convex and concave strategies (i.e., costless collars). He also asserts that unlevered firms with low levels of non-hedgeable risks are more likely to use linear hedging strategies, as suggested by Adler and Detemple (1988). Altogether, we predict that oil and gas producers that are either far from financial distress or deep in financial distress are more likely to use non-linear hedging strategies, while producers between those two extremes tend to use linear instruments and costless collars.

We construct the following three variables as proxies for financial distress. (1) Following Drucker and Puri (2009) and Campello et al. (2011), we implement the distance to default (DTD) as a measure of the future likelihood of default. The DTD is a market-based measure originating from Merton's (1974) approach and used by Moody's KMV, as described by Crosbie and Bohn (2003) (see Table 1.1 for more details). (2) Leverage is measured as the ratio of long-term debt in current liabilities plus one-half of long-term debt over the book value of total assets. (3) Financial constraint is measured by a binary variable that takes the value of one when both the leverage ratio and quick ratio are, respectively, above and below the industry's median and zero otherwise, in line with Dionne and Garand (2003).

1.2.6.2 Investment Expenditures

Froot, Scharfstein, and Stein (1993) argue that when future capital expenditures are a non-linear function of some hedgeable risk, then a non-linear strategy is required. Adam (2009) studies the options used in gold-mining firms and maintains that firms facing large capital expenditures that are a non-linear function of gold prices are more likely to use an insurance strategy (i.e., buying put options). It is expected that oil and gas producers with larger investment opportunities are more likely to use non-linear hedging strategies because they face non-linear capital expenditures that depend on oil and gas prices. In addition, non-linear instruments allow for future upside benefits.

We measure future investment opportunities with the following two proxies: 1) the ratio of the cost incurred over net property, plant, and equipment at the beginning of the quarter and 2) the quantity of proved undeveloped reserves for oil and gas, respectively.[6] These reserves could be seen as unexercised real options (Grullon, Lyandres, and Zhdanov, 2012) because oil and gas producers have the option but not an obligation to produce their undeveloped reserves after paying development costs.

1.2.6.3 Oil and Gas Market Conditions

Dolde (1993), Stulz (1996), and Bodnar, Hayt, and Marston (1998), in their surveys of corporate risk management practices, argue that managers incorporate their market views of future price movements by frequently altering either the size or the timing of their hedging positions. Stulz (1996) reports strong evidence of this view, which he refers to as speculative hedging. Empirically, Brown (2001) finds that the convexity of the hedging portfolios tends to be lower when the exchange rate volatility is higher relative to the FX exposures for near-term horizons, and it will be higher when the forward exchange rate is anticipated to be higher. Adam (2009) concludes that the option position is negatively related to gold spot price and uncorrelated with gold price volatility and gold basis (i.e., the difference between the forward and spot prices of gold). Accounting for oil and gas production uncertainties (i.e., quantity risk), we expect that the non-linearity of the hedging strategy will be positively related to oil and gas price volatility and anticipated prices, and negatively related to oil and gas spot prices.

We extract the oil and gas spot prices observed at the end of each quarter from the Bloomberg Financial Markets database. We use the West Texas Intermediate crude oil (WTI) index as a proxy for oil spot prices. For natural gas spot prices, we use the average index established by the Bloomberg Financial Markets database from different location indices (Gulf Coast, Henry Hub, Rocky Mountains, etc.). We calculate the volatility of oil and gas

[6] Undeveloped reserves are expected to be recovered (1) from new wells on undrilled acreage, (2) from deepening existing wells to a different reservoir, or (3) where a relatively large expenditure is required to (a) recomplete an existing well or (b) install production or transportation facilities for primary or improved recovery projects (World Petroleum Council).

for each quarter as the standard deviation of daily spot prices within the quarter. For future oil and gas prices, we use (i) the Bloomberg NYMEX Crude Oil 12-Month Strip futures price, and (ii) the Bloomberg NYMEX Henry Hub Natural Gas 12-Month Strip futures price. These two indices are established by the Bloomberg Financial Markets database as the arithmetic averages of oil (gas) futures contract prices over the next 12 months.

1.2.6.4 Additional Risks

Moschini and Lapan (1995), Franke, Stapleton, and Subrahmanyam (1998), Brown and Toft (2002), and Gay, Nam, and Turac (2002, 2003) predict that when a firm is facing increasing non-hedgeable risks, its total exposure becomes non-linear and optimal hedging should be non-linear. Adler and Detemple (1988) show in a portfolio context that borrowing or short selling constraints can create non-linear exposures and hence non-linear instruments are required to implement optimal hedging. Indeed, Brown and Toft (2002) show that in the presence of hedgeable risks that are not hedged for some reason, firms are more likely to use non-linear instruments. Empirically, Brown (2001) finds no significant relation between FX exposure volatility and the use of non-linear strategies and Adam (2009) asserts that gold production risk does not appear to motivate the use of options.

Firms operating in the petroleum industry face several risks in addition to oil and gas price risks. Some of these additional risks are non-hedgeable with current marketable derivative instruments. These include quantity risk caused by uncertainties in the quantities produced and production cost risk due to variability in production costs. Additional risks—FX risk, IR risk, and basis risk—could be hedged with marketable derivatives. Therefore, we predict that oil and gas producers facing additional hedgeable and non-hedgeable risks have more incentive to use non-linear instruments because their total exposure becomes non-linear.

Production uncertainty is measured by the coefficient of variation of the time series of daily production for oil and gas, respectively. The production cost risk is measured by the coefficient of variation of cash costs given by the barrel of oil equivalent (BOE).[7] For each firm, we calculate these coefficients of variation based on available observations until the current quarter. The FX risk, IR risk, and basis risk are measured by dummy variables, where each dummy variable takes the value of one if the firm hedges the given risk and zero otherwise.

1.2.6.5 Industrial Diversification

Another aspect of production flexibility comes from the complementary nature of oil and gas operations. Hence, firms operating in both the oil and gas segments could be seen as practicing industrial diversification. We construct two additional indices measuring the fraction of revenues derived from oil and gas production separately. These indices allow us to distinguish between producers operating primarily in the oil segment and those operating primarily in the gas segment.

Table 1.1 summarizes the definitions, construction, and data sources of the variables. Table A.1.1 (Appendix) summarizes the theoretical predictions arising from the literature review and illustrates their expected empirical implications, which we investigate for each of the hedging strategies adopted by oil and gas producers.

[7] The lifting costs per BOE are given on an annual basis. We repeat the annual observations for each quarter of the same fiscal year. Oil and gas producers typically quote production in BOEs. Naturally, one barrel of oil = 1 BOE. For natural gas production, 6,000 cubic feet (Mcf) of gas is counted as one BOE.

Table 1.1 Variables definitions, construction and data sources

Variable definition	Variable name	Construction	Data source
Variables that proxy for hedging activity			
Hedging dummy	*GAS_HEDG, OIL_HEDG, IR_HEDG, FX_HEDG, BASIS_HEDG*	For Commodity Risk, FX, and IR hedging activities for a specified fiscal quarter. This variable is coded as follows: 0 (no hedging), 1(hedging).	10-K and 10-Q reports
Variables that proxy for tax advantage of hedging			
Tax loss carryforwards	*TLCF*	Book value of the TLCF scaled by the book value of total assets	Compustat
Tax save	*TAX_SAVE*	Tax liability saving arising from a reduction of 5% of taxable income (Graham and Smith, 1999).	Compustat
Variables that proxy for financial distress costs			
Leverage	*LEV*	Book value of long-term debt in current liabilities + one-half of long-term debt scaled by the book value of total assets.	Compustat
Distance to default	*DTD*	Market-based measure of default risk based on Merton's (1974) approach and used by Moody's KMV. The DTD is equal to $\frac{V_a - D}{V_a \sigma_a}$, where D is defined as long-term debt in current liabilities plus one-half of long-term debts, V_a is the market value of assets, and σ_a is one-year asset volatility. The quantities V_a and σ_a are unobservable and are approximated from Merton's (1974) model by using the market value and volatility of equity, the three-month Treasury bill rate, and debts (D). See Crosbie and Bohn (2003) for more details on the construction of the DTD.	Manually constructed
Financial constraint	*CONSTRAINT*	Binary variable. It equals 1 when both the leverage ratio and quick ratio are, respectively, above and below the industry's median and 0 otherwise.	Compustat
Cash cost	*CASH_COST*	Production cost of a BOE	Bloomberg and 10-K reports
Variables that proxy for underinvestment costs			
Investment opportunities (IOs)	*INV_OPP*	Total costs incurred in oil and gas property acquisition, exploration, and development, scaled by net property, plant, and equipment at the beginning of the quarter.	Bloomberg and 10-K reports
Correlation FCF and IOs	*COR_IO_FCF*	Correlation coefficient between free cash flow and investment opportunities. This coefficient is calculated for each firm by using all the observations until the current quarter.	Bloomberg and 10-K reports
Undeveloped proved reserves (oil)	*UND_OIL*	Quantity of proved undeveloped oil reserves at the end of the quarter (in millions of barrels).	Bloomberg and 10-K reports
Undeveloped proved reserves (gas)	*UND_GAS*	Quantity of proved undeveloped gas reserves at the end of the quarter (in billions of cubic feet).	Bloomberg and 10-K reports

Continued

Table 1.1-*Continued*

Variable definition	Variable name	Construction	Data source
Variables that proxy for overinvestment			
Overinvestment problem	*OVER_INV*	Binary variable. It equals 1 when both the ratio of free cash flows scaled by the book value of total assets and investment opportunities are, respectively, above and below the industry's median and 0 otherwise.	Compustat
Variables that proxy for production characteristics			
Fraction of revenues from oil production	*OIL_REV*	Equals the fraction of oil production (i.e., oil daily production in BOEs, divided by daily oil and gas production in BOEs) multiplied by the fraction of oil and gas revenues (oil and gas revenues divided by the firm's total revenues).	Bloomberg and 10-K reports
Fraction of revenues from gas production	*GAS_REV*	Equals the fraction of gas production (i.e., gas daily production in BOEs, divided by daily oil and gas production in BOEs) multiplied by the fraction of oil and gas revenues (oil and gas revenues divided by the firm's total revenues).	Bloomberg and 10-K reports
Herfindahl index (oil production)	*HERF_OIL*	Equals $1-\sum_{i=1}^{N}\left(\frac{q_i}{q}\right)^2$, where q_i is the daily oil production in region i (Africa, Latin America, North America, Europe, and the Middle East) and q is total daily oil production.	Bloomberg and 10-K reports
Herfindahl index (gas production)	*HERF_GAS*	Equals $1-\sum_{i=1}^{N}\left(\frac{g_i}{g}\right)^2$, where g_i is the daily gas production in region i (Africa, Latin America, North America, Europe, and the Middle East) and g_i is total daily gas production.	Bloomberg and 10-K reports
Oil production uncertainty	*UNCER_OIL*	Coefficient of variation of daily oil production. This coefficient is calculated for each firm by using all the observations of daily oil production until the current quarter.	Bloomberg and 10-K reports
Gas production uncertainty	*UNCER_GAS*	Coefficient of variation of daily gas production. This coefficient is calculated for each firm by using all the observations of daily gas production until the current quarter.	Bloomberg and 10-K reports
Cash cost variability	*COST_CV*	Coefficient of variation of the cash (lifting) cost, by BOE. This coefficient is calculated for each firm by all the observations of cash costs until the current quarter.	Bloomberg and 10-K reports
Price–quantity correlation (oil)	*PQ_COR_OIL*	Correlation coefficient between daily oil productions and oil spot prices.	Bloomberg and 10-K reports
Price–quantity correlation (gas)	*PQ_COR_GAS*	Correlation coefficient between daily gas productions and gas spot prices.	Bloomberg and 10-K reports
Variables that proxy for firm size			
Sales	*SALES*	Total revenues from oil and gas sales (in millions of dollars)	Compustat
Market value	*MKT_VALUE*	Number of common shares outstanding * end-of-quarter per share price (in millions of dollars).	Compustat
Oil reserves	*RES_OIL*	Quantity of the total proved developed and undeveloped oil reserves (in millions of barrels).	Bloomberg and 10-K reports
Gas reserves	*RES_GAS*	Quantity of the total proved developed and undeveloped gas reserves (in billions of cubic feet).	Bloomberg and 10-K reports

Continued

Table 1.1-*Continued*

Variable definition	Variable name	Construction	Data source
Variables that proxy for managerial risk aversion			
Market value of CEO shareholding	*MV_CS_CEO*	Measured by the logarithm of 1 plus the market value of common shares held by the CEO at the end of each quarter.	Thomson Reuters
# CEOs stock options	*OPT_CEO*	Number of CEO stock options (in thousands).	Thomson Reuters
Variables that proxy for information asymmetry			
% Institutions shareholding	*%_CS_INST*	Percentage of institutions' common shares held.	Thomson Reuters
Variables that proxy for market conditions			
Oil future price	*FUTURE_OIL*	Average oil future prices for exchange-traded futures for the next 12 months.	Bloomberg
Oil spot price	*SPOT_OIL*	Oil spot price represented by the WTI in the NYMEX.	Bloomberg
Gas future price	*FUTURE_GAS*	Average gas future prices for exchange-traded futures for the next 12 months.	Bloomberg
Gas spot price	*SPOT_GAS*	Constructed as an average index established from principal locations' indices in the United States (Gulf Coast, Henry Hub, etc.)	Bloomberg
Oil price volatility	*VOL_OIL*	Historical volatility (standard deviation) using the spot price of the previous 60 days.	Bloomberg
Gas price volatility	*VOL_GAS*	Historical volatility (standard deviation) using the spot price of the previous 60 days.	Bloomberg
Variables that proxy for hedging substitutes			
Quick ratio	*Q_RATIO*	Cash and cash equivalents scaled by current liabilities.	Compustat
Book value of convertible debts	*BVCD*	Book value of convertible debts scaled by the book value of total assets.	Compustat

1.3 Data and Dependent Variables

1.3.1 Data Construction

The oil and gas industry is an excellent laboratory to test the different corporate risk management motivations and implications, for several reasons. First, firms in this industry share homogeneous risk exposures (i.e., fluctuations in crude oil and natural gas prices). Hence, diversity in the hedging strategies implemented should not come from differences in risk exposure, but is more likely to result from differences in firm characteristics. Second, the existence of financial derivatives on crude oil and natural gas offers these firms several price hedging methods. Futures contracts and options in oil and gas are traded in the NYMEX and forward contracts and swaps are traded in the over-the-counter market. Third, improvements in accounting disclosure related to oil- and gas-producing activities have made operational data available, pertaining to exploration, production and reserve quantities, cash costs, and so on.

A first list of 413 US oil and gas producers with the primary Standard Industrial Classification (SIC) code 1311[8] was extracted from Bloomberg. Only firms that met the following criteria were retained: They have at least five years of historical data on oil and gas reserves during the period 1998 to 2010, the 10-K and 10-Q reports are available from the EDGAR website, and the firm is covered by COMPUSTAT. The filtering process produced a final sample of 150 firms with an unbalanced panel of 6,326 firm–quarter observations. To our knowledge, this sample is the most recent and the largest in the empirical literature on risk management in the oil and gas industry.[9]

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[8] The SIC code 1311, Crude Petroleum and Natural Gas, comprises companies primarily involved in the operation of properties for the recovery of hydrocarbon liquids and natural gas.

[9] Jin and Jorion (2006) study a sample of 119 US oil and gas producers with 330 firm–year observations over the period 1998 to 2001. Haushalter (2000) uses a sample of 100 U.S oil and gas producers with 292 firm–year observations over the period 1992 to 1994. Haushalter, Heron, and Lie (2002) use a sample of 68 US oil producers with 155 firm–year observations over the period 1992 to 1994.

Data on these firms' financial and operational characteristics were gathered from several sources. Data regarding financial characteristics were taken from the COMPUSTAT quarterly dataset held by Wharton Research Data Services (WRDS). Other items related to institutional and managerial shareholdings and option holdings are from the Thomson Reuters dataset maintained by WRDS. Data related to oil and gas producers' reserves, production quantities, cash costs, geographical dispersion, exploration, development, and property acquisitions were taken from Bloomberg's annual dataset and verified and supplemented by hand-collecting data directly from 10-K annual reports. Quarterly data about oil and gas producers' hedging activities were hand-collected from 10-K and 10-Q reports.

1.3.2 Dependent Variables: Construction and Characteristics

Table 1.2 breaks down the sample of 6,326 firm–quarters into observations with and without gas and/or oil hedging. Oil and gas producers report hedging activities for 3,489 firm–quarters, which represents almost 55% of the whole panel. Out of these 3,489 firm–quarters, 2,255 report hedging activities for both oil and gas, almost 64.63% of the hedging subsample. Firm–quarters with only gas hedging represent 25.27% of the hedging subsample, with 882 observations. Finally, there are 352 firm–quarters with only oil hedging, or 10% of the hedging subsample.

Table 1.2 Distribution of hedging decisions by firm–quarter

	Hedging activity: Firm–quarter		
	Oil hedgers	Non-oil hedgers	Total
Gas hedgers	2,255	882	3,137
Non-gas hedgers	352	2,837	3,189
Total	2,607	3,719	6,326

Note:

This table breaks down the total sample of 6,326 firm–quarters into observations with and without oil hedging and with and without gas hedging.

To analyze the hedging behavior of oil and gas producers in greater depth, we collected information about the nature of hedging instruments already in use. Essentially, the hedging instruments consist of swap contracts; put options, costless collars, forward or futures contracts, and three-way collars. Table 1.3 presents a breakdown of the frequency of use for each hedging instrument. The most common hedging vehicles are swap contracts, with 45.58% (45.25%) of use in gas (oil) hedging. The second most frequently used instrument is the costless collar, with 37.19% (37.11%) for gas (oil) hedging. Next are put options, with 10.55% for gas hedging and 11.85% for oil hedging. The least used instruments are forward or futures contracts, with only 3.25% (2.78%) for gas (oil) hedging, and three-way collars, with only 3.42% (3.02%) for gas (oil) hedging. These observations show that oil and gas producers adopt quite similar strategies in their oil and gas hedging and that they prefer more swap contracts and costless collars.

Table 1.3 Hedging instruments used by oil and gas producers

	Gas hedging		Oil hedging	
Financial instrument	Number of firm–quarters	Percentage of use	Number of firm–quarters	Percentage of use
Swap contracts	2,255	45.58%	1,711	45.25%
Put options	522	10.55%	448	11.85%
Costless collars	1,840	37.19%	1,403	37.11%
Forwards or futures	161	3.25%	105	2.78%
Three-way collars	169	3.42%	114	3.02%
Total	4,947	100%	3,781	100%

Note:

This table reports the different types of financial instruments used by the sample firms that report oil and gas hedging activities in a given firm–quarter observation. The values for each instrument indicate the number of firm–quarters and the fraction (in percentage) of use.

We now analyze hedging strategies and, to save space, we skip observations related to forward/futures contracts, which account for only 3.25% of gas hedging activity and 2.78% of oil hedging activity. We also omit observations related to three-way collars, because they are used in only 3.42% of cases for gas hedging activity and 3.02% for oil hedging. Table 1.4 shows that two major hedging behaviors are adopted by oil and gas hedgers: the use of only one hedging instrument and the use of more than one hedging instrument simultaneously to form hedging portfolios with different payoff structures. Table 1.4 illustrates that swap contracts are used separately 45% of the time, with put options 6% of the time, costless collars 41% of the time, and put options and costless collars simultaneously 8% of the time. Put options are employed separately 29% of the time, with swap contracts 24% of the time, costless collars 14% of the time, and simultaneous swaps and collars 33% of the time. In addition, costless collars are used separately 36% of the time, with swaps 50% of the time, put options 4% of the time, and simultaneous swaps and puts 10% of the time.

Table 1.4 Hedging strategies adopted by oil and gas producers

	Swap only	Put only	Collar only	Swap+put	Swap+collar	Put+collar	Swap+put+collar
Panel A: Gas hedging strategies							
Number of firm–quarters	932	126	582	137	999	72	187
Percentage of use							
Swap contracts	41.33%			6.08%	44.30%		8.29%
Put options		24.14%		26.25%		13.79%	35.82%
Costless collars			31.63%		54.29%	3.91%	10.16%
Panel B: Oil hedging strategies							
	Swap only	Put only	Collar only	Swap+put	Swap+collar	Put+collar	Swap+put+collar
Number of firm–quarters	849	150	577	99	627	63	136
Percentage of use							
Swap contracts	49.62%			5.79%	36.65%		7.95%
Put options		33.48%		22.10%		14.06%	30.36%
Costless collars			41.13%		44.69%	4.49%	9.69%

Note:

This table reports the hedging strategies adopted by the sample firms. An oil and gas producer can use one or more instruments simultaneously. Overall, we distinguish seven hedging strategies: swap contracts only, put options only, costless collars only, swaps and puts, swaps and collars, puts and collars, and swaps, put, and collars for oil hedgers and gas hedgers, respectively. The value for each strategy represents the number of firm–quarter observations in which a firm reports the use of that strategy. The percentage of use for each instrument represents the number of firm–quarters of use of a given strategy scaled by the total number of firm–quarters of use of that instrument as given in Table 1.3.

Figures 1.1 and 1.2 show how these hedging strategies evolve over time and highlights some important facts. Use of swaps only declines starting 1999, particularly for gas hedging. The decrease in swap use seems to be compensated by an increase in collars use separately or in combination with swaps. The use of put options only or in combination with swaps is stable over time, in particular for gas hedging. Turning to the distribution of notional quantity for each hedging portfolio (i.e., a combination of instruments), we find significant variations in the time-series distribution of notional quantities between instruments.

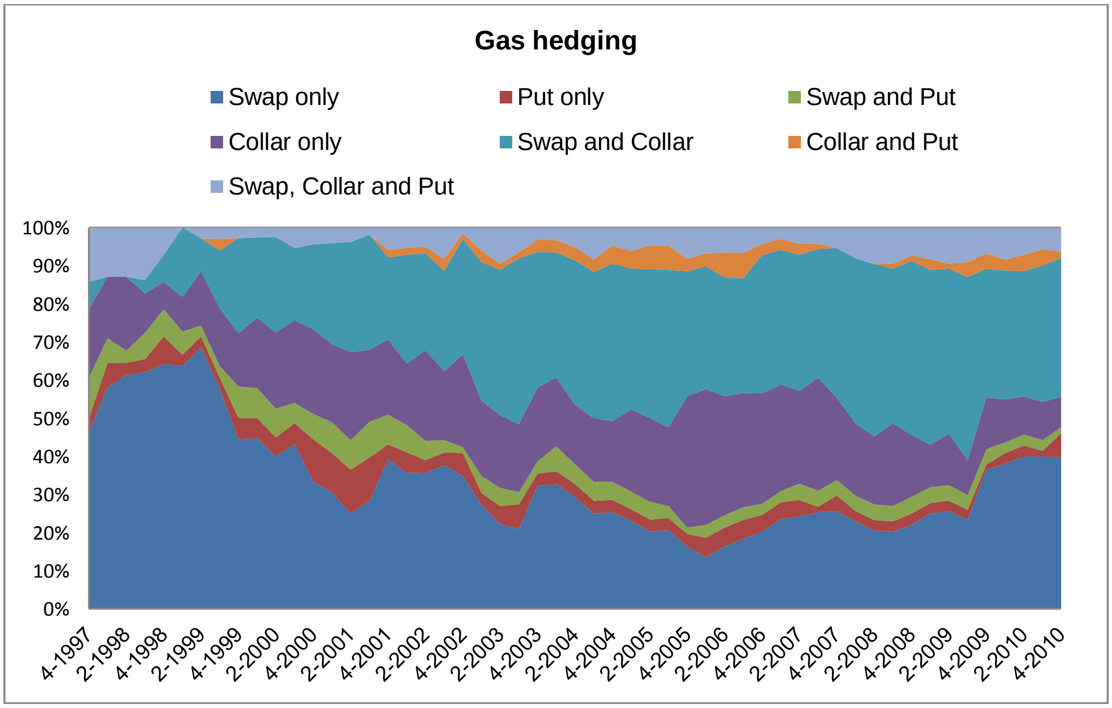

Figure 1.1 Frequency of use by hedging strategy over 1998-2010 for gas hedging

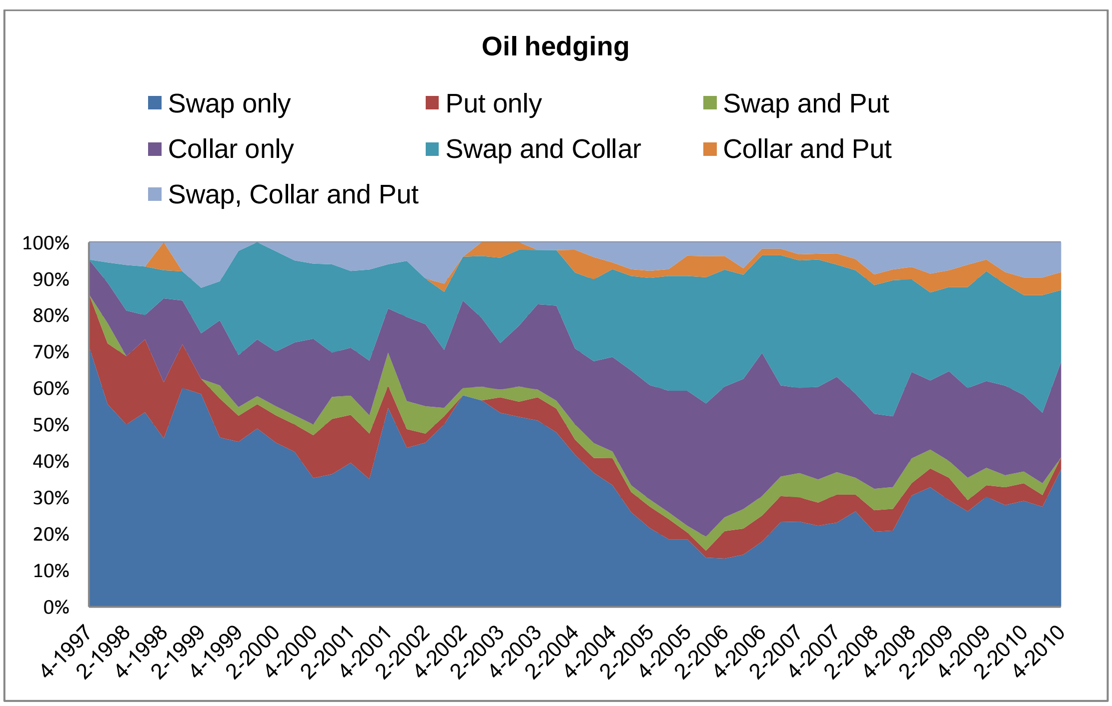

Figure 1.2 Frequency of use by hedging strategy over 1998-2010 for oil hedging

1.3.3 Econometric Methodologies

The transition probabilities reported in Table A.1.2 show extreme state dependence in the derivative choice for the sample hedgers. The elements of Table A.1.2 could be interpreted as conditional probabilities under the Markov model. The magnitude of the diagonal elements clearly shows the persistence or state dependence in hedging strategy choice. Persistence in hedging behavior arises from two main sources. One possibility is that persistence is caused by unobserved decision-maker-specific preferences for derivatives that are time invariant, which creates unobserved time-invariant individual heterogeneity (i.e., spurious state dependence, as noted by Heckman, 1981). Alternatively, persistence can be due to unobserved but time-variant characteristics of hedging strategies, which creates true state dependence. These unobserved time-variant characteristics could be transaction costs, liquidity risk, counterparty risk, and accounting concerns associated with different hedging instruments.

To disentangle the effects of unobserved individual heterogeneity and state dependence, we employ several dynamic discrete choice frameworks with random effects, retaining a first-order Markov process (i.e., including the first lagged dependent variable) and accounting for the initial condition problem. We consider derivative choice as multi-state process and examine the effects of investment opportunities, taxes, agency costs, distress costs, managerial risk aversion, overinvestment, production function characteristics, and market conditions on the choice of hedging strategy. Estimating these econometric dynamic settings allows us to distinguish the effects of past hedging strategy choice and observable and unobservable firm characteristics on current hedging behavior.

To control for the possibility of sample selection bias, the estimation of all our models is derived in the context of two-step Heckman regression with selection. This procedure captures the sequential decisions of oil and gas producers: a first decision to hedge or not and a second decision about the nature of the hedging strategy. In the first step, we follow the literature and model hedging activity as a function of variables that are proposed to be determinants of the hedging decision: tax incentives, leverage, liquidity, cash costs, book value of convertible debt, firm market value (size), sales (market risk exposure), and oil and gas reserve quantities (substitute to hedging). Table A.1.3 reports the estimation results of the first step, which allow us to obtain the estimated inverse Mills ratio for the second step. We observe that almost all variables are statistically significant and with appropriate signs, consistent with the previous literature on the decision to hedge (Tufano, 1996; Graham and Rogers, 2002; Campello et al, 2011; Dionne and Triki, 2013).

1.3.4 Dynamic Generalized Ordered Specification for Hedging Instrument Choice

This model is used for hedging strategies based on one instrument only, as identified in Table 1.4 (i.e., swap contracts only, put options only, and costless collars only). We include the first lagged value of the dependent variable to account for this state dependence in hedging strategy choice. This model is flexible and relaxes the single index or parallel-line assumption (i.e., same coefficient vector for all categories of the dependent variable) by making threshold parameters a linear function of the covariates (Maddala, 1983; Terza, 1985). We order hedging instruments in terms of their payoff non-linearity as follows: (1) put options only, (2) costless collars only, and (3) swaps only. The starting point for the econometric model is an unobserved latent dependent variable $h^*_{(i,t)}$ that describes the choice of hedging instrument, given that possible choices are $h_{i,t} = \{1,2,3\}$. The reduced form of the estimated model is

$$h^*_{i,t} = \beta X_{i,t} + \rho h_{i,t-1} + \varepsilon_{i,t} + u_i \quad (i = 1,..,N : t = 1,..,T_i), \tag{1}$$

where $X_{i,t}$ is a set of observed exogenous variables related to investment program specificities, taxes, financial distress costs, managerial risk aversion, overinvestment problem, production function characteristics, and market conditions, which may be associated with the hedging strategy choice of firm *i* at time *t*. In addition, $X_{i,t}$ includes the inverse Mills ratio from the first step of the Heckman regression with sample selection. u_i is firm-specific factor that is time invariant and thus represents unobserved individual heterogeneity; and $\varepsilon_{i,t}$ is the idiosyncratic error term that is assumed to be strictly exogenous, normally distributed, and uncorrelated across firms and time. $h_{i,t-1}$ is the observed instrument choice in the previous period that allows state dependence to be captured.

To overcome the initial condition problem, we parameterize the unobserved individual heterogeneity u_i as in the work of Wooldridge (2002):

$$u_i = \alpha_1 h_{i,0} + \alpha_2 \bar{X}_i + \upsilon_i \quad (i = 1, \ldots, N), \tag{2}$$

where $h_{i,0}$ is the first observation of hedging strategy choice for firm *i*. $\bar{X}_i$ and is a set of means over the sample period of the exogenous variables of firm *i* (i.e., $X_{i,t}$); and υ_i is assumed to be distributed as $N\left(0, \sigma^2_{\upsilon_i}\right)$ and independent of the exogenous variables, the initial condition, and the error term $\left(\varepsilon_{i,t}\right)$. Because the latent outcome $h^*_{i,t}$ is not observed, only an indicator of the hedging instrument in which the latent variable falls is observed:

$$h_{i,t} = j \text{ if } \mu_{j-1} < h^*_{i,t} \leq \mu_j, \tag{3}$$

where the μ_j with $j = \{1,2,3\}$ are the threshold parameters. We allow these threshold parameters to be a linear function of the observable characteristics $X_{i,t}$, $h_{i,t-1}$, $h_{i,0}$, and $\bar{X}_i$.

The conditional probability of observing each category $j = \{1,2,3\}$ is then given by an augmented generalized ordered probit with random effects including the lagged dependent variable and the initial observation. This approach, as for Williams (2006), leads to the estimation of $J-1$ (*J* is the number of categories) dynamic random effects probit models. The first model contrasts category 1 with categories $2, \ldots, J$; the second model contrasts categories 1 and 2 with categories $3, \ldots, J$. The model $J-1$ does the same regarding categories $1, \ldots, J-1$ versus category *J*. For each model among the $J-1$ dynamic random effects probit models, the current and lower-coded categories are recorded to 0 (i.e., reference group) and higher categories are recorded to 1. Therefore, positive coefficients mean that higher values on the explanatory variable are more related to higher categories than the current one. Negative coefficients indicate that higher values on the explanatory variable are more related to the current or lower-coded category. This model could be estimated by Gauss–Hermite quadrature[10] (see Boes, 2007 for more detail).

1.3.5 Dynamic Multinomial Specification for Hedging Portfolio Choice

Here we focus our attention on hedging portfolio choice (i.e., simultaneously using more than one instrument). Table 1.4 reveals that these hedging portfolios are constructed mainly from combinations of swap contracts with put options and/or costless collars. The transition probabilities reported in Table A.1.2 indicate higher persistence in these hedging portfolios, which motivates the use of a dynamic multinomial choice framework. Our econometric framework takes the form of a dynamic MMNL with random coefficients and correlated random effects.

We allow random effects to be correlated with the firm's time-variant characteristics. This specification is less restrictive than in a standard random effects model because it does not exhibit the restrictive assumption of independence from irrelevant alternatives and is more consistent with the random utility maximization assumption. The mixed logit also effectively captures random taste variation and habit formation. The utility for firm *i* from choosing hedging portfolio j at time *t*, $U_{i,t,j}$, is given by[11]:

$$U_{i,t,j} = X_{i,t}\beta_j + L_{i,t-1,j}\varphi_j + \varepsilon_{i,t,j} + u_{i,j} \quad (i = 1, \dots, N; t = 1, \dots, T_i; j = 1, \dots, J), \quad (4)$$

where $X_{i,t}$ is a set of observed exogenous variables related to hedging portfolio choice as in equation (1) with unknown weight β_j, and $L_{i,t-1,j}$ is a binary dummy variable indicating lagged hedging portfolio choice with parameter φ_j, with $L_{i,t-1,j} = 1$ if firm *i* chooses hedging portfolio j at time $t-1$ and $L_{i,t-1,j} = 0$ otherwise. Oil and gas producers have a set of four alternative hedging portfolios: swap contracts only $(j=1)$, which is our base

[10] The model is estimated using a *STATA* user-written program *regoprob2* developed by Pfarr, Schmid, and Schneider (2010) based on Gauss-Hermite quadrature.

[11] The notation in this section is largely adapted from Zucchelli, Harris, and Xueyan (2012).

outcome in the model; swap contracts combined with put options $(j=2)$; swap contracts combined with costless collars $(j=3)$; and swap contracts combined with put options and costless collars $(j=4)$. Here $u_{i,j}$ represents firm *i* and alternative *j* specific factors that are time invariant (i.e., unobserved heterogeneity). $u_i = (u_{i,1}, u_{i,2}, u_{i,3})$ are modeled as random effects by assuming that they come from a trivariate normal distribution. The term $\varepsilon_{i,t,j}$ is an idiosyncratic error term that is assumed to be independent from everything else in the model; it follows a Gumbel distribution.

Assume that at each time period $(t>1)$ a firm chooses the hedging portfolio associated with the highest level of utility. Then, $L_{i,t,j} = 1$ if $U_{i,t,j} > U_{i,t,k}$ for all $k \neq j\,(k=1,\ldots,J)$. Hence, the probability of making choice *j* at time $t > 1$ conditional on $X_{i,t}$, $L_{i,t-1,j}$, and $u_{i,j}$ takes the following logit form:

$$P_{i,t,j} = \mathrm{P}(L_{i,t,j} = 1 | X_{i,t}, L_{i,t-1,j}, u_{i,1}, \ldots, u_{i,J}) = \frac{\exp(X_{i,t}\beta_j + L_{i,t-1,j}\varphi_j + u_{i,j})}{\sum_{k=1}^{J} \exp(X_{i,t}\beta_k + L_{i,t-1,k}\varphi_k + u_{i,k})}, \quad (5)$$

For identification purposes, all coefficients for the first category $(j=1)$ and its unobserved heterogeneity are set to zero (i.e., hedging with swap contracts only). We assume that the individual unobserved heterogeneity for the remaining three hedging portfolios follows a trivariate normal distribution with zero mean and a variance–covariance matrix with non-zero correlation across unobserved heterogeneity for alternative hedging portfolios.

Train (2009) suggests approximating the sample likelihood (*SL*) for the multinomial logit with random effects using simulated maximum likelihood methods.[12] To account for the initial condition problem, we parameterize the distribution of the individual unobserved heterogeneity for each firm as a function of the means of the exogenous variables over the sample period and the hedging portfolio choice in the initial period.

[12] The model is estimated using a user-written *STATA* program *mixlogit* by Arne Risa Hole (2007) that implements simulation using Halton sequences. We use 200 Halton draws.

1.4 Results and Discussion

1.4.1 Descriptive Statistics: Independent Variables

Descriptive statistics are computed for the pooled dataset. Table 1.5 presents summary statistics for the financial and operational characteristics of the 150 US oil and gas producers in the sample. The findings suggest that US oil and gas producers are intensive hedgers. In fact, the hedging indicator variables show that gas hedging occurred in 49.58% of the firm–quarters in the sample and oil hedging occurred in 41.21% of the firm–quarters. In addition, IR, FX, and basis risk hedging occurred, respectively, in 17.18%, 4.5%, and 9.48% of the firm–quarters.

Table 1.5 Summary statistics for firm financial and operational characteristics

Variables	Obs	Mean	Median	1st quartile	3rd quartile	STD
Variables that proxy for hedging activity						
GAS_HEDG	6,326	0.496	0.000	0.000	1.000	0.500
OIL_HEDG	6,326	0.412	0.000	0.000	1.000	0.492
BASIS_HEDG	6,326	0.095	0.000	0.000	0.000	0.293
IR_HEDG	6,326	0.172	0.000	0.000	0.000	0.377
FX_HEDG	6,326	0.045	0.000	0.000	0.000	0.207
Variables that proxy for underinvestment costs						
INV_OPP	6,006	0.224	0.075	0.041	0.129	3.619
UND_OIL	6,326	95.153	2.109	0.118	19.106	450.444
UND_GAS	6,326	503.631	31.799	2.742	193.048	2028.157
COR_IO_FCF	6,196	0.055	0.046	-0.179	0.305	0.383
Variables that proxy for overinvestment						
OVER_INV	5,855	0.259	0.000	0.000	1.000	0.438
Variables that proxy for tax advantage						
TLCF	6,066	0.134	0.000	0.000	0.064	0.438
TAX_SAVE	6,160	0.052	0.048	0.029	0.070	0.051
Variables that proxy for financial distress costs						
DTD	5,686	2.234	2.052	1.323	2.862	1.361
LEV	6,063	0.158	0.142	0.053	0.220	0.153
CONSTRAINT	6060	0.321	0.000	0.000	1.000	0.467
CASH_COST	6,241	9.860	7.527	4.684	12.230	8.441
Variables that proxy for managerial risk aversion						
MV_CS_CEO	6,326	28.983	1.125	0.000	11.563	152.159
OPT_CEO	6,326	174.386	0.000	0.000	120.000	681.760
Variables that proxy for information asymmetry						
%_CS_INST	6,326	0.372	0.299	0.000	0.742	0.353
Variables that proxy for production characteristics						
UNCER_OIL	6,058	0.416	0.313	0.141	0.587	0.388
PQ_COR_OIL	6,119	0.229	0.455	-0.287	0.723	0.587
UNCER_GAS	6,078	0.408	0.303	0.146	0.582	0.359
COST_CV	6,167	0.292	0.252	0.148	0.396	0.556
PQ_COR_GAS	6,112	0.154	0.230	-0.174	0.504	0.419
OIL_REV	6,204	0.351	0.273	0.107	0.526	0.350
GAS_REV	6,204	0.519	0.566	0.242	0.785	0.311
HERF_GAS	6,180	0.063	0.000	0.000	0.000	0.183
HERF_OIL	6,178	0.100	0.000	0.000	0.000	0.233
Variables that proxy for firm size						
MKT_VALUE	5,922	6,439.084	268.290	47.502	1,625.050	33,014.790
SALES	6,326	1,379.558	22.071	2.762	162.717	7,771.860
RES_OIL	6,326	276.710	8.010	0.948	53.352	1,277.726
RES_GAS	6,326	1,504.194	99.463	13.711	571.699	5,888.217
Variables that proxy for hedging substitutes						
BVCD	6,065	0.025	0.000	0.000	0.000	0.102
Q_RATIO	6,069	1.555	0.275	0.079	0.850	5.334

Note:

This table provides financial and operational statistics for the 150 US oil and gas producers for the period 1998 to 2010. The terms *GAS_HEDG*, *OIL_HEDG*, *IR_HEDG*, *FX_HEDG*, and *BASIS_HEDG* are dummy variables for gas, oil, IR, FX, and basis risk hedging. Here *TLCF* stands for tax loss carry-forwards s scaled by the book value of total assets; *TAX_SAVE* for the expected percentage of tax savings; *LEV* for the leverage ratio; *DTD* for the distance-to-default; *CASH_COST* for the production cost per BOE; *INV_OPP* for investment opportunities; *COR_IO_FCF* for the correlation between free cash flows and investment opportunities; *UND_OIL* and *UND_GAS* for undeveloped proved oil (in millions of barrels) and gas (in billions of cubic feet) reserves, respectively; *OVER_INV* for the overinvestment problem; *OIL_REV* and *GAS_REV* for fractions of revenues from oil and gas production, respectively; *HERF_OIL* and *HERF_GAS* for the geographical dispersion of oil and gas production, respectively; *UNCER_OIL* and *UNCER_GAS* for the production uncertainty for oil and gas, respectively; *PQ_COR_OIL* and *PQ_COR_GAS* for the quantity–price correlation for oil and gas, respectively; *SALES* for sales*;* *MKT_VALUE* for common shares market value (in millions of dollars); *RES_OIL* and *RES_GAS* for the total reserves of oil and gas, respectively; *MV_CS_CEO* for the market value of common shares held by the firm CEO (in millions of dollars); *OPT_CEO* for the number of stock options held by the firm CEO (in thousands); *%_CS_INST* for the percentage of common shares held by institutional investors; *Q_RATIO* for the quick ratio; *BVCD* for the book value of convertible debts scaled by the book value of total assets; and *COST_CV* for the coefficient of variation of the cash cost per BOE.

The measure of firms' investment programs shows that oil and gas producers are also intensive investors. On average, firms expend the equivalent of 22.37% of the book value of their net property, plant, and equipment in exploration and reserve acquisition and development. The correlation between internal cash flows and investment opportunities has a mean (median) of 0.055 (0.046), with one-fourth of these firms having a correlation less than -0.18 and another fourth with a correlation greater than 0.30. The tax preference item, measured by the ratio of the book value of TLCFs scaled by the book value of total assets, has a mean (median) of 13.42% (0.00%). The expected tax saving benefits of hedging have a mean (median) of 5.24% (4.80%), which is quite close to the findings of Graham and Smith (1999).

The DTD of the sample has a mean (median) of 2.234 (2.052), which reflects little variation in the financial safety of the oil and gas producers in the sample. Those results are similar to statistics reported by Drucker and Puri (2009) and Campello et al. (2011). Oil and gas producers maintain low leverage levels, with a mean (median) of 15.8% (14.2%). Overall, oil and gas producers maintain relatively high cash balance levels (quick ratio) and have quite similar cash costs (lifting cost per BOE). The statistics also indicate that in 32% of the firm–quarters in our sample, producers are financially constrained, with a leverage ratio and quick ratio that are, respectively, above and below the industry's median. Managers' stock and option ownership varies considerably, with a mean (median) of $28.983 million ($1.125 million) for stockholding and 174,386 (0.000) options. Institutional ownership has a mean (median) of 37.17% (29.86%) and varies from no institutional ownership for the first quartile to higher than 74% for the top quartile of the firm–quarters in the panel. The market value of firms' outstanding common shares shows that the oil and gas industry mainly comprises relatively small firms and a few large producers. In addition, this market value varies strongly within the sample, with a mean (median) of $6.44 billion ($268 million). The same conclusion is validated by the means and medians of oil and gas sales and reserve quantities.

The two Herfindahl indices, measuring the geographical dispersion of the daily production of oil and gas, respectively, indicate that oil- and gas-producing activities are largely concentrated in the same region. The mean Herfindahl index is 0.06 for daily oil production and 0.10 for daily gas production. The results further show that oil and gas producers derive almost 87% of their total revenues from oil and gas production. On average, gas production contributes to 52% of total revenue and oil production to 32%. Production uncertainty, measured by the coefficient of variation in daily production, has a mean (median) of 0.41 (0.31) for oil and 0.41 (0.30) for gas production. In addition, the coefficient of variation of the cash cost per BOE has a mean (median) of 0.29 (0.25). This finding implies that oil and gas producers face higher additional risks related to input costs and output quantities.

1.4.2 Multivariate Results[13]

1.4.2.1 Hedging Instrument Choice

In this section, we investigate the empirical relevance of our hypotheses for hedging strategies based on one instrument only, as identified in Table 1.4 (i.e., swap contracts only, put options only, and costless collars only). The three hedging instruments are classified in terms of their linearity as follows: 1) put options, 2) costless collars, and 3) swap contracts. By nature, costless collars are situated between strict linear instruments (i.e., swap contracts) and strict non-linear instruments (i.e., put options). We use the dynamic generalized random effects ordered probit in equation (1). Tables 1.6 and 1.7 report the regression results of this model for four specifications for oil and gas hedgers separately. For each specification, we report the estimations EQ1 and EQ2, where EQ1 estimates put options versus swap contracts and costless collars and EQ2 estimates swap contracts versus put options and costless collars.

The inspection of regressions reported in Tables 1.6 and 1.7 clearly demonstrates state dependence in derivative choice. Hence, the coefficients of the lagged dependent variable for all the specifications are significant at the 1% level. Investigation of the coefficients of the initial observations further shows that this state dependence is more evident with significant coefficients at conventional levels. These findings show that managers maintain almost invariable hedging strategies for subsequent periods and suggest that recognition of the state dependence phenomenon would provide insight into management behavior and refines the association between each hedging instrument and observed firm characteristics, market conditions, and measures of managerial risk aversion.

[13] Appendix A discusses the results of our univariate analysis. Tables A.1.4 to A.1.7 report descriptive statistics of the independent variables and test for differences between the means and medians of the relevant variables for gas and oil hedgers separately. The univariate analysis is carried out by derivative instruments (Tables A.1.4 and A.1.5) and by hedging portfolios (Tables A.1.6 and A.1.7).

Table 1.6 Hedging instrument choice by gas hedgers

	Model 1		Model 2		Model 3		Model 4	
Independent variables	EQ1	EQ2	EQ1	EQ2	EQ1	EQ2	EQ1	EQ2
CONSTANT	-1.2893	-1.8507**	2.5375*	-3.4419***	1.7583*	-1.3599**	4.6938***	-0.9407
	(1.461)	(0.796)	(1.325)	(0.852)	(1.036)	(0.676)	(1.124)	(0.834)
LAG_LINEARITY	0.9050***	0.5171***	0.7999***	0.5536***	0.8237***	0.5241***	0.8176***	0.5656***
	(0.098)	(0.047)	(0.095)	(0.050)	(0.096)	(0.049)	(0.092)	(0.049)
LINEARITY_0	0.4744***	0.3447***	0.2875***	0.2460***	0.2316	0.1781*	0.3004***	0.2747***
	(0.132)	(0.070)	(0.104)	(0.061)	(0.168)	(0.105)	(0.105)	(0.067)
COR_IO_FCF	0.8547**	0.3906*	0.4023	0.5527***	0.9114***	0.2810	0.4913*	0.3787*
	(0.341)	(0.203)	(0.354)	(0.205)	(0.339)	(0.214)	(0.283)	(0.194)
HERF_GAS	-1.5110*	-1.2259			-1.1656	-1.5755		
	(0.845)	(1.209)			(0.880)	(1.473)		
PQ_COR_GAS			0.4927*	0.1033			0.3515	0.2871
			(0.298)	(0.213)			(0.284)	(0.211)
OVER_INV	0.3928*	0.1315			0.1286	0.1932		
	(0.238)	(0.148)			(0.228)	(0.147)		
OPT_CEO	-0.0019	-0.0070***	-0.0078**	-0.0056***	-0.0046	-0.0053***	-0.0070**	-0.0051***
	(0.003)	(0.002)	(0.003)	(0.002)	(0.003)	(0.002)	(0.003)	(0.002)
MV_CS_CEO	7.6396*	0.0335	14.2617**	0.7586	15.7783**	0.2278	13.4854**	1.3690
	(4.556)	(0.816)	(7.154)	(0.907)	(7.945)	(0.890)	(6.313)	(0.958)
%_CS_INST	2.4206***	-0.2793			2.5528***	-0.1002		
	(0.578)	(0.336)			(0.629)	(0.360)		
TAX_SAVE			2.7050	-3.9638**			4.4549	-3.9816***
			(4.009)	(2.002)			(3.688)	(1.480)
TLCF	-0.3503	-1.2245**			-0.0821	-1.1772**		
	(0.408)	(0.542)			(0.375)	(0.541)		
LEV			0.6896	0.0879			1.5010	-0.1194
			(0.974)	(0.488)			(0.969)	(0.487)
CONSTRAINT			-0.2590	-0.1184			-0.3311*	-0.0560
			(0.207)	(0.132)			(0.190)	(0.125)
DTD	-0.1458	-0.1894***			-0.1075	-0.1983***		
	(0.104)	(0.059)			(0.105)	(0.062)		
INV_OPP	0.1880	-1.7308***	-0.2869	-1.7637***				
	(0.642)	(0.528)	(0.708)	(0.618)				
UND_GAS					0.1043	-0.1332	1.2887**	-0.0904
					(0.254)	(0.115)	(0.518)	(0.111)
VOL_GAS	-0.4262***	-0.2158**			-0.3275**	-0.2768***		
	(0.140)	(0.098)			(0.128)	(0.100)		
FUTURE_GAS			0.0257	-0.3946***			0.0513	-0.4428***
			(0.085)	(0.062)			(0.081)	(0.062)
SPOT_GAS			0.0003	0.1799***			-0.0116	0.1992***
			(0.065)	(0.052)			(0.064)	(0.051)
UNCER_GAS	-2.8398***	-0.9969**			-3.2470***	-1.7510***		
	(0.807)	(0.419)			(0.848)	(0.519)		
COST_CV			1.5396*	1.1404**	1.3530*	1.3005***	1.4621*	1.0445**
			(0.786)	(0.462)	(0.766)	(0.488)	(0.760)	(0.478)
OIL_HEDG	0.8111***	0.0291						
	(0.208)	(0.139)						
IR_HEDG			-0.8117***	-0.0132				
			(0.252)	(0.167)				
FX_HEDG					-0.5379	0.2274		
					(0.792)	(0.565)		
BASIS_HEDG							-0.1312	0.2792
							(0.454)	(0.255)
GAS_REV			-0.9040	-1.9288***			0.2793	-2.1248***
			(0.759)	(0.573)			(0.717)	(0.567)
IMR_GAS	-0.3785	0.7645***	-0.2795	0.1406	-0.3495	0.7458**	0.0165	0.1285
	(0.450)	(0.276)	(0.411)	(0.271)	(0.410)	(0.296)	(0.384)	(0.203)
Rho	0.7364***		0.8564***		0.7452***		0.8092***	
	(0.028)		(0.017)		(0.027)		(0.019)	
Observations	1,630		1,601		1,597		1,615	
Log-likelihood (LL)	-691.9547		-642.5038		-673.5852		-663.3446	
LL constant only	-938.0734		-948.0657		-897.5861		-963.1919	
Wald stat.	492.2374		611.1238		448.0017		599.6946	
Significance	0.0000		0.0000		0.0000		0.0000	

Notes:

This table reports the coefficient estimates of the dynamic generalized random effects ordered probit model for the hedging instrument choice for the subsample of gas hedgers. The dependent variables are the hedging instruments classified in terms of the linearity of their final payoffs: (1) put options only, (2) costless collars only, and (3) swap contracts only. The term *LAG_LINEARITY* is the lagged dependent variable; *LINEARITY_0* is the initial condition; *COR_IO_FCF* for the correlation between free cash flows and investment opportunities*; HERF_GAS* for the geographical dispersion of gas production; *PQ_COR_GAS* for the gas quantity–price correlation; *OVER_INV* for overinvestment; *OPT_CEO* for the number of stock options held by the CEO; *MV_CS_CEO* for the market value of common shares held by the CEO; *%_CS_INST* for the percentage of common shares held by institutional investors; *TAX_SAVE* for the expected percentage of tax savings; *TLCF* stands for TLCFs scaled by the book value of total assets; *LEV* for the leverage ratio; *CONSTRAINT* for financial constraints; *DTD* for the DTD; *INV_OPP* for investment opportunities; *UND_GAS* for undeveloped proved gas reserves; *FUTURE_GAS*, *SPOT_GAS*, and *VOL_GAS* for gas future and spot prices and volatility, respectively; *UNCER_GAS* for gas production uncertainty; *COST_CV* for the coefficient of variation of the cash cost per BOE; *OIL_HEDG*, *IR_HEDG*, *FX_HEDG*, and *BASIS_HEDG* are dummy variables for oil, IR, FX, and basis risk hedging, respectively; *GAS_REV* for revenues from gas production; and *IMR_GAS* for the inverse Mills ratio from the first-step Heckman regression (Table A.1.3). The coefficients of the exogenous variables' means are not reported here for conciseness and are available upon request. Standard errors are in parentheses. The superscripts ***, **, and * indicate significance at the 1%, 5%, and 10% levels, respectively. EQ1 estimates put options (recorded to 0) versus collars and swaps (recorded to 1) and EQ2 estimates put options and collars (recorded to 0) versus swaps (recorded to 1).

Table 1.7 Hedging instrument choice by oil hedgers

	Model 1		Model 2		Model 3		Model 4	
Independent variables	EQ1	EQ2	EQ1	EQ2	EQ1	EQ2	EQ1	EQ2
CONSTANT	1.5749	1.6030*	-1.8533	-0.3196	0.2078	0.8690	-2.2690*	-0.7764
	(1.120)	(0.958)	(1.193)	(0.896)	(0.813)	(0.630)	(1.255)	(0.863)
LAG_LINEARITY	0.8105***	0.4950***	0.7590***	0.5549***	0.7930***	0.5448***	0.8104***	0.5218***
	(0.084)	(0.049)	(0.084)	(0.049)	(0.084)	(0.049)	(0.083)	(0.049)
LINEARITY_0	-0.0451	0.1490**	-0.0091	0.2210***	0.3347***	0.6320***	0.0037	0.1660**
	(0.087)	(0.067)	(0.100)	(0.077)	(0.090)	(0.080)	(0.097)	(0.070)
COR_IO_FCF	-0.4057	0.5639**	-0.3155	0.9665***	-0.2421	0.5257**	-0.3260	0.6227***
	(0.284)	(0.249)	(0.291)	(0.240)	(0.286)	(0.248)	(0.271)	(0.226)
HERF_OIL	-1.9644**	-1.8431***			-1.5977	-2.0155***		
	(0.844)	(0.546)			(1.041)	(0.606)		
PQ_COR_OIL			-0.2065	0.1530			-0.4315	0.0947
			(0.289)	(0.182)			(0.274)	(0.181)
OVER_INV	0.4060**	0.0342			0.5614***	0.1129		
	(0.202)	(0.151)			(0.207)	(0.153)		
OPT_CEO	0.0066	0.0027	0.0061	-0.0004	0.0099**	0.0006	0.0068	-0.0012
	(0.005)	(0.003)	(0.005)	(0.003)	(0.004)	(0.003)	(0.005)	(0.003)
MV_CS_CEO	-0.0796	-0.5522	4.0040*	0.0796	-0.2164	-0.6244	2.3725	-0.0503
	(1.784)	(0.802)	(2.312)	(0.846)	(2.010)	(0.853)	(1.960)	(0.832)
%_CS_INST	0.1454	-0.1763			0.2683	-0.1662		
	(0.522)	(0.366)			(0.541)	(0.396)		
TAX_SAVE			16.3462***	-2.4470			14.6409***	-2.1517
			(4.821)	(1.505)			(4.681)	(1.618)
TLCF	-0.6855	-2.8766***			-0.8622	-2.2270***		
	(0.490)	(0.683)			(0.547)	(0.711)		
LEV			0.3348	2.0412**			-0.4624	2.5572***
			(1.211)	(0.808)			(1.171)	(0.784)
CONSTRAINT			-0.2526	0.1381			-0.2456	0.0197
			(0.214)	(0.135)			(0.203)	(0.134)
DTD	0.2232**	-0.2352***			0.2040**	-0.2818***		
	(0.096)	(0.066)			(0.098)	(0.071)		
INV_OPP	0.1216	-1.2814***	0.1710	-1.3633***				
	(0.579)	(0.451)	(0.536)	(0.442)				
UND_OIL					1.0730	3.3914*	4.8559**	1.3811
					(2.690)	(1.925)	(2.373)	(1.858)
VOL_OIL	-0.0250	-0.0522**			-0.0303	-0.0237		
	(0.031)	(0.022)			(0.032)	(0.024)		
FUTURE_OIL			-0.1159***	-0.0149			-0.1175***	-0.0571**
			(0.033)	(0.023)			(0.032)	(0.023)
SPOT_OIL			0.1097***	0.0148			0.1094***	0.0504**
			(0.033)	(0.022)			(0.031)	(0.022)
UNCER_OIL	-1.5136**	0.6957*			-2.3282***	0.5672		
	(0.637)	(0.380)			(0.663)	(0.408)		
COST_CV			3.1899***	-1.1992*	1.0124	-1.5153***	3.1940***	-0.2282
			(0.936)	(0.646)	(0.848)	(0.523)	(0.876)	(0.637)
GAS_HEDG	0.8166***	0.1904						
	(0.252)	(0.190)						
IR_HEDG			0.8970***	0.3789**				
			(0.270)	(0.162)				
FX_HEDG					-1.1081***	0.5099		
					(0.413)	(0.371)		
BASIS_HEDG							0.0767	1.0981***
							(0.333)	(0.195)
OIL_REV			-1.7321**	1.3136**			-2.0957**	0.6999
			(0.784)	(0.586)			(0.819)	(0.580)
IMR_OIL	-1.1546**	0.2843	-0.5734	1.1021***	-0.8629	0.3470	-1.0220**	0.8544***
	(0.512)	(0.307)	(0.576)	(0.367)	(0.541)	(0.342)	(0.404)	(0.293)
Rho	0.7852***		0.7754***		0.7775***		0.7747***	
	(0.021)		(0.027)		(0.024)		(0.024)	
Observations	1,572		1,547		1,550		1,564	
Log-likelihood (LL)	-685.9948		-659.9249		-654.5332		-660.7962	
LL constant only	-945.5503		-878.7359		-884.8251		-894.4599	
Wald stat.	519.1109		437.6220		460.5838		467.3274	
Significance	0.0000		0.0000		0.0000		0.0000	

Note:

This table reports the coefficient estimates of the dynamic generalized random effects ordered probit model for the hedging instrument choice for the subsample of oil hedgers. The dependent variables are the hedging instruments classified in terms of the linearity of their final payoffs: (1) put options only, (2) costless collars only, and (3) swap contracts only. The term *LAG_LINEARITY* is the lagged dependent variable; *LINEARITY_0* is the initial condition; *COR_IO_FCF* for the correlation between free cash flows and investment opportunities*; HERF_OIL* for the geographical dispersion of oil production; *PQ_COR_OIL* for the oil quantity–price correlation; *OVER_INV* for overinvestment; *OPT_CEO* for the number of stock options held by the CEO; *MV_CS_CEO* for the market value of common shares held by the CEO; *%_CS_INST* for the percentage of common shares held by institutional investors; *TAX_SAVE* for the expected percentage of tax savings; *TLCF* stands for TLCFs scaled by the book value of total assets; *LEV* for the leverage ratio; *CONSTRAINT* for financial constraints; *DTD* for the DTD; *INV_OPP* for investment opportunities; *UND_OIL* for undeveloped proved oil reserves; *FUTURE_OIL*, *SPOT_OIL*, and *VOL_OIL* for oil future and spot prices and volatility, respectively; *UNCER_OIL* for oil production uncertainty; *COST_CV* for the coefficient of variation of the cash cost per BOE; *GAS_HEDG*, *IR_HEDG*, *FX_HEDG*, and *BASIS_HEDG* are dummy variables for gas, IR, FX, and basis risk hedging, respectively; *OIL_REV* for revenues from oil production; and *IMR_OIL* for the inverse Mills ratio from the first-step Heckman regression (Table A.1.3). The coefficients of the exogenous variables' means are not reported here for conciseness and are available upon request. Standard errors are in parentheses. The superscripts ***, **, and * indicate significance at the 1%, 5%, and 10% levels, respectively. EQ1 estimates put options (recorded to 0) versus collars and swaps (recorded to 1) and EQ2 estimates put options and collars (recorded to 0) versus swaps (recorded to 1).

Pertaining to the first hypothesis, the proxy *COR_IO_FCF* for the correlation between free cash flows and the firm's investment programs are significantly positively related to linear instruments, as predicted. For the subset of gas hedgers, *COR_IO_FCF* is related positively to swaps and collars. Particularly for oil hedgers, the association between this correlation and swaps is more evident. Overall, these findings empirically validate our Hypothesis 1 that firms with higher correlation between internal cash flows and future investment opportunities are more likely to use linear instruments because they benefit from a natural hedge and linear strategies suffice to provide value-maximizing hedges. Economically, it appears that oil and gas prices have a simultaneous positive impact on firm's generated cash flows and rents associated with future investment expenditures, and provide producers with a natural diversification.

In line with the production flexibility argument of Moschini and Lapan (1992), the results confirm our Hypothesis 2 and show that greater geographical diversification in production activities is associated more with the use of non-linear instruments. We find that geographical diversification in gas production (*HERF_GAS*) is more related to the use of put options and diversification in oil production (*HERF_OIL*) is associated with the use of put options and costless collars. However, the impact of geographical diversification is economically and statistically more significant for oil hedgers. Oil and gas producers seem to consider geographical dispersion in their production operations as a real option requiring that non-linear instruments be used to hedge. Whereas Moschini and Lapan (1992) suggest that production flexibility motivates firms to sell convexity (i.e., selling put and call options), we find that it motivates firms to go long in put options.

Results pertaining to the quantity–price correlation indicate that when gas production quantities and spot prices are positively correlated (*PQ_COR_GAS*), gas producers tend to hedge more with swaps and collars as predicted in Hypothesis 3. Despite its low statistical significance, this result is consistent with the conjectures of Brown and Toft (2002) and Gay, Nam, and Turac (2002, 2003) that when production quantity and spot prices are positively correlated, overhedging is less likely and linear instruments could achieve optimal hedging. Oil quantity–price correlation (*PQ_COR_OIL*) has no significant impact on hedging instrument choice. Although with similar production uncertainties, oil hedgers and gas hedgers react differently to the price–quantity correlation.

Overinvestment (*OVER_INV*), a problem identified by Morellec and Smith (2007) and Bartram, Brown, and Fehle (2009), seems to be largely supported by the multivariate results. Overinvestment is more likely for large, profitable firms that have fewer investment opportunities. Managers at these firms tend to overinvest because they derive private benefits from the investment. Overinvestment is significantly positively related to swap contracts and costless collars for oil hedgers, in particular. Consistent with our Hypothesis 4, when overinvestment is more likely, firms tend to use more linear instruments and to avoid put options. In the context of shareholder–manager conflict, hedging with linear instruments allows firms to attenuate the variability in their generated cash flows, which would benefit the managers who tend to overinvest. To our knowledge, the overinvestment problem has not been empirically investigated in the corporate risk management context.[14]

[14] As a robustness check, we proxy the overinvestment problem by creating a dummy variable that equals one for firms whose ratio of free cash flow to total assets is in the top quartile and zero otherwise. We interact and interact this dummy variable with investment opportunities and obtain the same results.

Regarding managerial risk aversion, particularly for gas hedgers, the results show that a CEO with higher firm-specific wealth (*MV_CS_CEO*) tends to use swap contracts and collars, and to avoid put options, as predicted in Hypothesis 5. Results also suggest that CEO option holding (*OPT_CEO*) is significantly negatively related to the use of swaps. Interestingly, we find that managerial stockholding and option-holding are strongly positively related to costless collars. A possible explanation for this finding is linked to the payoff structure of costless collars (i.e., buying put options and selling call options, which creates a linear-like payoff structure). Overall, the latter findings are consistent with the literature (Smith and Stulz, 1985), in which a risk-averse manager with higher stockholding tends to use linear instruments and to avoid non-linear ones. Managers with a convex payoff (i.e., higher option holding levels) will do the converse. The percentage of institutional shareholding *(%_CS_INST*) is significantly positively related to the use of swaps and collars. This finding could be explained by the fact that institutional investors act like risk-averse managers and seek higher insulation of firm value from the source of risk.

The empirical implications with respect to the convexity of the tax function (*TAX_SAVE*) are unclear. Although *TAX_SAVE* has a significant positive impact on the use of swap contracts and costless collars for oil hedgers as predicted, it is more related to collars and put options for gas hedgers. TLCF appears to be more associated with the use of collars and put options. Altogether, tax function convexity and TLCF seem to be more related to the use of collars.

The results pertaining to financial constraints show, particularly for oil hedgers, that swap contracts are positively related to leverage ratio (*LEV*) in a significant manner. In light of descriptive statistics (i.e., leverage ratio has a mean (median) of 15.8% (14.2%)). This finding corroborates the theoretical predictions of Adam (2002) and Adler and Detemple (1988) that linear instruments are optimal for average or no financial constraints. Results further show that more solvent oil and gas producers (i.e., with a higher DTD) tend to use costless collars. This finding indicates again that more leveraged firms tend to lock in predetermined revenues, while more solvent ones tolerate more variability in their future revenues by avoiding strict linear hedging strategies. In line with risk-shifting theory (Jensen and

Meckling (1976)), the results show that gas hedgers close to financial distress (*CONSTRAINT*) use more put options.

Interestingly, the results emphasize the fact that investment opportunities (*INV_OPP*) appear to be more associated with the use of costless collars and put options. Overall, these findings are consistent with Froot, Scharfstein, and Stein's (1993) argument that firms with larger investment programs tend to use more non-linear instruments, along with the empirical findings of Gay and Nam (1998) and Adam (2002, 2009). Further, undeveloped proved oil and gas reserves (*UND_GAS* and *UND_OIL*) seem to be more related to the use of swap contracts and costless collars. One explanation could be that because oil and gas producers already have larger undeveloped reserves, they face less pressure related to future development expenditures.

The results pertaining to the impact of market conditions are highly consistent with predictions. Accordingly, higher volatility (*VOL_GAS* and *VOL_OIL*) and higher anticipated future prices (*FUTURE_GAS* and *FUTURE_OIL*) are related to the use, in particular, of put options and collars. These findings mean that in a higher volatility environment or when prices are anticipated to be higher, oil and gas producers are more interested in maintaining any potential upside risk than protecting downside risk. Our findings contradict those of Brown (2001), who finds a negative association between volatility and the convexity of the hedging portfolio, and those of Adam (2009), who finds no significant relation between volatility and option use. As predicted, increasing spot prices (*SPOT_GAS* and *SPOT_OIL*) motivate firms to use swap contracts to lock in predetermined higher prices because they are anticipating that prices will decline in the future. These findings highlight the significant role of market conditions in derivative choice, which may explain firm hedging behavior.

Interestingly, the association between higher production uncertainty (*UNCER_GAS* and *UNCER_OIL*) and the use of put options is as predicted and is significant.[15] Overall, these findings contradict the empirical results of Brown (2001) and Adam (2009), who find no significant relation between firm's exposure fluctuation and option use, and corroborate the

[15] Model 1 in Table 1.11 illustrates an unexpected positive coefficient for oil production uncertainty and swap use, albeit with a lower significance level.

theoretical predictions of Moschini and Lapan (1995), Brown and Toft (2002), and Gay, Nam, and Turac (2002, 2003). The results further show that when oil and gas producers hedge simultaneously both commodities and basis risk (*GAS_HEDG*, *OIL_HEDG* and *BASIS_HEDG*), they tend to use more swaps and collars. A possible explanation for this finding could be that hedging the primary source of business risk (i.e., oil or gas price risk) attenuates the non-linearity of the firm's total exposure, which makes non-linear instruments less optimal.

Regarding IR risk and production cost variability (*COST_CV*), the results are significant and mixed. For oil hedgers, hedging FX risk is linked more to put options. Producers primarily engaged in gas production (i.e., with a higher *GAS_REV*) tend to use more put options or collars. In addition, producers primarily engaged in oil production (i.e., with a higher *OIL_REV*) tend to use more put options. This result is consistent with the empirical finding of Adam (2009), who confirms that more focused gold-mining firms are 30% more likely to use options strategies than diversified firms are.

1.4.2.2 Hedging Portfolio Choice

Tables 1.8 and 1.9 report the estimation results of the determinants of hedging portfolio choice for many specifications of the dynamic random effects MMNL model. The estimation was carried out for the subset of oil hedgers and gas hedgers separately. Because the main focus here is on oil and gas producers' rationales for choosing hedging portfolios with payoffs that depart from linearity to non-linearity (by combinations of swap contracts with put options and/or costless collars), swap contracts are chosen as our base outcome and all the results must be interpreted relative to choosing swap contracts. However, the level of non-linearity depends on the percentage of the notional hedged quantity of each instrument forming the portfolio. Table A.1.8 summarizes those hedging portfolios and breaks down the notional quantity hedged between the different instruments.

Table 1.8 Hedging portfolio choice by gas hedgers

Dependant variables	Model 1			Model 2			Model 3			Model 4		
	Swaps + Put options	*Swaps + Collars*	*Swaps + Collars + Put options*	*Swaps + Put options*	*Swaps + Collars*	*Swaps + Collars + Put options*	*Swaps + Put options*	*Swaps + Collars*	*Swaps + Collars + Put options*	*Swaps + Put options*	*Swaps + Collars*	*Swaps + Collars + Put options*
	(I)	(II)	(III)	(IV)	(V)	(VI)	(VII)	(VIII)	(IX)	(X)	(XI)	(XII)
COR_IO_FCF	0.1587	-0.4873	0.5000	0.4293	-0.2054	1.4151**	0.2622	-0.3965	0.6820	0.3626	-0.1519	1.3159**
	(0.798)	(0.353)	(0.659)	(0.846)	(0.353)	(0.665)	(0.807)	(0.346)	(0.636)	(0.872)	(0.350)	(0.657)
HERF_GAS	5.6000	0.6124	3.8470				6.6783	0.3125	3.7546			
	(5.830)	(1.491)	(3.026)				(5.612)	(1.498)	(3.056)			
PQ_COR_GAS				-0.2411	-0.6961*	-1.4700**				-0.2072	-0.7796**	-1.5082**
				(0.819)	(0.392)	(0.716)				(0.854)	(0.396)	(0.728)
OVER_INV				-1.5085**	0.0040	0.6479				-1.6354**	-0.0560	0.4625
				(0.690)	(0.251)	(0.480)				(0.737)	(0.248)	(0.472)
OPT_CEO	-0.0117	0.0009	0.0065*	-0.0140	0.0028	0.0003	-0.0128	0.0004	0.0051	-0.0141	0.0031	0.0002
	(0.012)	(0.002)	(0.004)	(0.013)	(0.002)	(0.002)	(0.013)	(0.002)	(0.004)	(0.013)	(0.002)	(0.002)
MV_CS_CEO	-4.0146	1.0181	-0.0421	-7.2996	1.3072	1.5108	-5.2502	1.0619	0.2951	-9.9613	0.9361	0.7024
	(7.073)	(1.086)	(3.629)	(9.097)	(1.259)	(3.059)	(8.163)	(1.104)	(3.310)	(11.096)	(1.264)	(3.270)
%_CS_INST				0.5147	1.4699**	-0.1865				0.5325	1.3982**	-0.3489
				(1.583)	(0.591)	(1.018)				(1.630)	(0.600)	(1.013)
TAX_SAVE				-11.3358	2.0227	-8.8088				-11.8664	2.0916	-7.6186
				(13.873)	(1.387)	(10.348)				(14.014)	(1.409)	(9.719)
TLCF	0.5614	0.3886	0.9566				1.0216	0.3481	1.6292			
	(1.739)	(0.954)	(1.851)				(1.919)	(0.971)	(1.739)			
LEV				-0.7111	-3.2276**	-0.8418				-1.0500	-3.2655**	-1.5442
				(1.735)	(1.350)	(2.114)				(1.789)	(1.346)	(2.243)
CONSTRAINT				0.0067	0.6903***	-0.6279				0.0198	0.6756***	-0.5603
				(0.566)	(0.228)	(0.389)				(0.593)	(0.230)	(0.383)
DTD	-0.2966	0.0443	-0.1564				-0.3682	0.0544	-0.0632			
	(0.207)	(0.089)	(0.168)				(0.231)	(0.089)	(0.166)			
INV_OPP	2.2211**	1.8193**	2.1679*	1.6198	1.9128	0.8811						
	(1.112)	(0.788)	(1.136)	(1.380)	(1.173)	(0.930)						
UND_GAS							-1.3290	0.0593	-0.1530	-1.2261	0.0909	0.1699
							(1.271)	(0.153)	(0.341)	(1.952)	(0.164)	(0.340)
VOL_GAS	0.4982	0.2629*	0.3655				0.5271	0.3138**	0.3294			
	(0.387)	(0.157)	(0.298)				(0.395)	(0.159)	(0.300)			
FUTURE_GAS				0.0064	0.2581**	0.2822				-0.0390	0.2500**	0.2701
				(0.299)	(0.104)	(0.198)				(0.316)	(0.104)	(0.191)
SPOT_GAS				-0.0106	-0.1080	-0.1661				0.0384	-0.0983	-0.1576
				(0.244)	(0.088)	(0.183)				(0.256)	(0.088)	(0.175)
UNCER_GAS	1.1570	1.8972***	5.5793***				0.8685	2.0719***	4.9724***			
	(1.776)	(0.682)	(1.406)				(1.911)	(0.756)	(1.648)			
COST_CV				-3.9733*	-0.7083	0.8668	-2.2789	-0.1849	1.2712	-2.7916	-0.4681	1.2027
				(2.095)	(0.757)	(0.993)	(1.586)	(0.721)	(0.991)	(1.816)	(0.720)	(0.939)
OIL_HEDG	-0.1000	0.4263	1.2311**									
	(0.590)	(0.273)	(0.562)									
IR_HEDG				1.1310	0.3743	1.1073**						
				(0.915)	(0.247)	(0.478)						
FX_HEDG							0.3080	0.4211	1.0414			
							(2.064)	(0.498)	(0.863)			
BASIS_HEDG										-2.1393	0.0652	0.0929
										(1.422)	(0.295)	(0.586)
GAS_REV	7.1128***	1.9334*	1.7740				9.0750***	1.5953	2.7445			
	(2.496)	(0.987)	(2.037)				(3.066)	(1.058)	(2.125)			
IMR_GAS	0.8591	-0.8247	-0.6898	0.2746	-0.6466	-1.3389	0.4013	-1.1196**	-0.2771	0.1380	-0.6983	-1.6001
	(1.098)	(0.514)	(1.000)	(1.173)	(0.610)	(1.112)	(1.141)	(0.568)	(1.077)	(1.240)	(0.651)	(1.139)
LAG	4.8491***	3.8356***	3.1484***	4.2207***	3.8633***	3.2324***	4.6935***	3.8528***	3.0547***	4.1282***	3.8411***	3.2357***
	(0.525)	(0.180)	(0.388)	(0.557)	(0.189)	(0.387)	(0.650)	(0.183)	(0.371)	(0.682)	(0.189)	(0.373)
LAG_0	-0.1002	0.2200	2.3247**	2.9400*	-0.4745	3.1734***	0.0418	0.6110	2.2957**	3.2006	0.2136	2.8169***
	(1.005)	(0.765)	(0.926)	(1.669)	(1.143)	(0.980)	(1.275)	(1.018)	(0.929)	(2.300)	(1.031)	(0.889)
uj	-8.0634*	-8.1426***	-4.0618	-10.7790	-4.0450*	-6.1800	-5.1669	-4.7398***	-0.6227	-7.3354	-1.9742	-4.3276
	(4.719)	(2.061)	(4.035)	(6.655)	(2.333)	(4.841)	(4.489)	(1.801)	(3.562)	(7.457)	(2.346)	(3.998)
Sigma_uj	1.9645***	1.3458***	2.4797***	2.2569***	1.4661***	2.0832***	2.3419***	1.3438***	1.9622***	3.0565**	1.5299***	1.9774***
	(0.456)	(0.202)	(0.450)	(0.649)	(0.221)	(0.432)	(0.707)	(0.202)	(0.439)	(1.262)	(0.239)	(0.399)
Rho_1_2		0.935			0.154			0.735			0.410	
Rho_1_3		0.993			0.793			0.999			0.929	
Rho_2_3		0.897			0.705			0.734			0.715	
Observations		2,188			2,168			2,134			2,168	
Log-likelihood (LL)		-889.3674			-860.5163			-875.4408			-870.0853	
LL constant only		-945.7635			-910.7239			-920.7931			-920.4412	
Wald stat.		112.7922			100.4151			90.7046			100.7117	
Significance		0.0000			0.0000			0.0000			0.0000	

Note:

This table reports the means of the coefficient estimates of the dynamic random effects MMNL to select one of three hedging portfolios—(1) *swap and put options*, (2) *swaps and collars*, and (3) *swaps, put options, and costless collars*—for the subsample of gas hedgers. The base case is using swap contracts only. *COR_IO_FCF* for the correlation between free cash flows and investment opportunities*; HERF_GAS* for the geographical dispersion of gas production; *PQ_COR_GAS* for the gas quantity–price correlation; *OVER_INV* for overinvestment; *OPT_CEO* for the number of stock options held by the CEO; *MV_CS_CEO* for the market value of common shares held by the CEO; *%_CS_INST* for the percentage of common shares held by institutional investors; *TAX_SAVE* for the expected percentage of tax savings; *TLCF* stands for TLCFs scaled by the book value of total assets; *LEV* for the leverage ratio; *CONSTRAINT* for financial constraints; *DTD* for the DTD; *INV_OPP* for investment opportunities; *UND_GAS* for undeveloped proved gas reserves; *FUTURE_GAS*, *SPOT_GAS*, and *VOL_GAS* for gas future and spot prices and volatility, respectively; *UNCER_GAS* for gas production uncertainty; *COST_CV* for the coefficient of variation of the cash cost per BOE; *OIL_HEDG*, *IR_HEDG*, *FX_HEDG*, and *BASIS_HEDG* are dummy variables for oil, IR, FX, and basis risk hedging, respectively; *GAS_REV* for revenues from gas production; *IMR_GAS* for the inverse Mills ratio from the first-step Heckman regression (Table A.1.3); *LAG* for the lagged dependent variable; and *LAG_0* for the first observation. The coefficients of the exogenous variables' means are not reported here for conciseness and are available upon request. Standard errors are in parentheses. The superscripts ***, **, and * indicate significance at the 1%, 5%, and 10% levels, respectively.

Table 1.9 Hedging portfolio choice by oil hedgers

	Model 1			Model 2			Model 3			Model 4		
Dependant variables	*Swaps + Put options*	*Swaps + Collars*	*Swaps + Collars + Put options*	*Swaps + Put options*	*Swaps + Collars*	*Swaps + Collars + Put options*	*Swaps + Put options*	*Swaps + Collars*	*Swaps + Collars + Put options*	*Swaps + Put options*	*Swaps + Collars*	*Swaps + Collars + Put options*
	(I)	(II)	(III)	(IV)	(V)	(VI)	(VII)	(VIII)	(IX)	(X)	(XI)	(XII)
COR_IO_FCF	-2.7309	-0.0486	0.0425	-4.2599**	-0.1835	-0.4804	-2.7180	0.1298	0.2752	-2.8437*	0.0247	-0.3498
	(1.850)	(0.431)	(0.746)	(1.688)	(0.436)	(0.707)	(1.910)	(0.429)	(0.752)	(1.511)	(0.435)	(0.699)
HERF_OIL	-0.9574	2.7762***	0.9429				-1.2176	3.0714***	1.5233			
	(3.814)	(1.045)	(1.827)				(3.727)	(1.063)	(1.807)			
PQ_COR_OIL				-1.8948	0.2817	0.2435				-1.8978	0.2664	-0.0109
				(1.661)	(0.328)	(0.700)				(1.485)	(0.328)	(0.661)
OVER_INV				2.3335*	0.2800	-0.6270				2.4165**	0.2073	-0.5909
				(1.192)	(0.299)	(0.545)				(1.149)	(0.293)	(0.542)
OPT_CEO	0.0501**	-0.0022	0.0043	0.0400*	0.0012	0.0015	0.0592***	-0.0040	0.0050			
	(0.020)	(0.005)	(0.014)	(0.021)	(0.003)	(0.003)	(0.021)	(0.005)	(0.013)			
MV_CS_CEO	-8.0300	2.2892*	0.2434	-7.7560	1.4191	0.0496	-8.0806	2.6113**	1.0862			
	(16.948)	(1.331)	(5.148)	(16.331)	(1.392)	(4.682)	(18.848)	(1.327)	(4.826)			
%_CS_INST				2.8521	0.0920	-0.2079						
				(2.903)	(0.712)	(1.330)						
TAX_SAVE				17.8661**	1.9370	-4.4769				16.8294*	1.7214	-1.7231
				(8.191)	(2.306)	(12.410)				(9.588)	(2.381)	(11.280)
TLCF	-0.1810	1.3681	-0.5394				0.8270	1.5653	-0.3020			
	(4.333)	(1.346)	(2.631)				(5.048)	(1.305)	(2.595)			
LEV				-8.0969	0.0268	1.4242				-7.2524	-0.1088	0.7652
				(7.121)	(1.632)	(2.607)				(6.500)	(1.568)	(2.440)
CONSTRAINT				0.6528	-0.0117	0.8732*				0.3328	-0.0198	0.9003**
				(0.897)	(0.274)	(0.447)				(0.840)	(0.271)	(0.433)
DTD	-0.1652	-0.0162	0.1090				-0.0758	-0.0232	0.0347			
	(0.411)	(0.120)	(0.227)				(0.439)	(0.122)	(0.229)			
INV_OPP	1.2251	1.3159*	1.7185*	0.3801	0.8754	1.0355						
	(1.463)	(0.712)	(0.895)	(1.800)	(0.742)	(0.824)						
UND_OIL							11.4982	0.7859	2.0579	6.3964	1.7266	4.5504
							(23.887)	(3.407)	(5.484)	(15.515)	(3.483)	(5.058)
VOL_OIL	0.1668	-0.0308	0.0071				0.2411	-0.0416	-0.0356			
	(0.135)	(0.042)	(0.083)				(0.167)	(0.045)	(0.082)			
FUTURE_OIL				0.3404*	-0.0169	0.0927				0.2288*	-0.0142	0.0749
				(0.177)	(0.038)	(0.074)				(0.127)	(0.038)	(0.071)
SPOT_OIL				-0.2962*	0.0299	-0.0789				-0.2091*	0.0297	-0.0630
				(0.162)	(0.038)	(0.073)				(0.122)	(0.038)	(0.070)
UNCER_OIL	-0.8425	-1.3400	-0.4906				0.7025	-2.3167**	-0.3717			
	(2.567)	(0.819)	(1.399)				(2.413)	(0.922)	(1.408)			
COST_CV				-7.5344	0.0743	-0.7213	-4.3151	1.5133	1.3351			
				(5.694)	(0.337)	(1.109)	(4.412)	(0.996)	(1.027)			
GAS_HEDG	-0.3332	0.4399	2.9815**									
	(1.382)	(0.557)	(1.451)									
IR_HEDG				-0.4810	0.1372	0.7083						
				(1.132)	(0.304)	(0.517)						
FX_HEDG							-3.2237	1.3204**	0.5769			
							(4.656)	(0.672)	(1.107)			
BASIS_HEDG										-1.8850	-0.5905	-0.4051
										(1.690)	(0.363)	(0.710)
OIL_REV	2.2294	0.7476	3.1159				0.7369	0.5417	1.1714			
	(4.157)	(1.303)	(2.416)				(4.063)	(1.284)	(1.993)			
IMR_OIL	0.2289	-1.1030*	-1.8762	1.6797	0.2603	0.4796	-0.2946	-0.7839	-1.8701	0.3296	0.3457	0.2947
	(1.817)	(0.659)	(1.238)	(2.578)	(0.772)	(1.110)	(1.939)	(0.705)	(1.208)	(2.019)	(0.730)	(1.082)
LAG	4.6163***	3.6750***	3.2885***	4.1698***	3.6499***	3.3325***	4.3804***	3.6805***	3.3783***	3.6572***	3.6687***	3.3198***
	(0.932)	(0.225)	(0.449)	(0.837)	(0.232)	(0.431)	(0.940)	(0.228)	(0.441)	(0.696)	(0.226)	(0.429)
LAG_0	(X)	(X)	-0.1268	(X)	(X)	1.6318	(X)	(X)	-0.0691	(X)	(X)	0.2900
			(1.513)			(1.380)			(1.372)			(1.632)
uj	-3.3900	-10.3039***	-8.4440**	-22.7548	0.6415	3.2016	2.9837	-5.2764**	-2.5449	1.0114	1.2818	2.2034
	(8.459)	(2.883)	(4.183)	(16.762)	(4.123)	(5.998)	(9.226)	(2.270)	(3.115)	(14.282)	(3.290)	(4.274)
Sigma_uj	3.2093**	2.0000***	2.3607***	6.2914**	2.3399***	2.9545***	3.8441**	1.9688***	2.1166***	7.1710**	2.4725***	3.0574***
	(1.634)	(0.322)	(0.559)	(2.586)	(0.381)	(0.578)	(1.933)	(0.327)	(0.487)	(3.266)	(0.393)	(0.614)
Rho_1_2		0.498			0.312			0.237			0.484	
Rho_1_3		0.862			0.786			0.652			0.855	
Rho_2_3		0.860			0.832			0.891			0.867	
Observations		1,632			1,650			1,605			1,678	
Log-likelihood (LL)		-619.8875			-628.8506			-615.5335			-653.7601	
LL constant only		-668.3723			-705.3281			-670.4718			-740.2093	
Wald stat.		96.9697			152.9549			109.8766			172.8985	
Significance		0.0000			0.0000			0.0000			0.0000	

Note:

This table reports the means of the coefficient estimates of the dynamic random effects MMNL to select one of the following three hedging portfolios—(1) *swap and put options*, (2) *swaps and collars*, and (3) *swaps, put options, and costless collars*—for the subsample of oil hedgers. The base case is using swap contracts only. *COR_IO_FCF* for the correlation between free cash flows and investment opportunities*; HERF_OIL* for the geographical dispersion of oil production; *PQ_COR_OIL* for the oil quantity–price correlation; *OVER_INV* for overinvestment; *OPT_CEO* for the number of stock options held by the CEO; *MV_CS_CEO* for the market value of common shares held by the CEO; *%_CS_INST* for the percentage of common shares held by institutional investors; *TAX_SAVE* for the expected percentage of tax savings; *TLCF* stands for TLCFs scaled by the book value of total assets; *LEV* for the leverage ratio; *CONSTRAINT* for financial constraints; *DTD* for the DTD; *INV_OPP* for investment opportunities; *UND_OIL* for undeveloped proved oil reserves; *FUTURE_OIL*, *SPOT_OIL*, and *VOL_OIL* for oil future and spot prices and volatility, respectively; *UNCER_OIL* for oil production uncertainty; *COST_CV* for the coefficient of variation of the cash cost per BOE; *GAS_HEDG*, *IR_HEDG*, *FX_HEDG*, and *BASIS_HEDG* are dummy variables for gas, IR, FX, and basis risk hedging, respectively; *OIL_REV* for revenues from oil production; *IMR_OIL* for the inverse Mills ratio from the first-step Heckman regression (Table A.1.3); *LAG* for the lagged dependent variable; and *LAG_0* for the first observation. The coefficients of the exogenous variables' means are not reported here for conciseness and are available upon request. Standard errors are in parentheses. The superscripts ***, **, and * indicate significance at the 1%, 5%, and 10% levels, respectively, and (X) indicates that the variable was omitted by *STATA* software during the regression because of co-linearity.

Tables 1.8 and 1.9 report the estimated coefficients' means for explanatory variables, as well as estimated means (uj), estimated standard deviations (*Sigma_uj*), and correlation coefficients (*Rho_1_2*, *Rho_1_3*, and *Rho_2_3*) of unobserved heterogeneity terms for the remaining three hedging portfolios, namely (1) swap contracts combined with put options, (2) swap contracts combined with costless collars, and (3) swap contracts combined with put options and costless collars. The results (see the lower parts of Tables 1.8 and 1.9) show a statistically non-zero standard deviation of the unobserved heterogeneity effects justifying the random effects specification. They also indicate higher correlations between the random effects of the three hedging portfolios for gas and oil hedgers, respectively. This higher correlation of the random effects across hedging portfolios implies that the firm-specific unobserved factors driving hedging portfolio choices overlap but are not the same. This finding appears to suggest that firm-specific random effects are a crucial element to consider and that our model should outperform other models without random effects.

Lagged hedging portfolio choice exhibits a great degree of persistence in all hedging portfolios. Results related to the correlation between internal cash flows and investment opportunities are mixed. Although, this correlation is negatively related to put options in a statistically significant manner for oil hedgers as predicted, it is positively related to the use of put options and collars for gas hedgers. The results further indicate that oil hedgers with greater geographical diversification tend to include costless collars in their hedging portfolios. For gas hedgers, geographic diversification has the predicted positive sign but with no significant impact. Consistent with the theoretical predictions of Brown and Toft (2002) and Gay, Nam, and Turac (2002, 2003) and previous findings, the positive price–quantity correlation for gas hedgers appears to have a significant negative impact on the use of put options and/or collars in combination with swaps. Hence, gas producers with a higher positive price–quantity correlation tend to use swap contracts only, to mitigate adverse movements in revenues because prices and quantities are moving in the same direction. However, there is no evidence of this relation for oil hedgers.

The impact of the overinvestment problem on hedging portfolio choice is mixed. Although overinvestment is significantly negatively associated with put options for the subset of gas hedgers as predicted, it appears to be positively related to put options for oil hedgers. Consistent with the prediction, CEO option-holding is positively related to the use of put options in a statistically significant manner (particularly for oil hedgers). Consistent with our findings in the previous section, a CEO's equity stake value in a firm is positively related to the use of collars. Overall, these results are consistent with Smith and Stulz's (1985) prediction. In addition, gas hedgers with higher percentages of institutional shareholding tend to use collars in combination with swaps. Contrary to expectations, tax function convexity is positively associated with the use of put options in addition to swaps for the subset of oil hedgers. TLCFs appear to have no real impact on hedging portfolio choice.

The results also show, particularly for gas hedgers, that collars are negatively related to leverage in a statistically significant manner. This finding suggests that gas producers that are more leveraged but not yet in financial distress tend to lock in predetermined revenues to satisfy their future commitments by resorting to swap contracts. The financial constraint proxy seems to be significantly related to the use of put options and/or collars. This finding corroborates risk-shifting theory. Surprisingly, DTD appears to have no real impact on hedging portfolio choice. In line with Froot, Scharfstein, and Stein (1993) and Adam (2009), the results show that investment opportunities are significantly positively related to the inclusion of put options and/or collars in hedging portfolios in addition to swap contracts.

This result confirms our findings in the dynamic ordered probit model. The results further show that undeveloped oil and gas reserves have no significant impact on hedging portfolio choice.

Gas future prices and gas price volatilities are significantly positively associated with costless collars. Furthermore, the results show that put options are negatively related to oil spot prices and positively impacted by oil future prices. These findings, pertaining to market conditions, corroborate our predictions and are consistent with the dynamic ordered probit model above. For the subset of gas hedgers, gas production uncertainty seems to be significantly positively related to the use of put options and collars, as predicted. Conversely, oil production uncertainty is negatively related to collars. However, production cost risk (i.e., cash cost variability) appears to be significantly negatively related to the use of put options for the subset of gas hedgers.

The results further show that the existence of additional hedgeable risk (i.e., FX and IR risk) is significantly positively related to the use of put options and/or collars in addition to swaps. This finding corroborates the theoretical predictions of Moschini and Lapan (1995), Brown and Toft (2002), and Gay, Nam, and Turac (2002, 2003) that additional risks make total exposure non-linear and therefore the hedging strategy should also tend to be non-linear. Surprisingly, producers more engaged in natural gas production tend to use more put options or collars in addition to swaps. This result is consistent with our previous results and those of Adam (2009).

1.4.2.3 Robustness Checks: Hedging Intensity by Derivative

Results in previous sections are based on discrete choice models where each hedging strategy is represented by a binary variable regardless of the quantity hedged. We now check the robustness of our results by constructing continuous measures of hedging intensity of using each of the major derivatives: swap contracts, put options and costless collars. Hedging intensity is measured by the ratio of derivative notional[16] position scaled by the total hedged quantity (i.e., the aggregate hedging portfolio). Going into further details, we distinguish between hedging intensities for the current fiscal year (i.e., *Year_0*) and those for the following fiscal years. For swaps and collars, we consider the subsequent three fiscal years (i.e., *Year_1-3*). For put options, two fiscal years ahead are considered (i.e., *Year_1-2*) because hedging activity for farther horizons are rare. This distinction gives deeper insight into hedging dynamism. We then run random-effects tobit regressions and correct standard errors for within-firm correlation (clustering) and heteroskedasticity using the Huber-White-Sandwich estimator.[17]The independent variables used in these regressions are measured at the end of the previous quarter.

Overall, results reported in Table 1.10 for gas hedgers and Table 1.11 for oil hedgers are consistent with predictions and our previous findings. As predicted, gas hedgers with positive correlation between generated cash flows and investment expenditures tend to intensify their swap positions and to rely less on collars. However, impacts of this positive correlation are more evident for farther horizons (*Year_1-3*). Results also show that put option intensity increases with geographical diversification in gas production activities for both near (*Year_0*) and longer hedging terms (*Year_1-2*). This empirical evidence corroborates our prediction and findings in the ordered probit specification. Counter to our predictions, for the three-year horizon, swap intensity becomes negatively related to gas price-quantity correlation. Results reported in Table 1.10, for gas hedgers, indicate that the overinvestment problem has significant positive impacts on swaps' intensity for the current year horizon and significant negative impacts on put option positions for the current and subsequent years. These results confirm earlier findings for gas hedgers.

[16] We follow Haushalter (2000) and use notional quantities for put options because we lack detailed information to calculate a delta-percentage for these options. At least, we have three attributes of our sample that could mitigate this shortcoming in our study: (i) put options are used on average in 11% (12%) of firm-quarters with gas (oil) hedging, (ii) put options are used most often with either swap/or collars, and (iii) the fraction of the quantity hedged by put options does not exceed 40% (50%) for gas (oil).

[17] The model is estimated using adaptive quadrature implemented in *Stata* by a program *GLLAMM* (Generalized Linear Latent and Mixed Models) using 30 integration points. For more details see Rabe-Hesketh, S., Skrondal, A. and Pickles, A. (2005).

Table 1.10 Hedging intensity by derivative by gas hedgers

Dependent variables	Swap contracts				Put options				Costless collars			
	Year_0	***Year_0***	***Year_1-3***	***Year_1-3***	***Year_0***	***Year_0***	***Year_1-2***	***Year_1-2***	***Year_0***	***Year_0***	***Year_1-3***	***Year_1-3***
	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII
CONSTANT	0.4110***	0.5412***	0.4928***	0.6281***	-1.1255***	-0.9992***	-1.4147***	-1.3139***	-0.0585	-0.1945**	-0.1823	-0.3376***
	(0.092)	(0.087)	(0.094)	(0.089)	(0.219)	(0.170)	(0.326)	(0.232)	(0.098)	(0.094)	(0.125)	(0.120)
COR_IO_FCF	0.1017	0.0914	0.1802**	0.1541**	0.0727	0.0538	0.0010	-0.0350	-0.1423*	-0.1072	-0.2226**	-0.1626
	(0.065)	(0.068)	(0.071)	(0.074)	(0.149)	(0.137)	(0.191)	(0.180)	(0.082)	(0.079)	(0.102)	(0.100)
HERF_GAS	0.0345	0.0872	-0.3556	-0.2617	0.8300*	0.8089*	1.8384**	1.8794**	-0.2995	-0.3327	0.0700	-0.0769
	(0.268)	(0.263)	(0.282)	(0.270)	(0.468)	(0.468)	(0.870)	(0.810)	(0.371)	(0.360)	(0.571)	(0.561)
PQ_COR_GAS	-0.0841	-0.0368	-0.2262**	-0.1553*	-0.1528	-0.1385	-0.0940	-0.0697	0.0789	0.0062	0.1644	0.0221
	(0.080)	(0.081)	(0.095)	(0.094)	(0.206)	(0.218)	(0.248)	(0.252)	(0.105)	(0.107)	(0.129)	(0.126)
OVER_INV	0.0699*	0.0666	0.0636	0.0563	-0.1896***	-0.1828**	-0.2679**	-0.2406**	-0.0146	-0.0037	-0.0052	0.0165
	(0.042)	(0.042)	(0.053)	(0.050)	(0.073)	(0.074)	(0.120)	(0.117)	(0.050)	(0.049)	(0.063)	(0.058)
MV_CS_CEO	-0.2633	-0.1801	-0.3615	-0.2267	-1.7726	-1.4764	-1.3869	-1.1762	0.3996	0.2071	0.6805***	0.4513*
	(0.231)	(0.219)	(0.233)	(0.236)	(1.098)	(0.954)	(0.996)	(0.919)	(0.249)	(0.258)	(0.261)	(0.272)
OPT_CEO	-0.0004**	-0.0004*	0.0001	0.0002	-0.0002	-0.0002	-0.0008	-0.0008	0.0003*	0.0002	-0.0001	-0.0002*
	(0.000)	(0.000)	(0.000)	(0.000)	(0.001)	(0.001)	(0.001)	(0.001)	(0.000)	(0.000)	(0.000)	(0.000)
TLCF	-0.0459	-0.1002	0.0516	-0.0175	0.2095	0.1730	0.4036***	0.2596*	-0.0661	-0.0018	-0.0965	0.0126
	(0.103)	(0.101)	(0.144)	(0.146)	(0.148)	(0.167)	(0.124)	(0.140)	(0.100)	(0.102)	(0.153)	(0.167)
TAX_SAVE	-0.1325	-0.1613	-0.3655	-0.4136	-0.0607	-0.0694	-0.1804	-0.0941	0.3442	0.4974*	0.4831*	0.6895**
	(0.222)	(0.250)	(0.253)	(0.299)	(0.739)	(0.722)	(1.057)	(0.978)	(0.247)	(0.265)	(0.256)	(0.270)
LEV	0.1691		0.2278		-0.1696		-0.2198		-0.1478		-0.2780	
	(0.160)		(0.169)		(0.413)		(0.559)		(0.232)		(0.267)	
CONSTRAINT		0.0022		0.0194		0.0243		0.0332		0.0171		-0.0498
		(0.034)		(0.041)		(0.078)		(0.098)		(0.038)		(0.048)
INV_OPP		0.0683		0.1008		0.0753		0.2799**		-0.0578		-0.1370
		(0.080)		(0.070)		(0.140)		(0.139)		(0.105)		(0.103)
VOL_GAS	-0.0661***		-0.0667***		0.0339		-0.0143		0.1032***		0.0940***	
	(0.021)		(0.022)		(0.045)		(0.071)		(0.024)		(0.029)	
SPOT_GAS		0.0140		0.0269**		0.0443*		0.0754**		-0.0263**		-0.0414***
		(0.010)		(0.012)		(0.024)		(0.036)		(0.011)		(0.015)
FUTURE_GAS		-0.0394**		-0.0588***		-0.0467		-0.0965*		0.0711***		0.0963***
		(0.017)		(0.019)		(0.036)		(0.053)		(0.019)		(0.025)
UNCER_GAS	0.0066		-0.0804		0.2437		0.0637		0.1913		0.2638*	
	(0.110)		(0.102)		(0.278)		(0.387)		(0.121)		(0.140)	
Sigma_u	0.4948***	0.4958***	0.5593***	0.5478***	0.9021***	0.8933***	1.0349***	1.0306***	0.5727***	0.5561***	0.7105***	0.6900***
	(0.044)	(0.043)	(0.051)	(0.048)	(0.087)	(0.084)	(0.126)	(0.123)	(0.053)	(0.050)	(0.063)	(0.059)
Log (Sigma_e)	-0.9662***	-0.9732***	-0.9597***	-0.9729***	-0.5709***	-0.5704***	-0.4711***	-0.4901***	-0.8132***	-0.8288***	-0.7682***	-0.7956***
	(0.056)	(0.056)	(0.056)	(0.056)	(0.095)	(0.094)	(0.125)	(0.116)	(0.045)	(0.045)	(0.053)	(0.051)
Observations	2,990	2,990	2,226	2,226	2,990	2,990	2,223	2,223	2,990	2,990	2,226	2,226
Uncensored Obs	2093	2093	1558	1558	476	476	241	241	1696	1696	1180	1180
Censored Obs	897	897	668	668	2514	2514	1982	1982	1294	1294	1046	1046
Number of firms	108	108	108	108	108	108	108	108	108	108	108	108
Log Likelihood	-1703.2744	-1687.3005	-1319.5858	-1294.7091	-949.0272	-948.6661	-572.9526	-564.9747	-1909.1494	-1871.1233	-1446.4524	-1399.9256

Note:

This table reports the coefficient estimates of the random effects tobit models. The dependent variables are the hedging intensity by derivative instrument (swap contracts, put options, and costless collars) for the subsample of gas hedgers: *Year_0*, *Year_1-2*, and *Year_1-3* are hedging intensities for the current fiscal year, the subsequent two years, and the subsequent three years, respectively. Independent variables, measured at the end of the previous quarter, are: *COR_IO_FCF* for the correlation between free cash flows and investment opportunities; *HERF_GAS* for the geographical dispersion of gas production; *PQ_COR_GAS* for the gas quantity–price correlation; *OVER_INV* for overinvestment; *MV_CS_CEO* for the market value of common shares held by the CEO; *OPT_CEO* for the number of stock options held by the CEO; *TLCF* stands for TLCFs scaled by the book value of total assets; *TAX_SAVE* for the expected percentage of tax savings; *LEV* for the leverage ratio; *CONSTRAINT* for financial constraints; *INV_OPP* for investment opportunities; *FUTURE_GAS*, *SPOT_GAS*, and *VOL_GAS* for gas future and spot prices and volatility, respectively; *UNCER_GAS* for gas production uncertainty. Standard errors, corrected for heteroskedasticity and clustering using Huber-White-Sandwich estimator, are in parentheses. The superscripts ***, **, and * indicate significance at the 1%, 5%, and 10% levels, respectively. *Sigma_u* and *Sigma_e* stand for the standard deviations of random-effects and error terms, respectively.

Table 1.11 Hedging intensity by derivative by oil hedgers

Dependent variables	Swap contracts				Put options				Costless collars			
	Year_0	***Year_0***	***Year_1-3***	***Year_1-3***	***Year_0***	***Year_0***	***Year_1-2***	***Year_1-2***	***Year_0***	***Year_0***	***Year_1-3***	***Year_1-3***
	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII
CONSTANT	0.2101*	0.3944***	0.0709	0.3592***	-1.5504***	-1.2456***	-1.6264***	-1.5595***	0.0552	-0.1142	0.1321	-0.0993
	(0.125)	(0.099)	(0.137)	(0.112)	(0.383)	(0.297)	(0.429)	(0.333)	(0.153)	(0.130)	(0.170)	(0.143)
COR_IO_FCF	0.0556	0.0371	0.1673	0.1331	0.2210	0.1567	-0.0088	-0.0723	-0.1294	-0.1051	-0.0146	0.0056
	(0.084)	(0.087)	(0.109)	(0.107)	(0.234)	(0.218)	(0.322)	(0.305)	(0.155)	(0.160)	(0.167)	(0.164)
HERF_OIL	-0.2161	-0.2127	-0.1342	-0.1606	0.0605	-0.0491	0.3605	0.3463	0.4095	0.4161	0.3543	0.3748
	(0.229)	(0.227)	(0.245)	(0.252)	(0.449)	(0.423)	(0.368)	(0.362)	(0.310)	(0.303)	(0.349)	(0.353)
PQ_COR_OIL	-0.0322	0.0028	-0.0405	0.0003	0.0507	0.1143	0.0981	0.1469	-0.0068	-0.0390	-0.0114	-0.0085
	(0.077)	(0.075)	(0.127)	(0.113)	(0.228)	(0.233)	(0.338)	(0.344)	(0.112)	(0.107)	(0.150)	(0.144)
OVER_INV	-0.0471	-0.0586	-0.0161	-0.0294	-0.1138	-0.1210	-0.0542	-0.0443	0.0400	0.0447	0.0498	0.0521
	(0.037)	(0.040)	(0.045)	(0.047)	(0.092)	(0.090)	(0.102)	(0.096)	(0.054)	(0.056)	(0.054)	(0.055)
MV_CS_CEO	0.0645	0.0866	-0.0978	-0.0833	-0.7063	-0.4744	-0.4632	-0.5655	-0.0947	-0.2122	0.0266	0.0488
	(0.141)	(0.164)	(0.156)	(0.156)	(0.583)	(0.440)	(0.593)	(0.587)	(0.235)	(0.246)	(0.178)	(0.202)
OPT_CEO	-0.0001	-0.0002**	0.0002**	0.0001	0.0006***	0.0005***	0.0004**	0.0003***	-0.0001	-0.0001	-0.0003***	-0.0002***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
TLCF	-0.2248	-0.1784	-0.1655	-0.0888	0.0672	0.1378	0.1491	0.1078	0.2303	0.1985	0.1863	0.1372
	(0.155)	(0.156)	(0.111)	(0.135)	(0.160)	(0.126)	(0.199)	(0.126)	(0.175)	(0.164)	(0.143)	(0.126)
TAX_SAVE	0.5213*	0.4672	0.1475	0.1494	-1.9599	-1.9629	-0.4864	0.1179	-0.3521	-0.2046	0.1211	0.0928
	(0.304)	(0.295)	(0.211)	(0.236)	(1.919)	(1.847)	(1.553)	(1.118)	(0.477)	(0.459)	(0.394)	(0.409)
LEV	0.4467**		0.7792**		0.3366		0.3537		-0.3072		-0.9027*	
	(0.225)		(0.371)		(0.634)		(0.777)		(0.329)		(0.493)	
CONSTRAINT		0.0437		0.0575		0.0964		0.0837		-0.0304		-0.0422
		(0.041)		(0.049)		(0.109)		(0.101)		(0.043)		(0.059)
INV_OPP		-0.0189		-0.0396		-0.0097		0.1635		0.0036		-0.0129
		(0.073)		(0.071)		(0.119)		(0.112)		(0.082)		(0.076)
VOL_OIL	-0.0064		-0.0033		0.0091		0.0123		0.0014		-0.0038	
	(0.007)		(0.008)		(0.015)		(0.013)		(0.007)		(0.008)	
SPOT_OIL		0.0133**		0.0155***		-0.0180		0.0024		-0.0097		-0.0150**
		(0.006)		(0.006)		(0.011)		(0.012)		(0.006)		(0.007)
FUTURE_OIL		-0.0152**		-0.0173***		0.0159		-0.0030		0.0120*		0.0164**
		(0.006)		(0.006)		(0.012)		(0.013)		(0.007)		(0.007)
UNCER_OIL	0.0765		0.1288		0.2452		0.0113		0.0056		0.0698	
	(0.150)		(0.144)		(0.372)		(0.359)		(0.177)		(0.159)	
Sigma_u	0.6004***	0.6022***	0.6301***	0.6470***	1.2103***	1.1683***	1.1272***	1.1222***	0.7356***	0.7305***	0.7790***	0.7742***
	(0.056)	(0.056)	(0.062)	(0.061)	(0.134)	(0.124)	(0.161)	(0.149)	(0.069)	(0.068)	(0.075)	(0.074)
Log (Sigma_e)	-0.8777***	-0.8872***	-0.8773***	-0.8862***	-0.5238***	-0.5218***	-0.5692***	-0.5735***	-0.7440***	-0.7514***	-0.7383***	-0.7380***
	(0.072)	(0.072)	(0.069)	(0.070)	(0.128)	(0.123)	(0.124)	(0.121)	(0.056)	(0.055)	(0.063)	(0.064)
Observations	2,485	2,489	1,668	1,668	2,485	2,489	1,668	1,668	2,485	2,489	1,668	1,668
Uncensored Obs	1593	1593	1070	1070	373	373	222	222	1246	1246	859	859
Censored Obs	892	892	598	598	2112	2112	1446	1446	1239	1239	809	809
Number of firms	101	101	99	99	101	101	99	99	101	101	99	99
Log Likelihood	-1562.1385	-1548.7033	-1070.4386	-1064.2835	-748.0900	-750.3951	-462.4174	-461.1464	-1563.3348	-1549.2701	-1096.1086	-1096.8090

Note:

This table reports the coefficient estimates of the random effects tobit models. The dependent variables are the hedging intensity by derivative instrument (swap contracts, put options, and costless collars) for the subsample of oil hedgers: *Year_0*, *Year_1-2*, and *Year_1-3* are hedging intensities for the current fiscal year, the subsequent two fiscal years, and the subsequent three fiscal years, respectively. Independent variables, measured at the end of the previous quarter, are: *COR_IO_FCF* for the correlation between free cash flows and investment opportunities; *HERF_OIL* for the geographical dispersion of oil production; *PQ_COR_OIL* for the oil quantity–price correlation; *OVER_INV* for overinvestment; *MV_CS_CEO* for the market value of common shares held by the CEO; *OPT_CEO* for the number of stock options held by the CEO; *TLCF* stands for TLCFs scaled by the book value of total assets; *TAX_SAVE* for the expected percentage of tax savings; *LEV* for the leverage ratio; *CONSTRAINT* for financial constraints; *INV_OPP* for investment opportunities; *FUTURE_OIL*, *SPOT_OIL*, and *VOL_OIL* for oil future and spot prices and volatility, respectively; *UNCER_OIL* for oil production uncertainty. Standard errors, corrected for heteroskedasticity and clustering using Huber-White-Sandwich estimator, are in parentheses. The superscripts ***, **, and * indicate significance at the 1%, 5%, and 10% levels, respectively. *Sigma_u* and *Sigma_e* stand for the standard deviations of random-effects and error terms, respectively.

Results further indicate, for gas hedgers, that collar intensity increases with managerial stockholding for the three-year horizon. Interestingly, managerial option-holding has a significant negative impact on swaps and collars' notional quantities, and significant positive effects on put option intensity. The impacts of option-holding on swaps and put options are evident for near and farther horizons. For collars, this effect is evident only for more distant horizons. These finding corroborate our earlier results, and give empirical evidence of the impact of managerial risk aversion on firms' hedging behaviors. Oil hedgers and gas hedgers in the progressive tax region tend to intensify their swap and collar positions respectively. As predicted, the positive relation between tax loss carryforwards and put options is more evident with the tobit model, particularly for gas hedgers. This latter finding corroborates Graham and Rogers (2002) conjecture that tax loss carryforwards capture a separate non-tax influence on firm's hedging behavior. In addition, higher level of tax loss carryforwards means that the firm recently accumulated losses and is more likely to be in financial distress. Consequently, firm's manager enters costly non-linear hedging (put options) as risk-shifting strategy.

Consistent with previous results, more leveraged oil hedgers tend to rely more on swap contracts and less on collars. Investment opportunities have a significant positive impact on put options' intensity for more distant horizons to avoid costly external financing and the underinvestment problem, as documented in our earlier results. For both *Year_0* and *Year_1-3* horizons, results support previous findings and show that swap (collar) intensity decreases (increases) with gas price volatility and oil and gas anticipated future prices, and increases (decreases) with oil and gas spot prices. Unlike findings in previous sections, results further indicate that put option intensity increases (decreases) with gas spot (future) prices. One explanation could be that in high spot prices environments, oil and gas producers tend to take larger put option positions to lock-in the current prices because they believe that prices are more likely to decrease in the future. Conversely, firms tend to hedge less by costly put options when future prices are anticipated to increase because shortfalls in future inflows are less likely and hedging needs are less pressing. Surprisingly, put option positions are not affected by gas price volatility or oil market conditions. Gas production uncertainty appears to be positively related to larger collars positions as in our earlier results.

Following Adam (2009), we re-estimate the random-effects tobit models using alternative measures of hedging intensity of put options and costless collars. Put options and collars' intensity are measured by $\frac{\text{Put options}}{\text{Swap contracts + Put options}}$ and $\frac{\text{Collars}}{\text{Swaps contracts + Collars}}$ respectively. Results reported in Table A.1.9 show some noticeable differences with the results of the mixed multinomial logit[18]. We find an unpredictable negative impact of diversification in oil activities on put options' intensity for the *Year_1-2* horizon. Gas diversification loses its statistical significance. However, this finding corroborates the multinomial logit results. The negative association between managerial stockholding and put options' extent is now more evident as predicted. Moreover, oil hedgers with tax loss carry forwards rely more on collars. Consistent with the multinomial logit results, tax function convexity is significantly positively related to put options for *Year_1-2* horizon, however, counter the prediction. Unlike multinomial logit models, for gas hedgers, put options are no longer positively related to investment opportunities but they are now significantly positively correlated to gas price

[18]Results using these alternative measures of hedging intensities could be seen as robustness checks of results of the mixed multinomial logit for hedging portfolios.

volatility. For oil hedgers, oil spot and future prices have no longer significant impact on put options' intensity.

Table A.1.10 summarizes our predictions and findings arising from the models used in the previous sections.

1.4.2.4 Robustness Checks: Other Specifications

In this section, we check the robustness of our previous results to other specifications related to hedging strategies classification and some variables construction. First, we classify hedging strategies into two categories: linear and non-linear. Linear strategies include swap contracts, forward and futures. Non-linear strategies comprise put options, costless collars and three-way collars. We after distinguish between firms using only linear strategies, a combination of linear and non-linear strategies, and only non-linear strategies. As before, we use a dynamic mixed multinomial logit for this new specification of the hedging strategies. The use of linear strategies only is the base case. We also recalculate the correlations between spot prices and produced quantities (*PQ_COR_GAS* and *PQ_COR_OIL*) and the coefficients of variation of produced quantities (*UNCER_GAS* and *UNCER_OIL*) and cash costs (*COST_CV*) based on rolling windows of eight quarterly observations.

Finally, we calculate the sensitivities of revenues and investment costs to the risk exposure in a more direct manner to test the argument of Froot, Scharfestein, and Stein (1993) exposed in *HYPOTHESIS 1*. We then calculate the correlation between firm's free cash flows (as previously defined) and oil (gas) spot prices. For the sensitivity of investment costs, we calculate the correlation between capital expenditures and oil (gas) spot prices. These coefficients of correlation are calculated at the end of each quarter using rolling windows of eight quarterly observations. Subsequently, we calculate the absolute value of the differential between both sensitivities of free cash flows and investment costs (i.e., sensitivity of investment costs minus the sensitivity of free cash flows). A smaller differential means that firm's revenues and investment costs have closer sensitivities to oil (gas) prices and bigger differential means dissimilar sensitivities. We predict a positive sign for the absolute values of these differentials in sensitivities (*DIFF_GAS* and *DIFF_OIL*).

Table A.1.11 reports the regression results for oil and gas hedgers separately and shows noticeable differences with previous results related to hedging portfolio choice using a mixed multinomial logit (Table 1.8 and Table 1.9). Surprisingly, differentials in sensitivities of firm's revenues and investment costs have no significant impact on the hedging strategy choice. Higher geographical diversity in oil production activities appears to be positively related to the use of non-linear strategies as predicted. The newly calculated variables, namely the correlation between produced quantities and spot prices, the production uncertainty, and cash cost risk, lose their significant impacts. Results related to managerial risk aversion and tax arguments are mixed. As predicted, the CEOs option-holding and tax loss carry-forwards are positively related to the use of non-linear strategies. However, CEOs shareholding and tax save measure have unpredicted positive association with non-linear strategies. Financial constraints measures have no real impacts on strategy choice. Consistent with predictions and previous results, investment opportunities, gas price volatility and gas future prices are positively related to the use of non-linear strategies. The results further show that when oil and gas producers hedge simultaneously both commodities and basis risks, they tend to use more linear strategies because the firm's aggregate exposure becomes less non-linear (e.g., Brown and Toft, 2002).

1.5 Concluding remarks

A rich body of empirical literature on corporate risk management explores the incentives, determinants, and virtues of hedging. While this empirical literature comprehensively answers why firms hedge risks and identifies the determinants of hedging extent and effects, the question of how firms hedge risks has been of lesser concern. Using a unique, hand-collected dataset of detailed, publicly available quarterly information on the risk management activities of 150 US oil and gas producers during the period from 1998 to 2010, we extend the empirical literature by investigating the determinants of hedging strategy choice.

Overall, our results show that the state dependence or preference characteristic in hedging strategy choice must be considered when explaining firm hedging behavior. We find that a positive correlation between internal funds and capital expenditures is positively related to the use of more linear hedging strategies because oil and gas producers are naturally diversified. In addition, we observe that geographic diversification in oil and gas production significantly affect the manner in which producers hedge their exposures. This operative flexibility is related to hedging strategies with payoffs departing from strict linearity. As predicted, the price–quantity correlation appears to impact the derivative choice in a significant manner and is associated positively with swap use for gas hedging particularly. Overinvestment appears to be a real concern when choosing hedging strategies and it motivates the use of more swap contracts only or collars only.

In line with our predictions, we find that CEOs with higher shareholding use more linear strategies and CEOs with higher option holding tend to use more hedging portfolios with non-linear payoffs. Surprisingly, the results show that higher stockholding and option holding are both positively related to the use of collars only. The presence of institutional investors also affects hedging programs. Tax function convexity has a significant and mixed impact on derivative choice. Tax loss carryforwards are negatively associated with the use of swap contracts as predicted.

Results further indicate that oil and gas producers that are more leveraged but not yet in financial distress tend to use swap contracts more frequently because they are seeking predetermined revenues to satisfy their future debt commitments. More solvent oil and gas producers tend to use collars only and to avoid swaps only. Consistent with risk-shifting theory, we find that oil and gas producers close to financial distress use more hedging portfolios with non-linear payoffs. Investment opportunities are related to more non-linear hedging strategies. Further, we find that hedging strategy choice is strongly correlated with the economic conditions of the oil and gas market (i.e., spot prices, future expected prices, and volatilities). Results pertaining to additional non-hedgeable risks (i.e., quantity and cost uncertainty) and additional hedgeable risks (FX, IR, and basis risks) indicate that these risks play an important role in hedging choices. More focused oil and gas producers tend to use more non-linear strategies. Finally, we check the robustness of our empirical findings using continuous measures of hedging intensity by instrument.

APPENDIX 1.1

HOW DO FIRMS HEDGE RISKS?
EMPIRICAL EVIDENCE FROM US OIL AND GAS PRODUCERS

Table A.1.1 Summary of empirical predictions

Theoretical predictions	Author(s)	Swap contracts only	Put options only	Costless collars only	Swaps and put options	Swaps and collars	Swaps, put options and collars	Collars and put options
Correlation between internal funds and investment opportunities (expenditures)	Froot, Scharfstein, and Stein (1993)	+	-	-/+	-	-/+	-	-
Production flexibility	Moschini and Lapan (1992)	-	+	+	+	+	+	+
Quantity–price correlation	Brown and Toft (2002); Gay, Nam, and Turac (2002, 2003).	+	-	-/+	-	-/+	-	-
Overinvestment (Free cash flow agency problem)	Jensen (1986); Morellec and Smith (2007); Bartram, Brown, and Fehle (2009)	+	-	+	-	+	-	-
Managerial shareholding	Smith and Stulz (1985); Tufano (1996)	+	-	-/+	-	-/+	-	-
Managerial option holding	Smith and Stulz (1985); Tufano (1996)	-	+	-/+	+	-/+	+	+
Tax function convexity	Mayers and Smith (1982); Smith and Stulz (1985)	+	-	-/+	-	-/+	-	-
Financial constraints	Adler and Detemple (1988)	-	+	+	+	+	+	+
Financial constraints	Adam (2002)	+	-	+	+	+	+	+
Investment opportunities (expenditures)	Froot, Scharfstein, and Stein (1993)	-	+	-/+	+	-/+	+	+
Market conditions:								
Spot prices	Adam (2009)	+	-	-	-	-	-	-
Future prices		-	+	+	+	+	+	+
Volatilities		-	+	+	+	+	+	+
Existence of additional hedgeable and non-hedgeable risks	Moschini and Lapan (1995); Franke, Stapleton, and Subrahmanyam (1998); Brown and Toft (2002); and Gay, Nam, and Turac (2002, 2003).	-	+	-/+	+	-/+	+	+

Note:

This table summarizes the empirical predictions for each of the seven hedging strategies adopted by US oil and gas producers.

Table A.1.2 Transition probabilities matrix for oil and gas hedging strategies

	Put only	Put+collar	Put+swap	Collar only	Collar+put+swap	Collar+swap	Swap only	Total
				Panel A: Gas hedging strategies (%)				
Put only	**85.45**	3.64	4.55	2.73	0.91	1.82	0.91	100
Put+collar	8.57	**71.43**	0.00	11.43	5.71	2.86	0.00	100
Put+swap	3.76	0.00	**84.96**	0.75	3.76	0.75	6.02	100
Collar only	0.73	1.81	0.00	**87.84**	0.73	7.62	1.27	100
Collar+put+swap	1.10	2.20	0.55	1.10	**79.67**	14.29	1.10	100
Collar+swap	0.00	0.10	0.10	4.29	1.99	**88.28**	5.23	100
Swap only	0.11	0.21	0.54	0.86	0.11	5.91	**92.27**	100
				Panel B: Oil hedging strategies (%)				
Put only	**89.76**	3.94	2.36	0.00	0.79	0.79	2.36	100
Put+collar	5.17	**72.41**	1.72	13.79	6.90	0.00	0.00	100
Put+swap	3.13	0.00	**87.50**	0.00	6.25	0.00	3.13	100
Collar only	0.18	1.10	0.00	**90.83**	0.73	6.42	0.73	100
Collar+put+swap	0.00	3.91	2.34	0.78	**79.69**	12.50	0.78	100
Collar+swap	0.17	0.00	0.17	6.35	1.67	**85.45**	6.19	100
Swap only	0.24	0.00	0.48	1.19	0.36	4.30	**93.44**	100

Table A.1.3 First step of the two-step Heckman regression with sample selection: Determinants of the oil or gas hedging decision

Dependent variables	Oil hedge (I)	Gas hedge (II)
TAX_SAVE	0.9005**	0.1232
	(0.366)	(0.428)
LEVERAGE	1.5843***	1.9170***
	(0.091)	(0.096)
CASH_COST	0.0398***	0.0605***
	(0.003)	(0.005)
BVCD	-1.2947***	-1.2417***
	(0.246)	(0.214)
Q_RATIO	-0.1056***	-0.1288***
	(0.014)	(0.014)
RESERVE	-0.0009***	-0.0001***
	(0.000)	(0.000)
MKT_VALUE	0.3924***	0.5700***
	(0.043)	(0.043)
SALES	0.1994***	0.0894***
	(0.019)	(0.017)
CONSTANT	-2.2678***	-2.1663***
	(0.088)	(0.089)
Observations	5,798	5,798
Pseudo-R squared	0.3025	0.3129
Chi squared	2399.4838	2512.4946
Significance	0.0000	0.0000

Note:
This table reports the coefficients estimates of the probit model. The dependent variable is the hedging decision dummy variable, which takes the value of one if the firm has oil or gas hedging position, respectively, for the quarter and zero otherwise. The independent variables are *TAX_SAVE* for the expected percentage of tax savings, *LEVERAGE* for the leverage ratio measured by the book value of long-term debt scaled by the book value of total assets, *CASH_COST* for the production cost per BOE, *BVCD* for the book value of convertible debts scaled by the book value of total assets, *Q_RATIO* for the quick ratio measured by the book value of cash and the equivalent of cash scaled by the book value of current liabilities, *RESERVE* for the quantities of proved reserves for oil (for oil hedgers) and gas (for gas hedgers), *MKT_VALUE* for the logarithm of the market value of common shares outstanding (i.e., closing price at the end of the quarter multiplied by the number of common shares outstanding), and *SALES* for the logarithm of sales at the end of the quarter. Standard errors are in parentheses. The superscripts ***, **, and * indicate significance at the 1%, 5%, and 10% levels, respectively.

APPENDIX 1.2

UNIVARIATE ANALYSIS

Univariate Analysis

Tables A.1.4 and A.1.5 report descriptive statistics of the independent variables and tests of differences between the means and medians of relevant variables by derivative instruments for gas and oil hedgers separately. The means are compared by using a *t*-test assuming unequal variances; the medians are compared by using a non-parametric Wilcoxon rank-sum *Z*-test and two-sided *p*-values. As discussed, we retain only the three major derivative instruments: put options, costless collars, and swap contracts (the three instruments correspond to more than 93% of all oil and gas hedging). These major instruments could be classified according to their payoff linearity. Put options are the most non-linear instruments, swap contracts are the most linear, and costless collars fall in between. Overall, the univariate results support the premise that firms with greater investment opportunities tend to use more non-linear instruments (i.e., put options and costless collars) than linear instruments (i.e., swap contracts).

Unexpectedly, higher undeveloped proved oil and gas reserves appear to be associated more with the use of swap contracts. On average, firms using more swap contracts and costless collars seem to have a higher correlation between internal cash flows and investment opportunities than those using put options as predicted. Interestingly, the univariate results support the prediction that large profitable oil and gas producers with fewer growth options tend to use more linear instruments to avoid the overinvestment problem, as suggested by Morellec and Smith (2007) and Bartram, Brown, and Fehle (2009).

The results related to tax incentives are mixed. Although tax function convexity and tax preference items (i.e., TLCFs) tend to be more related to the use of swaps for the subsample of oil hedgers as predicted, they are unpredictably more associated with put options and costless collars for the subsample of gas hedgers. On average, users of put options have a relatively lower DTD and lower leverage ratios. Interestingly, these findings suggest that there is a non-monotonic relation between the use of put options and firm financial health. Hence, firms either close to or far from financial distress tend to use more non-linear hedging strategies. In contrast, swap contracts are associated more with relatively higher DTDs and higher leverage ratios.

On average, swap contracts are associated with a higher CEO equity stake value in the firm, as predicted. Unexpectedly, put options are associated with fewer CEO option holdings, particularly for the subsample of oil hedgers. The results also show that a higher percentage of institutional shareholding is more related to the use of put options and costless collars. The results of the means comparison concerning the impact of additional non-hedgeable risks (i.e., production uncertainty, cash cost risk) are mixed. Although higher cash cost risk is more related to the use of costless collars and put options as predicted, oil and gas production uncertainties seem to be more associated with the use of swaps.

The results for the price–quantity correlation and geographical and industrial diversification are mixed. However, the use of put options is more closely related to a lower price–quantity correlation and higher geographical diversification for the subsample of gas hedgers, as predicted. The use of put options by oil hedgers is more strongly associated with a higher price–quantity correlation and lower geographical diversification. Tests further show that firms operating primarily in gas production use more collars and those operating primarily in oil production use more put options. Surprisingly, the results show no significant differences in the economic conditions of the oil and gas markets between swap contracts and put options. In fact, higher volatility, higher spot prices, and higher future prices are largely associated with the use of costless collars.

We now analyze financial and operational characteristics by hedging portfolios when oil and gas hedgers use more than one instrument simultaneously. Tables A.1.6 and A.1.7 report univariate results related to those portfolios. We retain comparisons involving the next two hedging portfolios: swaps combined with put options versus swaps combined with costless collars. The first portfolio is supposed to have a more non-linear payoff. As predicted, the results show that users of swap and collar portfolios have lower investment opportunities and larger undeveloped proved oil and gas reserves. Unexpectedly, swap and collar portfolios are associated with a lower correlation between internal cash flows and investment opportunities, lower expected tax savings, and lower tax preference items (TLCFs). In addition, users of swap and collar portfolios have fewer financial constraints coupled with a higher DTD and lower leverage ratios.

Consistent with the predictions, swap and collar portfolios are associated with a higher CEO equity stake value in the firm. Counter to predictions, these portfolios seem to be associated with higher stock option holding. As predicted, the results indicate that swap and collar portfolios are related to lower production uncertainty and a higher price–quantity correlation. Nonetheless, swaps and collars portfolios' users have higher cash cost variability and greater geographical diversification, contradicting the conjecture. For the subsample of gas hedgers, the univariate results show, unexpectedly, that swaps and collars portfolios are associated with higher gas price volatility and with higher gas future prices. As predicted, swaps and collars portfolios are related to higher gas spot prices.

Table A.1.4 Financial and operational characteristics of gas hedgers, by hedging instrument

Gas hedging instruments firm–quarter																					
	Swap			Put			Collar			Swap vs put				Swap vs collar				Collar vs put			
Variable	Obs	Mean	Median	Obs	Mean	Median	Obs	Mean	Median	*t*-Stat	*p*-Value	*Z*-Score	*p*-Value	*t*-Stat	*p*-Value	*Z*-Score	*p*-Value	*t*-Stat	*p*-Value	*Z*-Score	*p*-Value
Variables that proxy for hedging activity																					
OIL_HEDG	932	0.630	1.000	126	0.540	1.000	582	0.741	1.000	1.906	0.059	-1.955	0.051	-4.593	0.000	4.464	0.000	-4.172	0.000	-4.479	0.000
BASIS_HEDG	932	0.152	0.000	126	0.063	0.000	582	0.060	0.000	3.585	0.000	-2.683	0.007	6.003	0.000	-5.431	0.000	0.140	0.889	0.143	0.886
IR_HEDG	932	0.276	0.000	126	0.159	0.000	582	0.196	0.000	3.267	0.001	-2.803	0.005	3.625	0.000	-3.514	0.000	-1.015	0.311	-0.964	0.335
FX_HEDG	932	0.065	0.000	126	0.040	0.000	582	0.003	0.000	1.339	0.182	-1.122	0.262	7.329	0.000	-5.876	0.000	2.056	0.042	3.726	0.000
Variables that proxy for underinvestment costs																					
INV_OPP	927	0.092	0.068	126	0.129	0.086	555	0.116	0.086	-2.101	0.038	3.401	0.001	-2.974	0.003	4.841	0.000	0.679	0.498	0.207	0.836
UND_OIL	932	40.745	4.170	126	26.793	17.597	582	19.549	4.569	2.648	0.009	2.394	0.017	5.535	0.000	0.522	0.602	1.494	0.137	3.042	0.002
UND_GAS	932	371.744	89.290	126	228.131	124.412	582	193.096	46.350	2.827	0.005	-1.433	0.152	5.204	0.000	-5.830	0.000	0.677	0.499	2.540	0.011
COR_IO_FCF	932	0.146	0.154	126	-0.026	0.018	582	0.087	0.086	5.188	0.000	4.860	0.000	3.114	0.001	3.063	0.002	-3.435	0.000	-3.743	0.000
Variables that proxy for overinvestment																					
OVER_INV	932	0.328	0.000	126	0.230	0.000	552	0.225	0.000	2.411	0.017	2.221	0.026	4.402	0.000	4.249	0.000	0.132	0.895	0.134	0.894
Variables that proxy for the tax advantage of hedging																					
TLCF	928	0.044	0.000	126	0.092	0.000	571	0.085	0.000	-3.087	0.002	3.737	0.000	-3.547	0.000	4.563	0.000	0.343	0.732	1.143	0.253
TAX_SAVE	928	0.047	0.044	126	0.052	0.052	573	0.054	0.050	-1.733	0.084	3.266	0.001	-2.790	0.005	5.011	0.000	-0.551	0.582	0.305	0.761
Variables that proxy for financial distress costs																					
DTD	915	2,338	2,206	126	2,148	2,105	564	2,150	2,123	2.1573	0.0321	0.929	0.353	2.930	0.003	1.910	0.056	-0.027	0.978	0.098	0.922
CONSTRAINT	928	0.471	0.000	126	0.405	0.000	571	0.375	0.000	1.411	0.160	1.397	0.162	3.686	0.000	3.645	0.000	0.620	0.536	0.627	0.531
LEV	928	0.207	0.185	126	0.163	0.180	571	0.209	0.170	4.491	0.000	2.514	0.012	-0.248	0.804	1.454	0.146	-4.155	0.000	-1.360	0.174
Variables that proxy for managerial risk aversion																					
MV_CS_CEO	932	42.241	4.151	126	6.578	4.007	582	44.470	3.394	5.800	0.000	1.635	0.102	-0.214	0.830	2.561	0.010	-4.469	0.000	-0.095	0.924
OPT_CEO	932	229952	5000	126	173357	22500	582	197251	0.000	1.406	0.161	0.026	0.979	0.805	0.420	2.209	0.027	-0.457	0.647	1.382	0.167
Variables that proxy for information asymmetry																					
%_CS_INST	932	0.451	0.475	126	0.557	0.663	582	0.493	0.543	-3.227	0.002	3.440	0.001	-2.294	0.022	2.228	0.026	1.868	0.063	2.003	0.045
Variables that proxy for production characteristics																					
UNCER_OIL	887	0.409	0.286	126	0.365	0.358	562	0.435	0.374	1.768	0.079	0.138	0.890	-1.558	0.120	3.620	0.000	-2.802	0.006	-2.327	0.020
PQ_COR_OIL	900	0.213	0.450	126	0.330	0.579	562	0.375	0.565	-2.172	0.031	2.516	0.012	-5.520	0.000	5.637	0.000	-0.815	0.417	-0.660	0.509
UNCER_GAS	932	0.409	0.308	126	0.335	0.224	582	0.379	0.294	2.493	0.014	-2.714	0.007	1.781	0.075	-0.767	0.443	-1.445	0.150	-2.470	0.014
PQ_COR_GAS	932	0.225	0.312	126	0.024	0.027	582	0.249	0.374	5.232	0.000	-5.039	0.000	-1.187	0.235	2.192	0.028	-5.651	0.000	-5.449	0.000
COST_CV	913	0.243	0.194	126	0.260	0.217	568	0.275	0.262	-0.955	0.341	0.737	0.461	-3.856	0.000	4.167	0.000	-0.865	0.388	-1.443	0.149
OIL_REV	926	0.254	0.204	126	0.391	0.416	582	0.324	0.299	-6.245	0.000	-6.180	0.000	-6.183	0.000	-6.776	0.000	2.995	0.003	3.137	0.001
GAS_REV	926	0.587	0.656	126	0.562	0.541	582	0.638	0.638	1.139	0.255	1.702	0.088	-3.852	0.000	-1.885	0.059	-3.535	0.000	-3.693	0.000
HERF_GAS	932	0.044	0.000	126	0.142	0.000	582	0.028	0.000	-4.598	0.000	-5.443	0.000	2.735	0.006	4.623	0.000	5.407	0.000	8.358	0.000
HERF_OIL	897	0.100	0.000	126	0.140	0.000	567	0.085	0.000	-1.707	0.089	-2.584	0.009	1.324	0.186	2.498	0.012	2.302	0.022	4.245	0.000
Variables that proxy for market conditions																					
VOL_OIL	929	3.200	2.371	126	3.123	2.233	581	3.520	2.674	0.306	0.760	-0.070	0.944	-2.117	0.035	3.147	0.002	-1.490	0.138	-1.896	0.058
SPOT_OIL	929	49.140	35.760	126	47.959	32.520	581	54.813	56.500	0.450	0.654	-0.428	0.669	-3.816	0.000	4.139	0.000	-2.531	0.012	-2.912	0.004
FUTURE_OIL	929	49.212	33.311	126	47.983	30.298	581	54.985	58.710	0.454	0.651	-0.227	0.821	-3.785	0.000	4.068	0.000	-2.512	0.013	-2.758	0.006
VOL_GAS	929	0.687	0.456	126	0.784	0.543	581	0.828	0.695	-1.840	0.068	2.277	0.023	-4.766	0.000	5.532	0.000	-0.796	0.427	-0.850	0.395
SPOT_GAS	929	4.833	4.602	126	5.139	4.830	581	5.674	5.700	-1.256	0.211	1.326	0.185	-6.302	0.000	7.163	0.000	-2.116	0.036	-2.555	0.011
FUTURE_GAS	929	5.340	5.070	126	5.677	5.149	581	6.467	6.213	-1.441	0.152	1.704	0.088	-8.443	0.000	8.888	0.000	-3.242	0.001	-3.259	0.001

Note:

This table reports the univariate analysis results for the independent variables proposed to explain the use of hedging instruments by gas hedgers. The terms *OIL_HEDG*, *IR_HEDG*, *FX_HEDG*, and *BASIS_HEDG* are dummy variables for gas, oil, IR, FX, and basis risk hedging, respectively; *TLCF* stands for TLCFs scaled by the book value of total assets; *TAX_SAVE* for the expected percentage of tax savings; *LEV* for the leverage ratio; *DTD* for the DTD; *CONSTRAINT* for financial constraints; *INV_OPP* for investment opportunities; *COR_IO_FCF* for the correlation between free cash flows and investment opportunities; *UND_OIL* and *UND_GAS* for the undeveloped proved reserves of oil and gas, respectively; *OVER_INV* for overinvestment; *OIL_REV* and *GAS_REV* for the fraction of revenues from oil and gas production, respectively; *HERF_OIL* and *HERF_GAS* for the geographical dispersion of oil and gas production, respectively; *UNCER_OIL* and *UNCER_GAS* for the production uncertainty for oil and gas, respectively; *COST_CV* for the coefficient of variation of the cash cost per BOE; *PQ_COR_OIL* and *PQ_COR_GAS* for the quantity–price correlation for oil and gas, respectively; *MV_CS_CEO* for the market value of common shares held by the CEO; *OPT_CEO* for the number of stock options held by the CEO; *%_CS_INST* for the percentage of common shares held by institutional investors; *FUTURE_OIL*, *SPOT_OIL*, and *VOL_OIL* for oil future and spot prices and volatility, respectively; and *FUTURE_GAS*, *SPOT_GAS*, and *VOL_GAS* for gas future and spot prices and volatility. The means are compared by using a *t*-test, assuming unequal variances; the medians are compared by using the non-parametric Wilcoxon rank sum *Z*-score. Two-sided *p*-values are reported.

Table A.1.5 Financial and operational characteristics of oil hedgers, by hedging instrument

	Oil hedging instruments firm–quarter																				
	Swap			Put			Collar			Swap vs put				Swap vs collar				Collar vs put			
Variable	Obs	Mean	Median	Obs	Mean	Median	Obs	Mean	Median	*t*-Stat	*p*-Value	*Z*-Score	*p*-Value	*t*-Stat	*p*-Value	*Z*-Score	*p*-Value	*t*-Stat	*p*-Value	*Z*-Score	*p*-Value
Variables that proxy for hedging activity																					
OIL_HEDG	849	0.826	1.000	150	0.787	1.000	577	0.818	1.000	1.084	0.280	-1.145	0.252	0.370	0.712	-0.371	0.711	-0.843	0.400	-0.874	0.382
BASIS_HEDG	849	0.221	0.000	150	0.060	0.000	577	0.045	0.000	6.693	0.000	-4.579	0.000	10.578	0.000	-9.150	0.000	0.702	0.484	0.761	0.447
IR_HEDG	849	0.335	0.000	150	0.080	0.000	577	0.243	0.000	9.254	0.000	-6.290	0.000	3.810	0.000	-3.724	0.000	-5.704	0.000	-4.361	0.000
FX_HEDG	849	0.121	0.000	150	0.093	0.000	577	0.012	0.000	1.063	0.289	-0.982	0.326	9.021	0.000	-7.582	0.000	3.347	0.001	5.286	0.000
Variables that proxy for underinvestment costs																					
INV_OPP	842	0.105	0.073	146	0.118	0.070	560	0.130	0.080	-0.767	0.444	0.333	0.739	-1.979	0.048	1.724	0.085	-0.617	0.538	-0.868	0.385
UND_OIL	849	43.351	6.178	150	44.958	12.545	577	46.770	6.332	-0.250	0.803	1.161	0.246	-0.604	0.546	-2.189	0.029	-0.239	0.812	2.388	0.017
UND_GAS	849	441.004	112.765	150	344.652	57.215	577	362.649	56.098	1.503	0.134	-3.289	0.001	1.615	0.107	-5.990	0.000	-0.256	0.798	0.413	0.680
COR_IO_FCF	849	0.125	0.095	150	0.072	0.041	577	0.042	0.058	1.838	0.067	1.589	0.112	4.192	0.000	3.477	0.000	1.014	0.311	0.488	0.625
Variables that proxy for overinvestment																					
OVER_INV	838	0.285	0.000	146	0.226	0.000	558	0.339	0.000	1.554	0.122	1.475	0.140	-2.106	0.035	-2.123	0.034	-2.809	0.005	-2.607	0.009
Variables that proxy for the tax advantage of hedging																					
TLCF	844	0.077	0.000	146	0.045	0.000	577	0.101	0.000	2.762	0.006	-5.196	0.000	-1.794	0.073	0.119	0.905	-3.491	0.001	-5.390	0.000
TAX_SAVE	845	0.052	0.048	146	0.046	0.047	577	0.045	0.044	2.298	0.022	-1.871	0.061	3.689	0.000	-3.825	0.000	0.373	0.710	0.372	0.710
Variables that proxy for financial distress costs																					
DTD	819	2.390	2.530	146	2.127	2.048	576	2.276	2.214	2.893	0.004	2.159	0.031	1.748	0.080	1.250	0.211	-1.604	0.109	-1.393	0.164
CONSTRAINT	844	0.515	1.000	146	0.301	0.000	577	0.310	0.000	5.118	0.000	4.776	0.000	7.939	0.000	7.665	0.000	-0.207	0.836	-0.207	0.836
LEV	844	0.214	0.191	146	0.136	0.134	577	0.184	0.154	8.539	0.000	7.166	0.000	3.776	0.000	6.904	0.000	-4.699	0.000	-2.818	0.005
Variables that proxy for managerial risk aversion																					
MV_CS_CEO	849	68.804	4.661	150	11.598	3.572	577	53.203	3.731	5.402	0.000	2.819	0.005	1.163	0.245	2.773	0.005	-4.847	0.000	-0.996	0.319
OPT_CEO	849	230427	75000	150	98734	0.000	577	99958	0.000	5.855	0.000	4.976	0.000	8.080	0.000	7.221	0.000	-0.065	0.948	-0.533	0.594
Variables that proxy for information asymmetry																					
%_CS_INST	849	0.505	0.602	150	0.519	0.672	577	0.559	0.668	-0.452	0.652	1.016	0.310	-2.974	0.003	4.146	0.000	-1.220	0.224	-1.536	0.125
Variables that proxy for production characteristics																					
UNCER_OIL	846	0.408	0.288	150	0.332	0.259	577	0.460	0.448	2.821	0.005	-1.670	0.095	-2.972	0.003	5.176	0.000	-4.743	0.000	-5.824	0.000
PQ_COR_OIL	849	0.237	0.459	150	0.363	0.638	577	0.416	0.589	-2.461	0.015	3.912	0.000	-6.420	0.000	6.331	0.000	-1.039	0.300	0.419	0.675
UNCER_GAS	840	0.413	0.260	150	0.354	0.335	570	0.408	0.322	2.266	0.024	-0.618	0.537	0.282	0.778	2.552	0.011	-2.092	0.037	-1.836	0.066
PQ_COR_GAS	849	0.203	0.287	150	0.127	0.214	577	0.257	0.363	1.932	0.055	-1.531	0.126	-2.675	0.008	2.974	0.003	-3.252	0.001	-2.866	0.004
COST_CV	844	0.191	0.220	150	0.263	0.216	560	0.310	0.300	-1.629	0.104	0.791	0.429	-2.812	0.005	7.862	0.000	-2.790	0.006	-3.606	0.000
OIL_REV	842	0.311	0.250	145	0.459	0.519	577	0.387	0.320	-7.388	0.000	-7.340	0.000	-5.435	0.000	-5.751	0.000	3.389	0.008	4.215	0.000
GAS_REV	842	0.520	0.573	145	0.454	0.454	577	0.561	0.612	3.599	0.000	3.511	0.000	-2.715	0.006	-2.475	0.013	-5.554	0.000	-5.602	0.000
HERF_GAS	845	0.080	0.000	150	0.098	0.000	570	0.039	0.000	-1.013	0.312	-0.429	0.668	4.781	0.000	5.839	0.000	3.362	0.000	4.401	0.000
HERF_OIL	849	0.110	0.000	150	0.129	0.000	577	0.089	0.000	-0.822	0.412	-1.050	0.2936	1.785	0.074	2.253	0.024	1.745	0.082	2.547	0.011
Variables that proxy for market conditions																					
VOL_OIL	849	3.272	2.371	150	3.469	2.445	576	3.864	3.271	-0.764	0.446	0.785	0.433	-3.741	0.000	6.566	0.000	-1.475	0.141	-2.804	0.005
SPOT_OIL	849	47.999	32.520	150	51.612	44.600	576	59.790	61.050	-1.366	0.174	0.527	0.598	-8.101	0.000	8.483	0.000	-3.022	0.003	-3.788	0.000
FUTURE_OIL	849	47.768	30.298	150	51.797	46.388	576	60.371	64.847	-1.496	0.136	0.763	0.445	-8.410	0.000	8.366	0.000	-3.115	0.002	-3.642	0.000
VOL_GAS	849	0.710	0.458	150	0.747	0.526	576	0.857	0.760	-0.795	0.428	1.181	0.238	-4.972	0.000	6.216	0.000	-2.257	0.025	-2.386	0.017
SPOT_GAS	849	4.945	4.740	150	5.194	5.050	576	5.852	5.771	-1.042	0.299	0.720	0.471	-6.735	0.000	7.199	0.000	-2.639	0.009	-3.189	0.001
FUTURE_GAS	849	5.443	5.106	150	5.804	5.388	576	6.654	6.280	-1.557	0.121	1.581	0.114	-9.217	0.000	9.483	0.000	-3.520	0.001	-3.621	0.000

Note:
This table reports the univariate analysis for the independent variables proposed to explain the use of the hedging instrument by oil hedgers. The terms *GAS_HEDG*, *IR_HEDG*, *FX_HEDG*, and *BASIS_HEDG* are dummy variables for gas, oil, IR, FX, and basis risk hedging; *TLCF* stands for TLCFs scaled by the book value of total assets; *TAX_SAVE* for the expected percentage of tax savings; *LEV* for the leverage ratio; *DTD* for the DTD; *CONSTRAINT* for financial constraints; *INV_OPP* for investment opportunities; *COR_IO_FCF* for the correlation between free cash flows and investment opportunities; *UND_OIL* and *UND_GAS* for the undeveloped proved reserves of oil and gas, respectively; *OVER_INV* for overinvestment; *COST_CV* is the coefficient of variation of the cash cost per BOE; *OIL_REV* and *GAS_REV* for the fraction of revenues from oil and gas production, respectively; *HERF_OIL* and *HERF_GAS* for the geographical dispersion of oil and gas production, respectively; *UNCER_OIL* and *UNCER_GAS* for the production uncertainty for oil and gas, respectively; *PQ_COR_OIL* and *PQ_COR_GAS* for the quantity–price correlation for oil and gas, respectively; *MV_CS_CEO* for the market value of common shares held by the CEO; *OPT_CEO* for the number of stock options held by the CEO; *%_CS_INST* for the percentage of common shares held by institutional investors; *FUTURE_OIL*, *SPOT_OIL*, and *VOL_OIL* for oil future and spot prices and volatility, respectively; and *FUTURE_GAS*, *SPOT_GAS*, and *VOL_GAS* for gas future and spot prices and volatility, respectively. The means are compared by using a *t*-test assuming unequal variances; the medians are compared by using the non-parametric Wilcoxon rank sum *Z*-score. Two-sided *p*-values are reported.

Table A.1.6 Financial and operational characteristics of gas hedgers, by hedging portfolio

Gas hedging portfolios firm–quarter

	Swap+Put			Swap+Collar			Put+Collar			Swap+Put+Collar			Swap+Put vs Swap+Collar				Swap+Put vs Put+Collar				Swap+Collar vs Put+Collar			
Variable	Obs	Mean	Median	Obs	Mean	Median	Obs	Mean	Median	Obs	Mean	Median	*t*-Stat	*p*-Value	*Z*-Score	*p*-Value	t-Stat	*p*-Value	*Z*-Score	*p*-Value	*t*-Stat	*p*-Value	*Z*-Score	*p*-Value
Variables that proxy for hedging activity																								
OIL_HEDG	137	0.810	1.000	999	0.792	1.000	72	0.806	1.000	187	0.802	1.000	0.512	0.609	0.500	0.617	0.081	0.936	0.081	0.935	-0.283	0.778	0.278	0.781
BASIS_HEDG	137	0.153	0.000	999	0.284	0.000	72	0.069	0.000	187	0.299	0.000	-3.849	0.000	-3.243	0.001	1.942	0.054	1.741	0.082	6.437	0.000	-3.965	0.000
IR_HEDG	137	0.358	0.000	999	0.401	0.000	72	0.361	0.000	187	0.358	0.000	-0.996	0.321	-0.981	0.327	-0.049	0.961	-0.049	0.961	0.682	0.497	-0.674	0.500
FX_HEDG	137	0.007	0.000	999	0.063	0.000	72	0.000	0.000	187	0.107	0.000	-5.258	0.000	-2.653	0.008	1.000	0.319	0.725	0.469	8.196	0.000	-2.195	0.028
Variables that proxy for underinvestment costs																								
INV_OPP	137	0.141	0.077	982	0.109	0.077	72	0.106	0.077	184	0.132	0.091	1.841	0.068	0.547	0.585	1.642	0.102	0.537	0.592	0.202	0.841	-0.186	0.853
UND_OIL	137	21.872	11.089	999	54.792	6.983	72	10.047	6.748	187	28.092	6.711	-7.587	0.000	-0.852	0.395	3.950	0.000	1.256	0.209	12.537	0.000	-1.111	0.267
UND_GAS	137	180.869	71.715	999	593.408	209.100	72	80.778	45.638	187	474.645	124.706	-9.142	0.000	-6.339	0.000	2.985	0.003	2.275	0.023	15.422	0.000	-6.703	0.000
COR_IO_FCF	137	0.116	0.030	999	0.074	0.053	72	0.056	0.055	187	0.138	0.123	1.254	0.211	0.754	0.450	1.333	0.183	0.585	0.558	0.540	0.590	0.292	0.770
Variables that proxy for overinvestment																								
OVER_INV	137	0.212	0.000	973	0.319	0.000	72	0.222	0.000	183	0.197	0.000	2.807	0.005	-2.543	0.011	-0.174	0.862	-0.176	0.860	1.869	0.065	1.702	0.088
Variables that proxy for the tax advantage of hedging																								
TLCF	137	0.095	0.000	989	0.050	0.000	72	0.028	0.000	184	0.073	0.000	2.385	0.018	-3.009	0.003	3.357	0.001	0.361	0.718	2.677	0.009	-2.680	0.007
TAX_SAVE	137	0.044	0.041	994	0.049	0.046	72	0.054	0.052	187	0.055	0.049	-2.025	0.044	-1.429	0.153	-2.271	0.025	-2.953	0.003	-1.224	0.224	2.306	0.021
Variables that proxy for financial distress costs																								
DTD	130	2,680	2,609	955	2,567	2,451	72	2,147	2,090	174	2,431	2,264	0.981	0.327	1.091	0.275	3.687	0.000	3.051	0.002	4.135	0.000	3.007	0.002
CONSTRAINT	137	0.577	1.000	988	0.424	0.000	72	0.500	0.500	184	0.554	1.000	3.375	0.000	3.367	0.000	1.051	0.295	1.056	0.291	-1.236	0.219	-1.256	0.209
LEV	137	0.210	0.190	989	0.173	0.158	72	0.216	0.195	184	0.211	0.179	4.603	0.000	5.395	0.000	-0.353	0.724	0.024	0.981	-2.762	0.007	-2.630	0.008
Variables that proxy for managerial risk aversion																								
MV_CS_CEO	137	23.560	8.370	999	50.261	6.496	72	49.032	13.645	187	40.922	8.725	-4.061	0.000	-1.381	0.167	-1.912	0.059	-2.478	0.013	0.086	0.930	-2.679	0.007
OPT_CEO	137	78611	42563	999	262719	40000	72	55811	0.000	187	224892	25050	-4.587	0.000	-1.050	0.294	1.227	0.221	2.618	0.008	4.963	0.000	3.214	0.001
Variables that proxy for information asymmetry																								
%_CS_INST	137	0.579	0.668	999	0.629	0.760	72	0.550	0.562	187	0.563	0.684	-1.889	0.060	-2.728	0.006	0.743	0.458	1.112	0.266	2.514	0.014	-3.114	0.002
Variables that proxy for production characteristics																								
UNCER_OIL	117	0.384	0.349	982	0.429	0.373	72	0.560	0.497	179	0.530	0.313	-1.862	0.064	-1.156	0.248	-4.256	0.000	-4.507	0.000	-3.628	0.001	3.617	0.000
PQ_COR_OIL	117	0.318	0.578	982	0.352	0.563	72	0.626	0.699	179	0.286	0.621	-0.618	0.538	-1.053	0.293	-4.935	0.000	-4.158	0.000	-7.206	0.000	4.310	0.000
UNCER_GAS	137	0.504	0.601	999	0.468	0.339	72	0.391	0.441	187	0.509	0.328	1.171	0.243	2.317	0.021	3.047	0.003	2.778	0.006	2.747	0.007	-0.055	0.956
PQ_COR_GAS	137	0.240	0.316	999	0.314	0.413	72	0.235	0.263	187	0.232	0.273	-2.072	0.040	-1.639	0.101	0.099	0.921	0.341	0.733	1.752	0.084	-1.600	0.110
COST_CV	137	0.179	0.174	988	0.285	0.254	72	0.309	0.245	159	0.255	0.267	-3.553	0.001	-6.368	0.000	-3.681	0.000	-5.237	0.000	-1.152	0.252	1.035	0.301
OIL_REV	129	0.355	0.326	993	0.246	0.245	72	0.410	0.480	184	0.246	0.232	4.983	0.000	4.557	0.000	-1.623	0.106	-1.505	0.132	-6.050	0.000	-6.177	0.000
GAS_REV	129	0.533	0.583	993	0.653	0.673	72	0.510	0.489	184	0.645	0.714	-5.188	0.000	-4.786	0.000	0.762	0.447	1.437	0.151	6.659	0.000	5.996	0.000
HERF_GAS	137	0.011	0.000	999	0.051	0.000	72	0.024	0.000	187	0.035	0.000	-5.889	0.000	-3.634	0.000	-1.029	0.305	-0.591	0.554	2.166	0.032	2.169	0.030
HERF_OIL	137	0.016	0.000	986	0.122	0.000	72	0.026	0.000	187	0.093	0.000	-9.625	0.000	-5.180	0.000	-0.685	0.494	-1.276	0.202	6.942	0.000	3.128	0.002
Variables that proxy for market conditions																								
VOL_OIL	137	3.389	2.371	999	4.115	3.271	72	3.470	3.271	187	4.044	2.808	-2.630	0.009	-3.792	0.000	-0.217	0.829	-2.076	0.038	2.215	0.029	-0.668	0.504
SPOT_OIL	137	48.449	35.760	999	59.514	61.040	72	58.030	61.980	187	57.435	56.500	-4.249	0.000	-4.887	0.000	-2.896	0.004	-3.521	0.000	0.619	0.537	0.258	0.797
FUTURE_OIL	137	48.458	33.311	999	59.994	63.099	72	59.094	65.784	187	58.090	58.710	-4.331	0.000	-4.880	0.000	-3.061	0.003	-3.468	0.001	0.349	0.728	0.205	0.837
VOL_GAS	137	0.725	0.500	999	0.836	0.760	72	0.862	0.760	187	0.781	0.508	-2.276	0.024	-2.602	0.009	-1.706	0.090	-1.942	0.052	-0.379	0.706	0.415	0.678
SPOT_GAS	137	5.047	4.830	999	5.779	5.700	72	5.783	5.780	187	5.427	4.895	-3.097	0.002	-3.454	0.001	-2.060	0.041	-2.571	0.010	-0.011	0.991	0.396	0.692
FUTURE_GAS	137	5.617	5.264	999	6.507	6.072	72	6.709	6.304	187	6.170	5.872	-3.876	0.000	-3.927	0.000	-3.254	0.001	-3.331	0.001	-0.755	0.453	1.070	0.285

Note:

This table reports the univariate analysis for the independent variables proposed to explain the hedging portfolio choice by gas hedgers. The terms *OIL_HEDG*, *IR_HEDG*, *FX_HEDG*, and *BASIS_HEDG* are dummy variables for gas, oil, IR, FX, and basis risk hedging, respectively; *TLCF* stands for TLCFs scaled by the book value of total assets; *TAX_SAVE* for the expected percentage of tax savings; *LEV* for the leverage ratio; *DTD* for the DTD; *CONSTRAINT* for financial constraints; *INV_OPP* for investment opportunities; *COR_IO_FCF* for the correlation between free cash flows and investment opportunities; *UND_OIL* and *UND_GAS* for the undeveloped proved reserves of oil and gas, respectively; *OVER_INV* for overinvestment; *COST_CV* for the coefficient of variation of the cash cost per BOE; *OIL_REV* and *GAS_REV* for the fraction of revenues from oil and gas production, respectively; *HERF_OIL* and *HERF_GAS* for the geographical dispersion of oil and gas production, respectively; *UNCER_OIL* and *UNCER_GAS* for the production uncertainty for oil and gas, respectively; *PQ_COR_OIL* and *PQ_COR_GAS* for the quantity–price correlation for oil and gas, respectively; *MV_CS_CEO* for the market value of common shares held by the CEO; *OPT_CEO* for the number of stock options held by the CEO; *%_CS_INST* for the percentage of common shares held by institutional investors; *FUTURE_OIL*, *SPOT_OIL*, and *VOL_OIL* for oil future and spot prices and volatility, respectively; and *FUTURE_GAS*, *SPOT_GAS*, and *VOL_GAS* for gas future and spot prices and volatility, respectively. The means are compared by using a *t*-test assuming unequal variances; the medians are compared by using the non-parametric Wilcoxon rank sum *Z*-score. Two-sided *p*-values are reported.

Table A.1.7 Financial and operational characteristics of oil hedgers, by hedging portfolio

Oil hedging portfolios firm–quarter

	Swap+Put			Swap+Collar			Put+Collar			Swap+Put+Collar			Swap+Put vs Swap+Collar				Swap+Put vs Put+Collar				Swap+Collar vs Put+Collar			
Variable	Obs	Mean	Median	Obs	Mean	Median	Obs	Mean	Median	Obs	Mean	Median	*t*-Stat	*p*-Value	*Z*-Score	*p*-Value	*t*-Stat	*p*-Value	*Z*-Score	*p*-Value	*t*-Stat	*p*-Value	*Z*-Score	*p*-Value
Variables that proxy for hedging activity																								
OIL_HEDG	99	0.879	1.000	627	0.955	1.000	63	0.968	1.000	136	0.949	1.000	-2.253	0.026	-3.100	0.002	-2.249	0.026	-1.970	0.049	-0.544	0.588	-0.479	0.632
BASIS_HEDG	99	0.020	0.000	627	0.290	0.000	63	0.063	0.000	136	0.324	0.000	-11.719	0.000	-5.737	0.000	-1.271	0.207	-1.418	0.156	6.319	0.000	3.864	0.000
IR_HEDG	99	0.374	0.000	627	0.442	0.000	63	0.175	0.000	136	0.456	0.000	-1.290	0.199	-1.269	0.204	2.901	0.004	2.698	0.007	5.125	0.000	4.097	0.000
FX_HEDG	99	0.000	0.000	627	0.056	0.000	63	0.000	0.000	136	0.037	0.000	-6.084	0.000	-2.408	0.016	NA	NA	NA	NA	6.084	0.000	1.923	0.054
Variables that proxy for underinvestment costs																								
INV_OPP	99	0.146	0.079	622	0.131	0.081	61	0.113	0.058	133	0.114	0.064	0.653	0.515	0.636	0.525	1.182	0.239	1.987	0.047	0.898	0.371	1.638	0.101
UND_OIL	99	27.384	25.029	627	64.751	12.526	63	48.239	8.048	136	48.647	12.061	-7.072	0.000	0.248	0.804	-1.748	0.085	0.644	0.520	1.311	0.194	0.161	0.872
UND_GAS	99	81.416	57.054	627	436.400	136.510	63	300.440	44.932	136	322.188	62.288	-13.250	0.000	-5.883	0.000	-2.421	0.018	-0.328	0.743	1.451	0.151	3.466	0.001
COR_IO_FCF	99	0.181	0.133	627	0.090	0.070	63	0.100	0.085	136	0.074	-0.004	2.814	0.005	2.400	0.016	1.961	0.051	1.445	0.148	-0.365	0.716	-0.481	0.630
Variables that proxy for overinvestment																								
OVER_INV	99	0.242	0.000	621	0.273	0.000	61	0.295	0.000	132	0.166	0.000	-0.668	0.505	-0.652	0.514	-0.720	0.472	-0.733	0.463	-0.346	0.729	-0.355	0.722
Variables that proxy for the tax advantage of hedging																								
TLCF	99	0.100	0.000	624	0.062	0.000	62	0.068	0.000	133	0.072	0.000	1.874	0.064	0.063	0.950	1.150	0.252	1.189	0.235	-0.347	0.730	1.304	0.192
TAX_SAVE	99	0.055	0.059	627	0.053	0.049	61	0.060	0.065	136	0.057	0.050	0.531	0.596	1.371	0.170	-1.167	0.245	-1.713	0.087	-2.095	0.038	-3.324	0.001
Variables that proxy for financial distress costs																								
DTD	99	2.243	2.082	610	2.532	2.423	58	2.296	2.299	122	2.404	2.327	-2.483	0.014	-2.289	0.022	-0.276	0.782	-0.309	0.757	1.427	0.158	1.318	0.187
CONSTRAINT	99	0.545	1.000	624	0.463	0.000	62	0.452	0.000	133	0.639	1.000	1.520	0.131	1.523	0.128	1.156	0.249	1.155	0.248	0.172	0.863	0.174	0.862
LEV	99	0.215	0.197	624	0.181	0.166	62	0.233	0.194	133	0.220	0.196	3.988	0.000	4.140	0.000	-0.885	0.378	-0.212	0.832	-2.903	0.005	-2.671	0.007
Variables that proxy for managerial risk aversion																								
MV_CS_CEO	99	24.552	2.642	627	55.189	8.789	63	49.133	21.196	136	53.081	7.155	-3.265	0.001	-2.608	0.010	-1.963	0.053	-2.465	0.014	0.411	0.681	-1.289	0.197
OPT_CEO	99	53879	23333	627	228965	25000	63	610305	0.000	136	485481	0.000	-3.598	0.000	-2.261	0.024	-1.718	0.090	1.813	0.069	-1.165	0.248	3.301	0.001
Variables that proxy for information asymmetry																								
%_CS_INST	99	0.662	0.715	627	0.621	0.760	63	0.560	0.512	136	0.477	0.441	1.402	0.163	0.517	0.605	2.207	0.029	2.103	0.036	1.527	0.131	1.603	0.109
Variables that proxy for production characteristics																								
UNCER_OIL	92	0.502	0.376	627	0.455	0.375	63	0.446	0.447	124	0.367	0.202	1.311	0.192	1.747	0.081	1.331	0.185	0.193	0.847	0.292	0.771	-1.182	0.237
PQ_COR_OIL	93	0.415	0.651	627	0.448	0.670	63	0.553	0.748	124	0.399	0.650	-0.550	0.583	-1.493	0.135	-1.737	0.085	-2.552	0.011	-1.759	0.082	-1.760	0.078
UNCER_GAS	99	0.593	0.649	627	0.483	0.340	63	0.408	0.439	136	0.480	0.353	3.329	0.001	5.698	0.000	4.717	0.000	4.080	0.000	2.263	0.025	-0.625	0.532
PQ_COR_GAS	99	0.218	0.284	627	0.274	0.368	63	0.324	0.441	136	0.137	0.103	-1.431	0.155	-1.726	0.084	-2.109	0.037	-2.067	0.039	-1.327	0.188	-0.801	0.423
COST_CV	99	0.285	0.252	604	0.366	0.256	63	0.312	0.243	136	0.286	0.221	-2.155	0.032	-1.017	0.309	-1.104	0.272	-1.019	0.308	1.426	0.155	-1.011	0.312
OIL_REV	86	0.523	0.583	625	0.353	0.329	63	0.516	0.574	134	0.457	0.452	6.212	0.000	5.903	0.000	0.207	0.835	0.594	0.552	-6.900	0.000	-6.257	0.000
GAS_REV	86	0.430	0.396	625	0.564	0.609	63	0.446	0.397	134	0.517	0.548	-5.358	0.000	-4.841	0.000	-0.531	0.595	-0.832	0.405	5.750	0.000	4.827	0.000
HERF_GAS	99	0.096	0.000	627	0.062	0.000	63	0.072	0.000	136	0.063	0.000	1.568	0.119	0.160	0.873	0.773	0.440	0.543	0.587	-0.468	0.641	0.713	0.476
HERF_OIL	99	0.020	0.000	627	0.154	0.000	63	0.066	0.000	136	0.136	0.000	-9.116	0.000	-2.815	0.005	-1.845	0.068	0.415	0.678	3.452	0.000	2.435	0.015
Variables that proxy for market conditions																								
VOL_OIL	99	4.343	3.271	627	4.180	3.307	63	4.487	3.471	136	4.233	3.307	0.420	0.675	-0.364	0.716	-0.264	0.792	-1.234	0.217	-0.714	0.477	-1.256	0.209
SPOT_OIL	99	60.126	62.910	627	62.934	65.870	63	67.144	69.890	136	59.592	61.045	-0.871	0.386	-1.052	0.293	-1.609	0.110	-1.832	0.067	-1.257	0.213	-1.372	0.170
FUTURE_OIL	99	60.689	66.721	627	63.458	66.815	63	68.344	71.653	136	60.521	63.973	-0.849	0.398	-1.041	0.298	-1.736	0.085	-1.973	0.049	-1.441	0.154	-1.494	0.135
VOL_GAS	99	0.794	0.543	627	0.853	0.760	63	0.868	0.760	136	0.778	0.543	-1.038	0.301	-1.043	0.297	-0.828	0.409	-0.736	0.462	-0.199	0.843	-0.036	0.971
SPOT_GAS	99	5.554	5.530	627	5.937	5.771	63	5.870	5.780	136	5.384	4.602	-1.379	0.170	-1.486	0.137	-0.804	0.423	-1.021	0.307	0.211	0.834	0.137	0.891
FUTURE_GAS	99	6.414	6.129	627	6.729	6.280	63	6.816	6.213	136	6.067	5.264	-1.159	0.249	-1.079	0.281	-1.042	0.299	-1.035	0.301	-0.281	0.779	-0.352	0.725

Note:

This table reports the univariate analysis for the independent variables proposed to explain the hedging portfolio choice by oil hedgers. The terms *GAS_HEDG*, *IR_HEDG*, *FX_HEDG*, and *BASIS_HEDG* are dummy variables for gas, oil, IR, FX, and basis risk hedging, respectively; *TLCF* stands for TLCFs scaled by the book value of total assets; *TAX_SAVE* for the expected percentage of tax savings; *LEV* for the leverage ratio; *DTD* for the DTD; *CONSTRAINT* for financial constraints; *INV_OPP* for investment opportunities; *COR_IO_FCF* for the correlation between free cash flows and investment opportunities; *UND_OIL* and *UND_GAS* for the undeveloped proved reserves for oil and gas, respectively; *OVER_INV* for overinvestment; *COST_CV* for the coefficient of variation of the cash cost per BOE; *OIL_REV* and *GAS_REV* for the fraction of revenues from oil and gas production, respectively; *HERF_OIL* and *HERF_GAS* for the geographical dispersion of oil and gas production, respectively; *UNCER_OIL* and *UNCER_GAS* for the production uncertainty for oil and gas, respectively; *PQ_COR_OIL* and *PQ_COR_GAS* for the quantity–price correlation for oil and gas, respectively; *MV_CS_CEO* for the market value of common shares held by the CEO; *OPT_CEO* for the number of stock options held by the CEO; *%_CS_INST* for the percentage of common shares held by institutional investors; *FUTURE_OIL*, *SPOT_OIL*, and *VOL_OIL* for oil future and spot prices and volatility, respectively; and *FUTURE_GAS*, *SPOT_GAS*, and *VOL_GAS* for gas future and spot prices and volatility, respectively. The means are compared by using a *t*-test assuming unequal variances; the medians are compared by using the non-parametric Wilcoxon rank sum *Z*-score. Two-sided *p*-values are reported.

Table A.1.8 Fraction of the notional position by instrument

Panel A: Gas hedging (%)									
Strategy	Swap+put		Swap+collar		Collar+put		Swap+put+collar		
Instrument	Swap	Put	Swap	Collar	Collar	Put	Swap	Put	Collar
Mean	59.3	40.7	53.1	46.9	58.2	41.8	33.1	19.3	47.7
Median	64.9	35.1	55	45	60	40	30.6	13.8	46.5
SD	26.3	26.3	30	30	20.8	20.8	24.2	15.9	25.3
Min	7.2	0.5	0.2	0	2.6	1.1	0.1	0.4	3.1
Max	99.5	92.8	100	99.8	98.9	97.4	91.7	66.4	96.9
Panel B: Oil hedging (%)									
Strategy	Swap+put		Swap+collar		Collar+put		Swap+put+collar		
Instrument	Swap	Put	Swap	Collar	Collar	Put	Swap	Put	Collar
Mean	48.7	51.3	50.7	49.3	62.3	37.7	36.5	17.9	45.6
Median	49.2	50.8	51.6	48.4	66.6	33.4	30.3	15.8	48.6
SD	25.2	25.2	28.1	28.1	27	27	26.2	12.8	26.5
Min	4.4	2.3	0.02	1.3	0.5	2.1	1.4	0.5	0.8
Max	97.7	95.6	98.7	99.8	97.9	99.5	93	62.9	93.6

Note:

For a given hedging strategy, this table gives summary statistics of the fraction of notional position hedged by each instrument.

Table A.1.9 Alternative measures of hedging intensity for put options and costless collars

	Panel A : Gas hedgers								Panel B : Oil hedgers							
Dependent variables	Put options				Costless Collars				Put options				Costless collars			
	Year_0	Year_0	Year_1-2	Year_1-2	Year_0	Year_0	Year_1-3	Year_1-3	Year_0	Year_0	Year_1-2	Year_1-2	Year_0	Year_0	Year_1-3	Year_1-3
	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	XIII	XIV	XV	XVI
CONSTANT	-1.1717***	-1.3428***	-1.6028***	-1.4833***	0.0583	-0.0911	-0.1704	-0.3098**	-1.3926***	-1.3176***	-2.3438***	-2.2462***	0.1854	-0.0136	0.2970	-0.0412
	(0.416)	(0.327)	(0.519)	(0.357)	(0.096)	(0.104)	(0.125)	(0.131)	(0.532)	(0.391)	(0.843)	(0.706)	(0.157)	(0.131)	(0.181)	(0.151)
COR_IO_FCF	0.1889	0.1356	0.0985	0.0467	-0.2190**	-0.2029**	-0.2869***	-0.2538**	0.0694	0.0596	-0.1706	-0.1892	-0.1136	-0.1073	-0.0685	-0.0759
	(0.184)	(0.185)	(0.224)	(0.233)	(0.086)	(0.084)	(0.107)	(0.106)	(0.370)	(0.332)	(0.453)	(0.414)	(0.138)	(0.142)	(0.165)	(0.161)
HERF	0.1668	0.0718	0.7633	0.6845	0.0057	-0.0163	0.5394	0.4166	-0.0375	-0.1613	-0.4240	-0.5851**	0.4422	0.4460	0.2076	0.2301
	(0.198)	(0.202)	(0.584)	(0.735)	(0.371)	(0.368)	(0.496)	(0.476)	(0.158)	(0.213)	(0.285)	(0.295)	(0.315)	(0.307)	(0.415)	(0.421)
PQ_COR	0.0325	0.0341	0.3054	0.2790	0.0677	-0.0131	0.2090	0.0695	0.2388	0.2175	0.7028	0.8461	-0.0016	-0.0287	0.0180	0.0150
	(0.274)	(0.273)	(0.222)	(0.229)	(0.106)	(0.108)	(0.131)	(0.130)	(0.238)	(0.246)	(0.445)	(0.546)	(0.109)	(0.104)	(0.151)	(0.144)
OVER_INV	-0.1763	-0.1934	-0.3713**	-0.3583**	-0.0626	-0.0414	-0.0321	-0.0118	0.1103	0.1222	0.1715	0.2083	0.0260	0.0421	0.0167	0.0341
	(0.139)	(0.138)	(0.154)	(0.148)	(0.051)	(0.052)	(0.067)	(0.065)	(0.115)	(0.093)	(0.145)	(0.158)	(0.053)	(0.056)	(0.055)	(0.060)
MV_CS_CEO	-7.2211***	-8.1855***	-5.8748*	-6.7628*	0.3991*	0.2208	0.6221**	0.4073	-1.1286	-0.6299	-1.8382	-1.7448	-0.1821	-0.2979	0.0864	0.0647
	(2.776)	(2.872)	(3.173)	(3.688)	(0.240)	(0.246)	(0.267)	(0.277)	(1.681)	(1.283)	(1.980)	(2.084)	(0.220)	(0.229)	(0.182)	(0.199)
OPT_CEO	0.0046***	0.0052***	0.0020	0.0025	0.0002	0.0001	-0.0001	-0.0003**	-0.0003	-0.0009	0.0009	0.0004	-0.0000	-0.0001	-0.0002**	-0.0002**
	(0.002)	(0.002)	(0.002)	(0.002)	(0.000)	(0.000)	(0.000)	(0.000)	(0.003)	(0.003)	(0.002)	(0.001)	(0.000)	(0.000)	(0.000)	(0.000)
TLCF	0.7291*	0.7143	0.1714	0.1692	0.0615	0.1107	0.0178	0.0442	0.3235	0.3675	-0.4729	-0.3537	0.4176*	0.3761	0.4181***	0.3237*
	(0.430)	(0.446)	(0.330)	(0.472)	(0.139)	(0.144)	(0.382)	(0.403)	(0.493)	(0.421)	(0.544)	(0.438)	(0.239)	(0.229)	(0.143)	(0.170)
TAX_SAVE	-0.1927	0.0434	0.4917	0.6787	0.1422	0.2926	0.3213	0.5257**	0.6516	-0.0437	1.4569*	1.4740*	-1.0031	-0.7576	-0.3454	-0.2575
	(0.747)	(0.602)	(0.403)	(0.470)	(0.205)	(0.223)	(0.258)	(0.265)	(1.330)	(1.679)	(0.848)	(0.798)	(0.628)	(0.571)	(0.438)	(0.474)
LEV	-0.4121		0.0492		-0.1781		-0.2774		-1.1310		-0.7271		-0.3780		-1.1906**	
	(0.646)		(0.509)		(0.227)		(0.275)		(1.010)		(1.129)		(0.356)		(0.569)	
CONSTRAINT		-0.0277		0.0087		0.0277		-0.0019		-0.1153		-0.0928		-0.0181		-0.0492
		(0.097)		(0.092)		(0.042)		(0.058)		(0.140)		(0.108)		(0.047)		(0.069)
INV_OPP		0.1081		0.1261		0.0759		-0.0762		-0.0153		0.0481		0.1094		0.1156
		(0.073)		(0.095)		(0.119)		(0.119)		(0.085)		(0.079)		(0.074)		(0.076)
VOL	0.1447***		0.0952		0.1088***		0.0962***		-0.0057		-0.0052		0.0056		-0.0023	
	(0.046)		(0.076)		(0.022)		(0.026)		(0.023)		(0.013)		(0.007)		(0.010)	
SPOT		0.0304		0.0575		-0.0240**		-0.0394**		-0.0181		0.0022		-0.0079		-0.0120
		(0.031)		(0.050)		(0.012)		(0.017)		(0.020)		(0.018)		(0.007)		(0.007)
FUTURE		0.0215		-0.0294		0.0696***		0.0943***		0.0157		-0.0043		0.0104		0.0141*
		(0.049)		(0.068)		(0.020)		(0.027)		(0.020)		(0.021)		(0.007)		(0.008)
UNCER	0.4377		0.3380		0.2195*		0.3460**		0.0604		0.3074		0.0189		0.0604	
	(0.498)		(0.622)		(0.133)		(0.151)		(0.524)		(0.514)		(0.175)		(0.183)	
Sigma_u	1.2473***	1.3003***	1.3545***	1.3219***	0.5619***	0.5467***	0.6978***	0.6728***	1.4802***	1.4422***	2.1420***	2.1317***	0.7061***	0.7017***	0.7365***	0.7309***
	(0.149)	(0.189)	(0.225)	(0.203)	(0.049)	(0.046)	(0.061)	(0.055)	(0.233)	(0.187)	(0.517)	(0.455)	(0.070)	(0.069)	(0.078)	(0.075)
Log (Sigma_e)	-0.8832***	-0.8778***	-0.7993***	-0.8008***	-0.8889***	-0.9043***	-0.8129***	-0.8322***	-0.6398***	-0.6362***	-0.8650***	-0.8715***	-0.8186***	-0.8262***	-0.7867***	-0.7828***
	(0.138)	(0.143)	(0.172)	(0.174)	(0.047)	(0.047)	(0.054)	(0.054)	(0.182)	(0.172)	(0.196)	(0.181)	(0.056)	(0.055)	(0.071)	(0.071)
Observations	1,143	1,143	776	776	2,388	2,388	1,790	1,790	1,043	1,047	627	627	1,976	1,979	1,322	1,322
Uncensored Obs	247	247	127	127	1459	1459	975	975	219	220	124	124	1095	1095	717	717
Censored Obs	896	896	649	649	929	929	815	815	824	827	503	503	881	884	605	605
Number of firms	89	89	76	76	104	104	102	102	75	75	64	64	97	97	92	92
Log Lik	-346.9759	-347.0528	-210.5145	-209.6560	-1458.8852	-1427.6203	-1151.9868	-1123.2630	-356.5632	-360.7287	-174.2065	-173.5380	-1230.7488	-1216.7463	-867.6313	-870.2438

Note:
This table reports the coefficient estimates of the random effects tobit models. The dependent variables are the ratios of (i) put option notional position scaled by the sum of swap and put option's notional positions, and (ii) costless collar notional position scaled by the sum of swap and collar's notional positions: *Year_0*, *Year_1-2*, and *Year_1-3* are hedging intensities for the current fiscal year, the subsequent two fiscal years, and the subsequent three fiscal years, respectively. Independent variables, measured at the end of the previous quarter, are: *COR_IO_FCF* for the correlation between free cash flows and investment opportunities; *HERF* for the geographical dispersion of oil (gas) production; *PQ_COR* for the oil (gas) quantity–price correlation; *OVER_INV* for overinvestment; *MV_CS_CEO* for the market value of common shares held by the CEO; *OPT_CEO* for the number of stock options held by the CEO; *TLCF* stands for TLCFs scaled by the book value of total assets; *TAX_SAVE* for the expected percentage of tax savings; *LEV* for the leverage ratio; *CONSTRAINT* for financial constraints; *INV_OPP* for investment opportunities; *FUTURE*, *SPOT*, and *VOL* for oil (gas) future and spot prices, and volatility, respectively; *UNCER* for oil (gas) production uncertainty. Standard errors, corrected for heteroskedasticity and clustering using Huber-White-Sandwich estimator, are in parentheses. The superscripts ***, **, and * indicate significance at the 1%, 5%, and 10% levels, respectively. *Sigma_u* and *Sigma_e* stand for the standard deviations of random-effects and error terms, respectively.

Table A.1.10 Summary of our predictions and findings

		Hedging strategies based on one instrument only		Hedging portfolios			Hedging intensity		
Econometric Models		Dynamic RE Generalized Ordered Probit		Dynamic RE Mixed Multinomial Logit			RE Tobit		
Hedging strategies		Put versus swap and collar	Put and collar versus swap	Swaps and put options	Swaps and collars	Swaps, put options, and collars	Swap contracts	Put options	Costless collars
Correlation between internal funds and Investment programs	Predicted	+	+	-	-	-	+	-	**?**
	Gas Hedgers	+***	+***	+	-	+**	+**	-/+	-**
	Oil Hedgers	-	+***	-**	-/+	-/+	+	-/+	-/+
Oil and gas production characteristics									
Geographic diversification	Predicted	-	-	+	+	+	-	+	**?**
	Gas Hedgers	-*	-	+	+	+	-/+	+**	-/+
	Oil Hedgers	-**	-***	-	+***	+	-	-/+	+
Price–quantity correlation	Predicted	+	+	-	-	-	+	-	**?**
	Gas Hedgers	+*	+	-	-**	-**	-***	-	+
	Oil Hedgers	-	+	-	+	-/+	-/+	+	-
Free cash flow agency problem									
Overinvestment	Predicted	+	+	-	-	-	+	-	**?**
	Gas Hedgers	+*	+	-**	-/+	+	+*	-***	-/+
	Oil Hedgers	+***	+	+**	+	-	-	-	+
Managerial risk aversion									
Managerial shareholding	Predicted	+	+	-	-	-	+	-	**?**
	Gas Hedgers	+**	+	-	+	-/+	-	-	+***
	Oil Hedgers	+*	-/+	-	+**	+	-/+		-/+
Managerial option-holding	Predicted	-	-	+	+	+	-	+	**?**
	Gas Hedgers	-**	-***	-	+	+*	-**	-	-*/+*
	Oil Hedgers	+**	-/+	+***	-/+	+	-**/+**	+***	-***
Tax function convexity									
Tax save	Predicted	+	+	-	-	-	+	-	**?**
	Gas Hedgers	+	-***	-	+	-	-	-	+***
	Oil Hedgers	+***	-	+**	+	-	+*	-/+	-/+
Tax loss carry forwards	Predicted	-	-	+	+	+	-	+	**?**
	Gas Hedgers	-	-**	+	+	+	-/+	+***	-/+
	Oil Hedgers	-	-***	-/+	+	-	-	+	+
Financial constraints									
Leverage	Predicted	+	+	-	-	-	+	-	**?**
	Gas Hedgers	+	-/+	-	-**	-	+	-	-
	Oil Hedgers	-/+	+***	-	-/+	+	+**	+	-*
Distance to default	Predicted	-	-	+	+	+	-	+	**?**
	Gas Hedgers	-	-***	-	+	-	**n/a**	**n/a**	**n/a**
	Oil Hedgers	+**	-***	-	-	+	**n/a**	**n/a**	**n/a**

Continued

Table A.1.10-*Continued*

		Hedging strategies based on one instrument only		Hedging portfolios			Hedging intensity		
Econometric Models		Dynamic RE Generalized Ordered Probit		Dynamic RE Mixed Multinomial Logit			RE Tobit		
Hedging strategies		Put versus swap and collar	Put and collar versus swap	Swaps and put options	Swaps and collars	Swaps, put options, and collars	Swap contracts	Put options	Costless collars
Financial constraint	Predicted	-	-	+	+	+	-	+	**?**
	Gas Hedgers	-*	-	+	+***	-	+	+	-/+
	Oil Hedgers	-	+	+	-	+**	+	+	-
Investment programs and real options									
Investment opportunities	Predicted	-	-	+	+	+	-	+	**?**
	Gas Hedgers	-/+	-***	+**	+**	+*	+	+**	-
	Oil Hedgers	+	-***	+	+*	+*	-	-/+	-/+
Undeveloped reserves	Predicted	-	-	+	-/+	+	-	+	**?**
	Gas Hedgers	+**	-	-	+	-/+	**n/a**	**n/a**	**n/a**
	Oil Hedgers	+**	+*	+	+	+	**n/a**	**n/a**	**n/a**
Oil and gas market conditions									
Spot price	Predicted	+	+	-	-	-	+	-	-
	Gas Hedgers	-/+	+***	-/+	-	-	+**	+**	-***
	Oil Hedgers	+***	+**	-*	+	-	+***	-/+	-**
Future price	Predicted	-	-	+	+	+	-	+	+
	Gas Hedgers	+	-***	-/+	+**	+	-***	-*	+***
	Oil Hedgers	-***	-**	+*	-	+	-***	-/+	+**
Price volatility	Predicted	-	-	+	+	+	-	+	+
	Gas Hedgers	-***	-***	+	+**	+	-***	-/+	+***
	Oil Hedgers	-	-**	+	-	-/+	-	+	-/+
Additional risk									
Production uncertainty	Predicted	-	-	+	+	+	-	+	**?**
	Gas Hedgers	-***	-***	+	+***	+***	-/+	+	+*
	Oil Hedgers	-***	+*	-/+	-**	-	+	+	+
Production cost variability	Predicted	-	-	+	+	+	-	+	**?**
	Gas Hedgers	+*	+***	-*	-	+	**n/a**	**n/a**	**n/a**
	Oil Hedgers	+***	-***	-	+	-/+	**n/a**	**n/a**	**n/a**
Industrial diversification									
Industrial diversification	Predicted	-	-	+	+	+	-	+	**?**
	Gas Hedgers	-/+	-***	+***	+*	+	**n/a**	**n/a**	**n/a**
	Oil Hedgers	-**	+**	+	+	+	**n/a**	**n/a**	**n/a**

Note
This table presents a summary of our predictions and findings pertaining to the hypotheses tested in our models. The superscripts ***, **, and * mean that the sign is significant at the 1%, 5%, and 10% levels, respectively; ? means that we are unable to make a prediction about the sign associated with the hedging strategy (particularly for costless collars only); -/+ means that the given variable takes the minus sign in some specifications and the plus sign in others, but with no significant effects. n/a stands for non-available and means that the given variable is not included in the regression. RE stands for random effects.

Table A.1.11 Alternative specifications for hedging strategies

Dependant variables	**Gas hedgers**				**Oil hedgers**			
	Model 1		Model 2		Model 1		Model 2	
	Linear + Non-linear	*Non-linear only*	*Linear + Non-linear*	*Non-linear only*	*Linear + Non-linear*	*Non-linear only*	*Linear + Non-linear*	*Non-linear only*
	(I)	(II)	(III)	(IV)	(V)	(VI)	(VII)	(VIII)
DIFF_(GAS/OIL)	0.1798	0.1424	0.1723	0.0205	0.1879	-0.0670	0.1153	-0.0553
	(0.254)	(0.326)	(0.256)	(0.328)	(0.293)	(0.324)	(0.295)	(0.328)
HERF_(GAS/OIL)	0.8649	-0.0807	1.2503	0.0182	2.2401**	2.5245**	1.8389*	1.4475
	(1.580)	(2.016)	(1.563)	(2.005)	(1.041)	(1.249)	(1.048)	(1.226)
PQ_COR_(GAS/OIL)	0.1676	0.2100	0.1300	0.1402	0.0026	-0.1334	0.0209	-0.0702
	(0.176)	(0.222)	(0.180)	(0.226)	(0.199)	(0.219)	(0.200)	(0.218)
OVER_INV	0.0196	-0.4174	-0.0804	-0.3650	-0.0892	-0.2101	-0.2517	-0.2251
	(0.250)	(0.311)	(0.242)	(0.307)	(0.288)	(0.314)	(0.287)	(0.313)
MV_CS_CEO	0.3311	3.2528**	-0.2955	2.4382	0.6460	-0.2728	0.0609	0.0255
	(1.045)	(1.529)	(1.114)	(1.579)	(1.420)	(1.658)	(1.481)	(1.708)
OPT_CEO	0.0008	0.0107***	0.0001	0.0123***	-0.0026	-0.0012	-0.0019	0.0004
	(0.002)	(0.004)	(0.002)	(0.004)	(0.004)	(0.006)	(0.002)	(0.004)
%_CS_INST	0.5135	0.6789	0.0685	-0.0228	0.5507	-0.1640	-0.0055	-0.4158
	(0.580)	(0.731)	(0.583)	(0.728)	(0.683)	(0.792)	(0.712)	(0.838)
TAX_SAVE	2.2821	3.3056	1.6079	3.8772*	0.4959	-6.9269	0.7088	-6.7426
	(1.480)	(2.346)	(1.516)	(2.330)	(3.094)	(5.348)	(2.894)	(5.621)
TLCF	-0.3354	0.8256	-0.0896	0.4786	1.8781	4.0882***	1.8221	3.3872**
	(0.927)	(1.064)	(0.928)	(1.039)	(1.281)	(1.409)	(1.235)	(1.322)
LEV			-1.6363	0.3711			-1.2516	-1.5883
			(1.152)	(1.148)			(1.633)	(1.834)
CONSTRAINT			0.3587	0.2771			0.1811	-0.2086
			(0.222)	(0.284)			(0.262)	(0.296)
DTD	0.0288	0.1448			-0.0067	0.1647		
	(0.092)	(0.122)			(0.125)	(0.140)		
INV_OPP	1.9229**	0.9639			1.4812**	0.7823		
	(0.748)	(0.880)			(0.611)	(0.736)		
UND_(GAS/OIL)			-0.0803	0.3042			0.0399	-0.3821
			(0.161)	(0.274)			(3.435)	(4.217)
VOL_(GAS/OIL)	0.4430***	0.6279***			-0.0532	0.0031		
	(0.165)	(0.202)			(0.042)	(0.049)		
SPOT_(GAS/OIL)			-0.0466	-0.1238			0.0460	0.0034
			(0.087)	(0.107)			(0.038)	(0.044)
FUTURE_(GAS/OIL)			0.1776*	0.3720***			-0.0361	0.0031
			(0.100)	(0.123)			(0.039)	(0.045)
UNCER_(GAS/OIL)	0.5578	-0.1533	0.9666	-0.5581	0.9259	-0.2136	0.9220	-0.6909
	(0.658)	(0.895)	(0.622)	(0.856)	(0.718)	(0.828)	(0.704)	(0.821)
COST_CV	0.3517	0.1974	0.2410	0.1123	-0.2855	0.3165	-0.5222	-0.1703
	(0.789)	(0.826)	(0.764)	(0.821)	(1.040)	(1.074)	(1.066)	(1.096)
(OIL/GAS)_HEDG	0.0276	-0.7331**			0.0258	-1.1669***		
	(0.268)	(0.327)			(0.475)	(0.437)		
FX_HEDG	-0.1298	-1.0422			0.2706	-0.3783		
	(0.568)	(0.960)			(0.738)	(0.848)		
IR_HEDG			0.4268*	-0.0718			-0.2068	-0.4610
			(0.252)	(0.333)			(0.309)	(0.359)
BASIS_HEDG			0.0521	-0.8459*			-0.5224	-1.6466***
			(0.320)	(0.455)			(0.386)	(0.461)
(GAS/OIL)_REV	1.3379	1.8800	1.3320	2.1100*	0.3201	-1.1906	0.3663	-0.7394
	(0.980)	(1.162)	(0.976)	(1.177)	(1.156)	(1.238)	(1.152)	(1.243)
IMR	-0.1343	0.3301	0.1117	1.0068	-0.6089	-0.6089	-0.1254	-0.1157
	(0.540)	(0.641)	(0.587)	(0.655)	(0.648)	(0.648)	(0.708)	(0.789)
LAG	4.8612***	7.7323***	4.7203***	7.5889***	4.7574***	6.0465***	4.7322***	5.9883***
	(0.211)	(0.753)	(0.208)	(0.759)	(0.256)	(0.473)	(0.260)	(0.479)
LAG_0	0.3053	2.0497**	0.6227	1.6652*	0.3764	3.2136**	0.5687	4.0424***
	(0.479)	(0.879)	(0.552)	(0.928)	(1.193)	(1.414)	(1.171)	(1.510)
uj	-4.9440***	-3.3724	-3.1510	-6.5407**	-8.9105***	-8.9957***	-7.0245**	-12.0699***
	(1.773)	(2.844)	(1.978)	(3.333)	(2.543)	(3.237)	(2.841)	(3.461)
Observations	2,865		2,892		2,396		2,420	
Log-likelihood (LL)	-1076.5184		-1081.8621		-910.0535		-907.2457	
LL constant-only	-1102.9459		-1116.2981		-947.4364		-944.7210	
Wald stat	52.8549		68.8719		74.7659		74.9507	
Significance	0.0000		0.0000		0.0000		0.0000	

Note:

This table reports the means of the coefficient estimates of the dynamic random effects MMNL to select one of the following two hedging strategies—(1) *linear and non-linear strategies*, and (2) *only non-linear strategies*—for the gas hedgers and oil hedgers separately. The base case is using only linear strategies. *DIFF_GAS (OIL)* is the absolute value of differentials in firm's revenues and investment costs sensitivities to gas (oil) price fluctuations*; HERF_GAS (OIL)* for the geographical dispersion of gas (oil) production; *PQ_COR_GAS (OIL)* for the gas (oil) quantity–price correlation calculated using rolling windows of eight quarterly observations; *OVER_INV* for overinvestment; *OPT_CEO* for the number of stock options held by the CEO; *MV_CS_CEO* for the market value of common shares held by the CEO; *%_CS_INST* for the percentage of common shares held by institutional investors; *TAX_SAVE* for the expected percentage of tax savings; *TLCF* stands for TLCFs scaled by the book value of total assets; *LEV* for the leverage ratio; *CONSTRAINT* for financial constraints; *DTD* for the DTD; *INV_OPP* for investment opportunities; *UND_GAS (OIL)* for undeveloped proved gas (oil) reserves; *FUTURE_GAS (OIL)*, *SPOT_GAS (OIL)*, and *VOL_GAS (OIL)* for gas (oil) future and spot prices and volatility, respectively; *UNCER_GAS (OIL)* for gas (oil) production uncertainty measured by the coefficient of variation of daily produced quantities using rolling windows of eight quarterly observations; *COST_CV* for the coefficient of variation of the cash cost per BOE using rolling windows of eight quarterly observations; *GAS(OIL)_HEDG*, *IR_HEDG*, *FX_HEDG*, and *BASIS_HEDG* are dummy variables for gas (oil), IR, FX, and basis risk hedging, respectively; *GAS(OIL)_REV* for revenues from gas (oil) production; *IMR* for the inverse Mills ratio from the first-step Heckman regression (Table A.1.3); *LAG* for the lagged dependent variable; and *LAG_0* for the first observation. The coefficients of the exogenous variables' means are not reported here for conciseness and are available upon request. Standard errors are in parentheses. The superscripts ***, **, and * indicate significance at the 1%, 5%, and 10% levels, respectively.

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CHAPITRE II

ARTICLE 2

THE MATURITY STRUCTURE OF CORPORATE HEDGING:
THE CASE OF THE U.S. OIL AND GAS INDUSTRY

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ABSTRACT

This paper investigates how firms design the maturity of their hedging programs, and the real effects of maturity choice on firm value and risk. Using a new dataset on hedging activities of 150 U.S. oil and gas producers, we find strong evidence that hedging maturity is influenced by investment programs, market conditions, production specificities, and hedging contract features. We also give empirical evidence of a non-monotonic relationship between hedging maturity and measures of financial distress. We further investigate the motivations of early termination of contracts. Finally, we show that longer hedging maturities could attenuate the impacts of commodity price risk on firm value and risk.

Keywords: Risk management, maturity choice, early termination, economic effects, oil and gas industry.

JEL classification: D8, G32.

2.1 Introduction

We explore a new channel in corporate risk management literature through which firms could create value and reduce risk by considering the following questions: How far ahead do firms hedge? What are the determinants of the maturity structure of firms' hedging programs? What are the economic effects of hedging maturities on firm value and risk? These questions are still largely unexplored because of the lack of empirical analysis due to limitations of the data. Using an extensive and new hand-collected dataset on the risk management activities of 150 U.S. oil and gas producers with quarterly observations over the period 1998-2010, we fill this gap in the literature and answer the above questions. It is important to understand why firms within the same industry and with the same risk exposure differ in terms of their hedging maturity structure.

We contribute to the literature on corporate hedging in several ways. Our first contribution is to provide empirical evidence of the rationales and determinants of the maturity structure of hedging contracts at inception; we also study the rationales for early termination of hedging contracts, and the real implications of maturity choice on firm value and risk. We hence add new significant results to the empirical literature; the scant empirical studies discuss the maturity structure of hedging in a largely descriptive manner.[19] In

[19] Dolde (1993) surveys the hedging practices of 244 Fortune 500 companies and finds that the common practice is to hedge cash flow exposures within a horizon of two to four quarters. In line with Dolde (1993), Tufano (1996) provides statistics about the percentage of the production hedged for North American gold mining firms for 1991-1993, and finds that they hedge 61.2% of their gold production for the current year (1991) and 10% and 11% for the subsequent two years. In a Wharton survey of financial risk management practices and derivatives of 399 U.S. non-financial firms, Bodnar et al., (1998) report that 82% of the questioned firms use foreign currency derivatives with an initial maturity of 91 days or less, and only 12% use foreign currency derivatives with maturities exceeding 3 years. They also find that hedging ratios at longer maturities decreased dramatically during 1998. Adam and Fernando (2006 and 2008) study the cash flow gains from selective hedging for a sample of 92 North American gold producers from 1989 to 1999 and report descriptive statistics of hedging ratios up to five years. They find that gold producers use hedging programs with one-year maturities in 90% of firm-quarters with non-zero hedging with a mean hedging ratio of 54% of expected gold production, hedging programs with three-year maturities in 51% of hedging quarters with an average hedging ratio of 25%, and programs with five-year maturities in 18% with an average hedging ratio of 28%. They also point out that near-term hedging ratios are more volatile than those with longer horizons. Carter, Rogers, and Simkins (2006) investigate the jet fuel hedging activities of U.S. airline firms during 1992-2003 and find that hedging maturities vary significantly between firms (e.g., from one year to six years ahead) and that hedging ratios of the next year's fuel consumption are very disparate (e.g., from 1% to 43%).

addition, our data collected from publicly disclosed information avoid the non-response bias associated with questionnaires and provide detailed information about real hedging activities. Finally, we study hedging activities of both commodities (oil and gas) separately, which gives deeper insight into oil and gas producers' hedging dynamics.

Consistent with our predictions, results of our base model (i.e., Dynamic System-GMM Panel Model) show that oil and gas producers, having substantial growth options, use hedging contracts with longer maturities to avoid shortfalls in their future cash flows. We also find that oil and gas producers with a higher positive correlation between their investment expenditures and internal cash flows tend to use short-term hedging contracts because they benefit from a natural hedge. In line with Fehle and Tsyplakov's (2005) prediction, we give strong evidence of the non-monotonic (concave) relationship between measures of the likelihood of financial distress (i.e., leverage) and hedging maturity. This non-monotonic relationship means that hedging maturities increase and then decrease with the likelihood of financial distress.

Results also indicate that distressed oil and gas producers (i.e., with insufficient liquidity) enter long-term put options as a risk-shifting (asset substitution) strategy. Costly put options with long maturities increase rather than eliminate the firm's payoff volatility and decrease assets available for debtholders. Results further show that oil and gas producers with higher cash flow volatility, due to higher production uncertainty and/or higher price-quantity correlation, tend to use farther hedging positions to avoid shortfalls in their future revenues. We also observe strong evidence of the impact of market conditions on hedging maturity choice. Oil and gas price volatilities are significantly positively related to longer maturities hedging, as predicted by Fehle and Tsyplakov (2005). Accordingly, higher price volatility makes firms reluctant to incur costly early termination of their hedging contracts unless spot prices increase significantly. We further verify that when future prices are expected to be higher, firms tend to use short-term hedging. Consistent with Fehle and Tsyplakov (2005), we find empirical evidence of a non-monotonic (concave) relationship between oil and gas spot prices and hedging maturities.

Results show that the hedging contract features (i.e., moneyness, strike price) have an evident impact on maturity choice. As predicted, oil and gas producers keep in-the-money hedging contracts until they mature and terminate out-of-the-money contracts early. Results further imply that a hedging contract initiated at a sufficiently higher strike price is more likely to be kept for longer periods. Consistent with our prediction, tax function convexity motivates the use of long-term contracts and tax loss carry-forwards seem to be a disincentive to hedge longer exposures because they could be used as a caution to reduce firms' future tax liabilities. With respect to asset-liability management, we find that oil and gas producers seek to match the maturities of their hedging and of their oil and gas developed reserves (i.e., assets) and debt.

Results are largely robust to other data collection criteria. Specifically, we use maturity choice at inception of the hedging contracts and find results largely similar to those of our base specification (i.e., Dynamic System-GMM Panel Model). Our results are validated again when we study the determinants of the early termination of hedging contracts. Finally, we give novel evidence of the impact of hedging maturity on firm value and risk, and find that long-term hedging lowers the sensitivity of the stock return to changes in gas prices, in particular. However, we find no significant impact on sensitivity to oil and gas price volatility.

The rest of the paper is organized as follows. In Section 2, we state our hypotheses. In Section 3, we describe our data, and dependent and independent variables. Section 4 presents the retained econometric methodology. Section 5 reports univariate results and Section 6 investigates the empirical evidence of the maturity structure of corporate risk management. In Section 7, we test the robustness of our results by exploring the determinants of maturity choice at the inception of hedging contracts and the determinants of early termination of outstanding hedging contracts. We then investigate the real implications of hedging maturity choice empirically in Section 8, and Section 9 concludes the paper.

2.2 Hypotheses

The lack of testable theoretical predictions on hedging maturity structure was compensated by Fehle and Tsyplakov (2005). They present an infinite-horizon continuous time model of a firm that can adjust the hedge ratio and maturity of its hedging instruments dynamically in response to fluctuations in firm output price. Their model is calibrated to replicate empirical observations for a gold mining firm and produces a number of new theoretical predictions pertaining to the optimal timing, adjustment, and rollover of hedging contracts and their maturities, which we will describe in depth to develop our hypotheses in this section and test empirically after.

2.2.1 Financial distress

A large body of the empirical literature has analyzed the positive relationship between financial constraints and firms' hedging activities (e.g., Nance et al., 1993; Géczy et al., 1997; Tufano, 1996; Gay and Nam, 1998; Adam, 2002, 2009). In line with this extant literature, Fehle and Tsyplakov (2005) analyzed the implications of financial distress on risk management adjustments. Based on simulations of output (gold) spot prices, they find a non-monotonic relationship between hedging maturity and measures of the probability of financial distress. This non-monotonicity means that hedging maturity first increases and then decreases with the probability of financial distress. To put it another way, firms near distress are often observed with short-run hedging contracts, and may terminate longer contracts at a high cost as a result of risk-shifting behavior. Firms far from distress opt for short-term contracts because of the low marginal benefits of hedging for wealthy firms (e.g., Stulz, 1996).

Fehle and Tsyplakov (2005) also find that financial distress costs are negatively related to hedging maturity. Their simulations show that firms with high distress costs tend to use shorter maturity hedging. Thus, distress costs increase when the firm's cash inflows (i.e., its selling prices) are insufficient to cover production costs and debt payments. Hence we posit:

HYPOTHESIS 1: *Hedging maturity is negatively related to (i) either high or low likelihood of financial distress, and (ii) higher distress costs.*

To verify the empirical relevance of this prediction we use the following two measures of the distress likelihood: (1) the leverage ratio as measured by the book value of long-term debt in current liabilities plus half of long-term debt scaled by book value of total assets as used by Moody's-KMV, and (2) distance-to-default, which is a market-based measure originating from Merton's (1974) approach. This measure gives the number of standard deviations that the firm is away from default (Crosbie and Bohn, 2003). We also use leverage squared and distance-to-default squared to capture non-linearity between financial soundness and hedging maturity. We predict a positive sign for the leverage ratio and distance-to-default and a negative sign for their squared values.

Following Fehle and Tsyplakov's (2005) methodology, we measure firm's incurred distress costs by the following product $I[\,Liquidity - M]\,max[0, -p + c + d]$ where I is an indicator function and Liquidity is the quick ratio (i.e., cash and cash equivalents scaled by the book value of current liabilities). We use the quick ratio because a firm could use this liquidity as a caution to repay future debt requirements (see Dionne and Triki, 2013). M is the median quick ratio of the oil and gas industry. $I[Liquidity - M] = 1\; if\; Liquidity < M$ and 0 otherwise. $max[0, -p + c + d]$ means that a firm incurs distress costs that are proportional to the shortfall of its realized selling prices p compared with its production costs c and debt payments d. These realized prices[20] include the monetary effects of hedging activities, if any. The letter c is for cash cost.[21] Debt payments are measured by the quarterly interest expenses and the outstanding proportion of long-term debt to current liabilities at the end of the quarter, and are represented by d. The variables p, c and d are expressed per Barrel of Oil Equivalent (BOE). Therefore, a firm incurs distress costs when its liquidity is below the industry's median and its actual cash inflows (i.e., realized selling prices net of

[20] Firms disclose their realized selling prices for oil and gas, respectively, on an annual basis. For each firm, we repeat the annual observation for each quarter of the same fiscal year. These realized prices include the monetary effects of the firm's hedging activities if any.
[21] Cash costs are disclosed annually. For each firm, we repeat the same observation for each quarter of the same fiscal year.

production costs) are insufficient to meet debt requirements. These distress costs may entail higher future external financing costs.

2.2.2 Market conditions

The corporate hedging literature shows that market conditions, namely spot prices and their volatilities, play a crucial role in why firms hedge, how much they hedge, and how they hedge (see for instance Bodnar et al., 1998; Stulz, 1996; Brown and Toft, 2002; Adam, 2009). Fehle and Tsyplakov (2005) investigate the evolution of risk management contracts and the spot price history by simulating the stochastic process of the gold spot price. Basically, they find strong evidence of a non-monotonic relationship between spot price and hedging contract maturity. This means that when spot prices are very high or low, firms choose short maturity hedging. As for Hypothesis 1, when spot prices are very high (low), the likelihood of distress is very low (high). For the range of spot prices between these two extremes, firms tend to adjust their risk management instruments more frequently and then tend to enter into newly initiated contracts with longer maturities.

Moreover, Fehle and Tsyplakov (2005) find that firms with higher price volatility tend to choose longer hedging contracts. In a higher price uncertainty environment, firms tend to refrain from costly early termination of their outstanding contracts unless spot prices increase significantly. These firms often conclude long-run contracts. In addition, we expect that when future prices are anticipated to be higher, firms tend to terminate their outstanding contracts and initiate new risk management contracts with higher exercise prices. Moreover, the newly initiated contracts will be for short-term maturities to prevent them from being worthless in the future. We therefore posit:

HYPOTHESIS 2: *Hedging maturity is negatively related to (i) either very high or very low spot prices, and (ii) higher anticipated prices. Conversely, firms prefer longer maturity contracts when price volatility is higher.*

We extract the oil and gas spot prices observed at the end of each quarter from the Bloomberg Financial Markets database.[22] We calculate the volatility of oil and gas for each quarter as the standard deviation of daily spot prices within the quarter. As a proxy for the future tendency of oil and gas prices, we calculate an expected return by $E[R_t] = log[F_t/S_t]$ where F_t and S_t are respectively the prices of 12-month Futures[23] contracts and the spot prices observed at the end of quarter t. We expect a positive sign for spot prices and volatilities, and a negative sign for spot prices squared and expected returns $E[R_t]$.

2.2.3 Hedging contract features

Fehle and Tsyplakov (2005) find that features of existing hedging contracts, namely moneyness, remaining maturity and strike price, play an important role in optimal rollover and adjustment decisions. Regarding these features, they derive the following prediction that we will investigate empirically.

HYPOTHESIS 3: *Hedging contracts initiated at higher strike prices are more likely to be kept until maturity because they are more likely to be in the money for a longer period.*

As proxy for the strike price at initiation of the hedging contracts, we calculate the mean of the spot price during the quarter of the initiation. This proxy will give the information on the level of the strike price of the initiated contract. The moneyness is calculated by the strike price as previously mentioned minus the mean spot price in the current quarter. We predict a positive sign for both strike price and moneyness.

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[22] We use the West Texas Intermediate crude oil (WTI) index as proxy for the oil spot prices. For natural gas spot prices, we use an average index established by Bloomberg Financial Markets database from different location indices (Gulf Coast, Henry Hub, Rocky Mountains, etc.).

[23] For future oil and gas prices, we use (i) Bloomberg NYMEX Crude Oil 12-Month Strip futures price, and (ii) Bloomberg NYMEX Henry Hub Natural Gas 12-Month Strip futures price. These two indices are established by the Bloomberg Financial Markets database as the arithmetic averages of oil (gas) futures contract prices over the next 12 months.

2.2.4 Underinvestment costs

Froot, Scharfstein, and Stein (1993) argue that firms with future investment expenditures and higher marginal costs of external financing should hedge to reduce the investment financing costs. Subsequent corporate risk management literature shows that hedging is more valuable for firms with substantial investment opportunities and costly external financing. The main argument is that hedging allows firms to reduce their cash flow volatility and hence avoid cutting planned profitable projects. In the same context, Froot, Scharfstein, and Stein (1993) assert that a firm tends to hedge less the more closely correlated its internal cash flows are with its future investment opportunities. We thus explore the impact of the underinvestment argument on hedging contract maturity and we predict:

HYPOTHESIS 4: *Hedging maturity is positively related to firm's growth options and negatively related to a positive correlation between internal cash flows and investment expenditures.*

Investment opportunities are measured by the ratio of the cost incurred over the net property, plant and equipment (net PP&E) at the beginning of the quarter.[24] In the oil and gas industry, the cost incurred includes the total costs of oil and gas property acquisition, exploration and development. We also calculate the correlation coefficient between generated cash flows and costs incurred.[25] It is worth noting that these calculated cash flows are not polluted or contaminated by the monetary effects of hedging because these effects are reported in comprehensive income as suggested by the new derivative accounting standard FASB 133, effective since 1998. The correlation coefficients are calculated, for each firm, in a rolling window by taking all the observations available until the current quarter.

[24] The cost incurred is given on an annual basis. We suppose that these costs are linearly dispersed over the year and divide the annual amount by four to get a quarterly cost incurred for the fiscal year.

[25] Internally generated cash flows are measured by the Free Cash Flow before capital expenditures, as in Lehn and Poulsen (1989). They calculate Free Cash Flow before investment as operating income before depreciation less total income taxes plus changes in the deferred taxes from the previous quarter to the current quarter less gross interest expenses on short- and long-term debt less the total amount of preferred dividends less the total dollar amount of dividends declared on common stock.

2.2.5 Production characteristics

Several studies,[26] mostly theoretical, have investigated the role of characteristics of production activity on firm's hedging behavior. These studies demonstrate the importance of production uncertainty (i.e., quantity risk) and the correlation between produced quantities and spot prices on firm's hedging programs (i.e., hedging extent and strategy choice). We explore the effects of these characteristics on hedging maturity choice. By deriving the optimal hedge analytically, Brown and Toft (2002) show that firms tend to hedge less for longer exposures because of the difficulty in forecasting their future produced quantities accurately.

These theoretical models also highlight the important impact of the correlation between produced quantities and spot prices on hedging decisions. Brown and Toft (2002) and Gay, Nam, and Turac (2002, 2003) find that firms with a negative price-quantity correlation benefit from a natural hedge with declining quantities and increasing prices, and vice versa. On the contrary, a positive price-quantity correlation leads to higher variations in firm's cash flows because both prices and quantities are moving in the same direction. Hence we propose:

HYPOTHESIS 5: *Hedging maturity is negatively related to production uncertainty and positively related to price-quantity correlation.*

For each firm, we measure production uncertainty by the coefficient of variation of daily production[27] for oil and gas respectively by taking all the observations available until the current quarter. We calculate the correlation coefficient between daily oil (gas) production and oil (gas) spot prices by taking all the firm's observations available until the current quarter.

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[26] These studies include Moschini and Lapan (1995), Brown and Toft (2002), Gay, Nam, and Turac (2002, 2003) and Adam (2009).

[27] Daily production for oil and gas, respectively, are disclosed by firms annually. We repeat the annual observation for each quarter of the same fiscal year.

2.2.6 Other control variables

We include the following control variables largely retained in the corporate risk management literature.

2.2.6.1 Managerial risk aversion

As proxy for managerial risk aversion, we include the number of options and the market value[28] of the firm's stocks held by the CEO. According to Smith and Stulz (1985), managers should undertake hedging activities more actively if their utility is a concave function of firm value, and they should be reluctant to engage risk management activities if their utility is a convex function of the firm's value. Therefore, we predict that a CEO owning a significant fraction of the firm's common shares tends to use hedging contracts with longer maturities because he would like to insulate the firm value from the underlying risks. Conversely, we expect a CEO with significant option holdings to tolerate more volatility in firm value, and consequently prefer short-term hedging contracts.

2.2.6.2 Tax incentives

The tax argument for corporate hedging is accounted for using a simulation procedure proposed by Graham and Smith (1999) to measure the expected percentage of tax savings arising from a 5% reduction in the volatility of pre-tax income. The tax argument means that hedging increases the firm's after-tax value when its local tax function is convex. A firm will thus hedge more extensively when its taxable income is in the progressive region of the tax structure. We expect firms with higher tax function convexity to use hedging contracts with longer maturities that would increase the tax benefits of hedging. We also use the book value of tax loss carry-forwards scaled by the book value of total assets. Graham and Rogers (2002) argue that tax loss carry-forwards are uncorrelated with tax function convexity, and that this

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[28] We use the number of options held by the firm's CEO at the end of each quarter and we measure the CEO's firm-specific wealth by the logarithm of one plus the market value of common shares held by the CEO at the end of each quarter. We use the logarithm specification of the market value of common shares held by CEOs to reflect the fact that the CEOs' risk aversion should decrease as their firm-specific wealth increases (Tufano, 1996).

variable might measure other corporate characteristics. Thus, we expect that it represents a disincentive to hedge because firms could use this tax shield to minimize their future tax liabilities. Therefore, we predict that firms with higher tax loss carry-forwards tend to use short-term hedging contracts.

2.2.6.3 Asset-Liability Management

Asset-Liability Management is also accounted for in our analysis. Maturity matching is a common best practice in corporate finance. We use the following two measures: (1) a weighted average maturity of debt. This average maturity is calculated as the book value-weighted average maturities of debt that mature within one, two, three, four and five years[29]; and (2) an expected life duration (in years) of developed reserves for oil and gas separately. This expected life duration is calculated by dividing the current quantity of oil (gas) developed reserves by the current annual oil (gas) production. These two variables allow us to capture any maturity matching between both the hedging strategy and the firm's assets (proven reserves, which are the most important components of an oil and gas producer's assets) and hedging strategy and the firm's future debt commitments.

2.3 Sample construction and characteristics

2.3.1 Sample construction

This study is implemented on a sample of 150 US oil and gas producers over the period of 1998 to 2010. The oil and gas industry is an excellent laboratory to test corporate risk management motivations and implications for several reasons. First, firms in this industry share homogenous risk exposures (i.e. fluctuations in crude oil and natural gas prices). Hence, diversity in hedging strategies implemented does not come from differences in risk exposure, but is more likely to result from differences in firm characteristics. Second, the existence of financial derivatives on crude oil and natural gas offer these firms several price

[29] These items are disclosed by COMPUSTAT on an annual basis. We repeat the annual observation for each quarter of the same fiscal year.

hedging methods. Third, improvements in accounting disclosure related to oil and gas producing activities have made operational data available. These data pertain to exploration, production and reserve quantities, cash costs, etc.

A preliminary list of 413 US oil and gas producers with the primary Standard Industrial Classification (SIC) code 1311[30] (Crude Petroleum and Natural Gas) was extracted from Bloomberg. Only firms that met the following criteria were retained: have at least five years of historical data of oil and gas reserves during the period 1998-2010; the 10-K and 10-Q reports are available from the EDGAR website, and the firm is covered by COMPUSTAT. The filtering process produced a final sample of 150 firms with an unbalanced panel of 6,326 firm-quarter observations. To our knowledge, this sample is the most recent and the largest in the empirical literature on risk management in the oil and gas industry.

Data on these firms' financial and operational characteristics were gathered from several sources. Data regarding financial characteristics were taken from the COMPUSTAT quarterly dataset held by Wharton Research Data Services (WRDS). Other items related to institutional and managerial share-holding and option-holding were taken from the Thomson Reuters dataset maintained by WRDS. Data related to oil and gas producers' reserves, production quantities, cash costs, exploration, development and property acquisitions were taken from Bloomberg's annual data set and verified and supplemented by hand-collecting data directly from 10-K annual reports. Quarterly data about oil and gas producers' hedging activities were hand-collected from 10-K and 10-Q reports.

Table 2.1 summarizes the definitions, construction and data sources of the variables.

[30] SIC code 1311 ''Crude Petroleum and Natural Gas,'' which comprises companies primarily involved in the operation of properties for the recovery of hydrocarbon liquids and natural gas.

Table 2.1 Variable definition, construction and data sources

Variable definition	Variable name	Construction	Data source
Variables that proxy for tax advantage of hedging			
Tax loss carry-forwards	*TLCF*	Book value of the TLCF scaled by the book value of total assets	Compustat
Tax save	*TAX_SAVE*	Tax liability saving arising from a 5% reduction in taxable income (Graham and Smith, 1999).	Compustat
Variables that proxy for financial distress costs			
Leverage	*LEV*	Book value of long-term debt in current liabilities + one-half of long-term debt scaled by the book value of total assets.	Compustat
Distance-to-default	*DTD*	Market-based measure of default risk based on Merton's (1974) approach and used by Moody's KMV. The DTD is equal to $\frac{V_a - D}{V_a \sigma_a}$, where D is defined as long-term debt in current liabilities plus one-half of long-term debt, V_a is the market value of assets, and σ_a is one-year asset volatility. The quantities V_a and σ_a are unobservable and are approximated from Merton's (1974) model by using the market value and volatility of equity, the three-month Treasury bill rate, and debt (D). See Crosbie and Bohn (2003) for more details on the construction of the DTD.	Manually constructed
Financial distress costs	*DIST_COSTS*	Measured by $I[\,Liquidity - M]\; max[0, -p + c + d]$ where Liquidity is the quick ratio, M is the median quick ratio of the oil and gas industry, p are the realized selling prices, c are production costs, and d debt payments. p, c and d are expressed per Barrel of Oil Equivalent. $I[Liquidity - M] = 1\ if\ Liquidity < M$ and 0 otherwise.	Manually constructed
Cash cost	*CASH_COST*	Production cost of a BOE	Bloomberg and 10-K reports
Variables that proxy for underinvestment costs			
Investment opportunities (IOs)	*INV_OPP*	Total costs incurred in oil and gas property acquisition, exploration, and development, scaled by net property, plant, and equipment at the beginning of the quarter.	Manually constructed
Correlation between investment expenditures and free cash flows.	*COR_CI_CF*	Correlation coefficient between free cash flow and costs incurred. This coefficient is calculated for each firm by using all the observations until the current quarter.	Manually constructed
Variables that proxy for production characteristics			
Oil production uncertainty	*PROD_CV_OIL*	Coefficient of variation of daily oil production. This coefficient is calculated for each firm by using all the observations of daily oil production until the current quarter.	Manually constructed
Gas production uncertainty	*PROD_CV_GAS*	Coefficient of variation of daily gas production. This coefficient is calculated for each firm by using all the observations of daily gas production until the current quarter.	Manually constructed
Price–quantity correlation (oil)	*COR_PQ_OIL*	Correlation coefficient between daily oil production and oil spot prices.	Manually constructed
Price–quantity correlation (gas)	*COR_PQ_GAS*	Correlation coefficient between daily gas production and gas spot prices.	Manually constructed

Continued

Table 2.1-*Continued*

Variable definition	Variable name	Construction	Data source
Variables that proxy for firm size			
Sales	*SALES*	Total revenues from oil and gas sales (in millions of dollars)	Compustat
Market value	*MKT_VALUE*	Number of common shares outstanding * end-of-quarter per share price (in millions of dollars).	Compustat
Oil reserves	*RES_OIL*	Quantity of the total proven developed and undeveloped oil reserves (in millions of barrels).	Bloomberg and 10-K reports
Gas reserves	*RES_GAS*	Quantity of the total proven developed and undeveloped gas reserves (in billions of cubic feet).	Bloomberg and 10-K reports
Variables that proxy for managerial risk aversion			
Market value of CEO shareholding	*CEO_CS*	Measured by the logarithm of 1 plus the market value of common shares held by the CEO at the end of each quarter.	Thomson Reuters
# CEOs stock options	*CEO_OPT*	Number of CEO stock options (in thousands).	Thomson Reuters
Variables that proxy for market conditions			
Oil expected return	*OIL_RET*	Measured by $E[R_t] = \log[F_t/S_t]$ where F_t and S_t are respectively the oil prices of 12-month Futures contracts and the oil spot prices observed at the end of quarter t.	Manually constructed
Oil spot price	*OIL_SPOT*	Oil spot price represented by the WTI in the NYMEX.	Bloomberg
Gas expected return	*GAS_RET*	Measured by $E[R_t] = \log[F_t/S_t]$ where F_t and S_t are respectively the gas prices of 12-month Futures contracts and the gas spot prices observed at the end of quarter t.	Manually constructed
Gas spot price	*GAS_SPOT*	Constructed as an average index established from principal locations' indices in the United States (Gulf Coast, Henry Hub, etc.)	Bloomberg
Oil price volatility	*OIL_VOL*	Historical volatility (standard deviation) using the spot price of the previous 60 days.	Manually constructed
Gas price volatility	*GAS_VOL*	Historical volatility (standard deviation) using the spot price of the previous 60 days.	Manually constructed
Variables that proxy for the asset-liability management			
Weighted-average maturity of debt (in years)	*DEBT_MAT*	Calculated as the book value-weighted average maturities of debt that mature within one, two, three, four and five years.	Manually constructed
Expected life duration of oil and gas reserves (in years)	*RES_MAT_(OIL/GAS)*	Calculated by dividing the current quantity of oil (gas) developed reserves by the current annual oil (gas) production.	Manually constructed
Variables that proxy for hedging contract features			
Contract strike price	*STRIKE*	Measured by the average spot price during the quarter of the initiation of the hedging contract	Manually constructed
Contract moneyness	*MONEYNESS*	Calculated as the contract strike price minus the average spot price during the current quarter	Manually constructed
Variables that proxy for hedging substitutes			
Quick ratio	*Q_RATIO*	Cash and cash equivalents scaled by current liabilities.	Compustat
Book value of convertible debt	*BVCD*	Book value of convertible debt scaled by the book value of total assets.	Compustat

2.3.2 Sample characteristics

2.3.2.1 Descriptive statistics: Dependent variable

Our dependent variable is hedging maturity measured by the average remaining maturity weighted by the hedged notional quantity as follows:

$$HM_{i,j,t} = \sum_{T=k}^{k+5} \frac{N_{T,j} \times T}{\sum_{T=k}^{k+5} N_{T,j}}, \quad (1)$$

where $HM_{i,j,t}$ is the weighted-average remaining maturity for firm i at quarter t and hedging instrument j. The hedging instrument could be swap contracts, put options, costless collars, forward or future contracts and 3-way collars. $N_{T,j}$ is the hedged notional quantity[31] for instrument j and horizon T. T departs from the current fiscal year to five years ahead. We retain a maximum of five years because we rarely find firms with hedging positions exceeding this horizon. k takes the value of 1 at the beginning of the current fiscal year or a fraction of the year otherwise (e.g., 0.75 for nine months).

Table 2.2 contains descriptive statistics of the weighted-average hedging maturity by hedging instruments for oil and gas hedgers separately. Overall, Table 2.2 shows that gas hedgers and oil hedgers adopt quite similar hedging horizons for each hedging instrument. For example, the average remaining maturity for swap contracts is 1.286 (1.227) years for gas (oil) hedgers. For put options, the remaining maturity is, on average, 1.023 (1.083) years for gas (oil) hedgers. Moreover, statistics show little variation of average remaining maturities across instruments. Swaps contracts and 3-way collars seem to have the longest average remaining maturity with respectively 1.286 and 1.187 years for gas hedgers, and 1.227 and 1.448 years for oil hedgers. Forward and future contracts appear to have the nearest average

[31] We follow Haushalter (2000) and use notional quantities for put options because we lack detailed information to calculate a delta-percentage for these options. At least, we have three attributes of our sample that could mitigate this shortcoming in our study: (i) put options are used on average in 11% (12%) of firm-quarters with gas (oil) hedging, (ii) put options are used with either swap/or collars most, and (iii) the fraction of the quantity hedged by put options does not exceed 40% (50%) for gas (oil).

remaining maturities with 0.856 (0.818) years for gas (oil) hedgers. We also calculate the average remaining maturity for oil (gas) hedging portfolios that include two or more instruments simultaneously. Hedging portfolios have an average remaining maturity of 1.222 (1.204) years for gas (oil) hedgers. Hedging horizons therefore seem to not differ significantly across oil and gas and across hedging instruments. Statistics related to hedging maturities reported in Table 2.2 are in line with previous empirical findings that firms tend to hedge near-term positions.

Table 2.2 Weighted-average maturity by hedging instrument (in years)

Hedging Instrument	Obs	% of use	Mean	Median	1st quartile	3rd quartile	Min	Max	Std Dev
				Panel A: Gas hedgers					
Swap contracts	2255	45.58%	1.286	1.161	0.894	1.582	0.250	5	0.651
Costless Collars	1840	37.19%	1.156	1.032	0.822	1.404	0.250	4.190	0.539
Put options	522	10.55%	1.023	1	0.750	1.273	0.250	3.220	0.538
Forwards or Futures	161	3.25%	0.856	0.914	0.616	1.002	0.250	1.942	0.330
3-way Collars	169	3.42%	1.187	1.096	0.881	1.427	0.250	3.101	0.511
Gas hedging portfolio maturity	**3137**		**1.222**	**1.111**	**0.906**	**1.478**	**0.250**	**5**	**0.559**
				Panel B: Oil hedgers					
Swap contracts	1711	45.25%	1.227	1.061	0.750	1.530	0.250	3.758	0.644
Costless Collars	1403	37.11%	1.221	1.050	0.799	1.500	0.250	4.439	0.621
Put options	448	11.85%	1.083	1	0.750	1.416	0.250	2.970	0.548
Forwards or Futures	105	2.78%	0.818	0.750	0.500	1	0.250	1.750	0.332
3-way Collars	114	3.02%	1.448	1.230	0.855	1.840	0.250	4.212	0.878
Oil hedging portfolio maturity	**2607**		**1.204**	**1.061**	**0.820**	**1.489**	**0.250**	**3.935**	**0.575**

Table 2.2 also shows that gas hedging occurred in 3137 firm-quarters (49.58% of the firm-quarters in the sample) and oil hedging occurred in 2607 firm-quarters (41.21% of the firm-quarters in the sample). Table 2.2 presents a breakdown of the frequency of use for each hedging instrument. The most common hedging vehicles used in the oil and gas industry are swap contracts, with 45.58% (45.25%) of use in gas (oil) hedging. The second most frequently used instrument is costless collars, with 37.19% (37.11%) for gas (oil) hedging. Next are put options, with 10.55% for gas hedging and 11.85% for oil hedging. The least used instruments are forward or futures contracts, with only 3.25% (2.78%) for gas (oil) hedging and 3-way collars, with only 3.42% (3.02%) for gas (oil).

2.3.2.2 Descriptive statistics: Independent variables

Descriptive statistics are computed on the pooled dataset. Table 2.3 gives the mean, median, 1st quartile, 3rd quartile and standard deviation for the 150 U.S. oil and gas producers in the sample. Statistics show that oil and gas producers expend, on average, the equivalent of 22.37% of the book value of their net property, plant and equipment in exploration and reserve acquisition and development. The correlation between internal cash flows and investment expenditures has a mean (median) of 0.307 (0.373), with one fourth of the sample having a correlation less than -0.015 and another fourth a correlation greater than 0.70. These two specificities of the firm's investment programs create opposite effects on the hedging needs of oil and gas producers because investment expenditures accentuate these needs and a higher positive correlation attenuates them. The two measures of financial constraints, namely distance-to-default and the leverage ratio, indicate that oil and gas producers have a relatively solid financial situation. Distance-to-default and leverage ratio have, respectively, a mean (median) of 2.234 (2.052) and 15.8% (14.2%), which reflects little variation in the financial solvency of the sample firms.[32] Surprisingly, statistics indicate that oil and gas producers in financial distress (i.e., with liquidity below the industry's median, and realized selling prices insufficient to cover production costs and debt requirements) incurred on average distress costs of 2.3$/BOE. However, 75% of the sample does not incur any distress costs, and only a few producers have insufficient operating income to meet their debt commitments.

[32] Drucker and Puri (2009) examine the secondary market for loan sales in the USA over the 1999-2004 period. Using a sample of 7261 loans, they find a mean (median) for Distance-to-Default of 2.304 (1.929). Campello et al. (2011) study the implications of hedging for corporate financing and investment. Using a dataset of 1185 firms over the period 1996-2002, they find a mean (median) for the Distance-to-Default of 2.464 (1.861).

Table 2.3 Summary statistics for sample firms financial and operational characteristics

Variable	Obs	Mean	Median	1st quartile	3rd quartile	Std. Dev
Variables that proxy for underinvestment costs						
INV_OPP	6,006	0.224	0.075	0.041	0.129	3.619
COR_CI_CF	6,196	0.307	0.373	-0.015	0.693	0.452
Variables that proxy for financial distress costs						
DTD	5,686	2.234	2.052	1.323	2.862	1.361
LEV	6,063	0.158	0.142	0.053	0.220	0.153
DIS_COSTS	6,298	2.347	0	0	0	16.957
Variables that proxy for production characteristics						
PROD_CV_OIL	6,058	0.416	0.313	0.141	0.587	0.388
COR_PQ_OIL	6,119	0.229	0.455	-0.287	0.723	0.587
PROD_CV_GAS	6,078	0.408	0.303	0.146	0.582	0.359
COR_PQ_GAS	6,112	0.154	0.230	-0.174	0.504	0.419
Variables that proxy for managerial risk aversion						
CEO_CS	6,326	28.983	1.125	0.000	11.563	152.159
CEO_OPT	6,326	174.386	0.000	0.000	120.000	681.760
Variables that proxy for tax advantage						
TLCF	6,066	0.134	0.000	0.000	0.064	0.438
TAX_SAVE	6,160	0.052	0.048	0.029	0.070	0.051
Variables that proxy for the asset-liability management						
DEBT_MAT	6,116	2	2	0	3.349	1.640
RES_MAT_OIL	6,157	9.055	7.542	5.050	10.639	10.846
RES_MAT_GAS	6,180	9.506	7.476	5.206	10.439	10.657

Note:

This table provides financial and operational statistics for the 150 US oil and gas producers for the period 1998-2010. *INV_OPP* for investment opportunities; *COR_CI_CF* for the correlation between free cash flows and cost incurred; *DTD* for distance-to-default; *LEV* for the leverage ratio measured by the sum of long-term debt in current liabilities plus one-half long-term debt scaled by book value of total assets; *DIS_COSTS* for distress costs (in $); *PROD_CV_OIL* and *PROD_CV_GAS* measure the production uncertainty for oil and gas respectively; *COR_PQ_OIL* and *COR_PQ_GAS* measure the quantity-price correlation for oil and gas respectively; *CEO_CS* for the market value of common shares held by firm's CEO (in MM$); *CEO_OPT* for the number of stock options held by firm's CEO (in 000); *TLCF* for tax loss carry-forwards scaled by the book value of total assets; *TAX_SAVE* for the expected percentage of tax saving; *DEBT_MAT* is the long-term debt maturity (in years); *RES_MAT_OIL* and *RES_MAT_GAS* are the expected life of proven oil and gas reserves (in years).

Statistics further show higher production uncertainty, as measured by the coefficient of variation in daily production, with a mean (median) of 0.41 (0.31) for oil and 0.41 (0.30) for gas production respectively. Interestingly, the price-quantity correlation is relatively positive with a mean (median) of 0.23 (0.45) for oil and 0.15 (0.23) for gas. The higher level of production uncertainty and the positive price-quantity correlation create additional variability in generated cash flow, and consequently greater hedging needs for oil and gas producers. The tax preference item, measured by the ratio of the book value of tax loss carry-forwards scaled by the book value of total assets, has a mean (median) of 13.42% (0.00%). The expected tax saving benefits of hedging have a mean (median) of 5.24% (4.80%), which are quite similar to the findings of previous studies. The manager's stock and option ownership varies considerably, with a mean (median) of 28.983 MM$ (1.125 MM$) for stockholding and 174,386 (0.000) for options. Debt maturity has a mean and median of 2 years. Oil and gas proven reserves have almost similar expected life durations, with a mean (median) of 9 (7) years.

2.4 Econometric methodology

The inspection of the time series characteristics of the remaining hedging maturity by instrument shows a higher first-order serial correlation ranging from 0.8 to 0.9. This motivates the modeling of the hedging behavior within a dynamic rather than a static framework. The general model of the data-generating process is as follows:

$$HM_{i,t,j} = \rho_j HM_{i,t-1,j} + \beta_j X_{i,t} + \varphi_j Y_{j,t} + \varepsilon_{i,t,j} + u_{i,j}; \quad |\rho_j| < 1; \ (i = 1, \dots, N: t = 1, \dots, T_i), \quad (2)$$

where $HM_{i,t,j}$ is the remaining maturity for hedging instrument *j* used by firm *i* at time *t*. Hedging instrument *j* might be swaps contracts, put options, costless collars, forward and future contracts, or 3-way collars. $HM_{i,t-1,j}$ is the observation on the same series for the same firm in the previous period. $X_{i,t}$ is a set of observed exogenous variables related to investment programs, financial distress, taxes, managerial risk aversion, production function characteristics, oil and gas market conditions and asset-liability management, which may be associated with hedging maturity choice for instrument *j* by firm *i* at time *t*. $X_{i,t}$ also includes the Inverse Mills Ratio coming from the first step of the Heckman regression with sample selection. $Y_{j,t}$ contains hedging contract *j* features at time *t*, namely, moneyness and strike price. $u_{i,j}$ is the unobserved firm-instrument specific effects and $\varepsilon_{i,j,t}$ is the disturbance term that is assumed to be independent across firms with

$$E(u_{i,j}) = E(\varepsilon_{i,j,t}) = E(u_{i,j}\ \varepsilon_{i,j,t}) = 0.$$

We follow Arellano and Bover (1995) and Blundell and Bond (1998) in estimating the model in equation (2) by a Dynamic System-GMM Panel Model (SYS-GMM hereafter). We choose this special econometric specification because other econometric frameworks (e.g., OLS, 2SLS and Within Group estimates) lead to asymptotically inefficient estimates as mentioned by Bond (2002), especially for small time-series panel data. Moreover, we prefer a SYS-GMM specification over the Difference-GMM, developed by Arellano and Bond (1991), because the latter model suffers from poor finite sample properties in terms of bias and precision, especially when the series are close to a random-walk, as was subsequently well documented by Blundell and Bond (1998).

A SYS-GMM[33] estimate for dynamic panel data combines moment conditions for the model in first difference with moment conditions for the model in level which improves the estimates even when the series are very persistent. We use two-step estimation, which leads to standard errors that are theoretically robust to heteroskedasticity and arbitrary patterns of autocorrelation within individuals, but they are downward biased, as suggested by Roodman (2009a). To control for this bias, we implement the Windmeijer (2005) correction for the potential downward bias in the standard errors produced by two-step estimation. In addition, two-step estimation allows a robust Hansen J-test, which is not available in one-step estimation. Following the good practice guideline suggested by Roodman (2009a, 2009b), we report statistics that allow us to test the validity of the econometric specification of the estimated SYS-GMM Model.

To control for the possibility of sample selection bias, the estimation of all our models was derived in the context of the Two-Step Heckman Regression with Selection. This procedure captures the sequential decisions of oil and gas producers: a first decision to hedge or not and a second decision about the nature of the hedging strategy. In the first step, we follow the literature and model the existence of hedging activity as a function of variables

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[33] We estimate the model in equation (2) with the user-written command *xtabond2* in Stata Software developed by Roodman (2009b).

that are conjectured to be determinants of the hedging decision: tax incentives, leverage ratio, liquidity, cash costs, convertible debt, firm market value, sales to capture the market risk exposure of firms, and oil and gas reserves quantities that should be qualified as hedging substitutes. Table A.2.1 reports the estimation results of the first step. We observe that almost all variables are statistically significant and with appropriate signs, as already obtained in the previous literature on the decision to hedge (Tufano, 1996; Graham and Rogers, 2002; Campello et al., 2011; Dionne and Triki, 2013).

2.5 Univariate results

Table 2.4 presents our univariate results, comparing oil and gas producers' characteristics and market conditions, based on the remaining maturities of hedging portfolios (i.e., a simultaneous combination of hedging instruments). We then classify the remaining weighted-average maturities as (1) short-term maturities (i.e., below one year ahead), (2) medium-term maturities (i.e., between one and two years ahead), and (3) long-term maturities, exceeding two years ahead. Tests of differences between means and medians of relevant variables contrast short- and medium-terms to long-term maturities and are conducted for gas and oil hedgers separately. Comparison of means is constructed using a *t*-test assuming unequal variances; comparison of medians is constructed using a non-parametric Wilcoxon rank-sum *Z*-test and two-sided *p*-values are computed.

Table 2.4 Characteristics of oil and gas producers and market conditions by hedging maturity

Characteristics of oil and gas producers and market conditions by hedging maturity														
		Short Maturity			Medium Maturity			Long Maturity		Short vs. Long		Medium vs. Long	
Variable	Obs	Mean	Median	Obs	Mean	Median	Obs	Mean	Median	*p*-Value (Mean)	*p*-Value (Median)	*p*-Value (Mean)	*p*-Value (Median)
						Panel A: Gas hedgers							
Financial distress													
LEV	1287	0.183	0.160	1555	0.198	0.176	267	0.231	0.183	0.000	0.000	0.006	0.024
DTD	1271	2.305	2.237	1516	2.402	2.312	250	2.615	2.379	0.002	0.019	0.036	0.173
DIS_COSTS	1299	1.612	0	1569	1.339	0	269	2.586	0	0.129	0.000	0.045	0.000
Underinvestment costs													
INV_OPP	1284	0.098	0.078	1533	0.111	0.078	268	0.134	0.068	0.016	0.101	0.131	0.071
COR_CI_CF	1299	0.418	0.502	1569	0.427	0.529	269	0.282	0.369	0.000	0.000	0.000	0.000
Production characteristics													
PROD_CV_GAS	1299	0.346	0.266	1569	0.474	0.369	269	0.528	0.439	0.000	0.000	0.083	0.497
COR_PQ_GAS	1299	0.207	0.306	1569	0.306	0.391	269	0.201	0.306	0.811	0.807	0.000	0.002
Managerial risk aversion													
CEO_CS	1299	33.373	3.682	1569	52.285	6.381	269	46.969	12.917	0.146	0.000	0.565	0.000
CEO_OPT	1299	203,532	20,000	1569	210,316	18,655	269	421,252	6,000	0.034	0.425	0.043	0.814
Tax incentives													
TAX_SAVE	1287	0.048	0.046	1563	0.050	0.047	269	0.049	0.046	0.686	0.172	0.492	0.634
TLCF	1287	0.069	0	1554	0.054	0	268	0.037	0	0.000	0.018	0.033	0.007
Asset-liability management													
RES_MAT_GAS	1299	7.407	6.642	1569	8.609	7.728	269	10.872	8.826	0.000	0.000	0.000	0.000
DEBT_MAT	1299	2.147	2.200	1569	2.709	3	269	2.666	3	0.000	0.000	0.664	0.495
Market conditions													
GAS_SPOT	1298	5.049	4.830	1566	5.598	5.530	269	5.357	5.050	0.084	0.070	0.171	0.075
GAS_VOL	1298	0.714	0.468	1566	0.816	0.622	269	0.788	0.549	0.036	0.002	0.437	0.534
GAS_RET	1298	0.121	0.100	1566	0.145	0.110	269	0.137	0.100	0.227	0.387	0.525	0.601
						Panel B: Oil hedgers							
Financial distress													
LEV	1172	0.198	0.173	1169	0.189	0.169	250	0.175	0.163	0.003	0.042	0.046	0.045
DTD	1151	2.341	2.240	1145	2.379	2.308	240	2.669	2.707	0.000	0.000	0.000	0.000
DIS_COSTS	1177	1.256	0	1173	1.661	0	250	0.899	0	0.451	0.913	0.139	0.585
Underinvestment costs													
INV_OPP	1161	0.093	0.068	1158	0.130	0.079	250	0.180	0.089	0.000	0.000	0.016	0.038
COR_CI_CF	1180	0.405	0.486	1177	0.457	0.559	250	0.359	0.378	0.110	0.073	0.000	0.000
Production characteristics													
PROD_CV_OIL	1176	0.374	0.282	1175	0.464	0.384	234	0.490	0.376	0.000	0.000	0.325	0.808
COR_PQ_OIL	1180	0.281	0.509	1175	0.446	0.639	234	0.456	0.574	0.000	0.000	0.748	0.916
Managerial risk aversion													
CEO_CS	1180	57.791	3.951	1177	52.202	7.002	250	76.033	15.016	0.150	0.000	0.037	0.000
CEO_OPT	1180	182,748	50,000	1177	194,666	7	250	448,562	3,212	0.024	0.055	0.035	0.445
Tax Incentives													
TAX_SAVE	1173	0.048	0.047	1174	0.052	0.048	250	0.047	0.046	0.478	0.429	0.011	0.071
TLCF	1172	0.091	0	1169	0.067	0	250	0.034	0	0.000	0.000	0.000	0.000
Asset-liability management													
RES_MAT_OIL	1180	7.883	6.971	1177	8.599	8.149	250	11.078	9.972	0.000	0.000	0.000	0.000
DEBT_MAT	1180	2.331	2.636	1177	2.715	3	250	2.870	3.037	0.000	0.000	0.148	0.233
Market conditions													
OIL_SPOT	1179	46.648	32.500	1177	62.638	65.870	250	73.421	70.610	0.000	0.000	0.000	0.000
OIL_VOL	1179	3.168	2.233	1177	4.189	3.306	250	4.930	3.654	0.000	0.000	0.002	0.000
OIL_RET	1179	-0.024	-0.023	1177	0.006	0.016	250	0.019	0.025	0.000	0.000	0.000	0.003

Note:

This table provides the mean and median values of firms' financial and operational characteristics and market conditions according to the weighted-average maturity of the hedging portfolio. For each firm-quarter with hedging activity, a hedging portfolio maturity is classified as short-term maturity if it is below one year ahead, a medium-term maturity if it is between one and two years ahead, and a long-term maturity if it exceeds two years ahead. *INV_OPP* for investment opportunities; *COR_CI_CF* for the correlation between free cash flows and cost incurred; *DTD* for distance-to-default; *LEV* for the leverage ratio measured by the sum of long-term debt in current liabilities plus one-half long-term debt scaled by book value of total assets; *DIS_COSTS* for distress costs (in $); *PROD_CV_OIL* and *PROD_CV_GAS* measure production uncertainty for oil and gas respectively; *COR_PQ_OIL* and *COR_PQ_GAS* measure the quantity-price correlation for oil and gas respectively; *CEO_CS* for the market value of common shares held by firm's CEO (in MM$); *CEO_OPT* for the number of stock options held by firm's CEO (in 000); *TLCF* for tax loss carry-forwards scaled by the book value of total assets; *TAX_SAVE* for the expected percentage of tax saving; *DEBT_MAT* is the long-term debt maturity (in years); *RES_MAT_OIL* and *RES_MAT_GAS* are the expected life of proven oil and gas reserves (in years); *GAS_SPOT* and *OIL_SPOT* are spot prices; *GAS_VOL* and *OIL_VOL* are historical volatilities of spot prices over the current quarter; *GAS_RET* and *OIL_RET* are oil and gas returns measured by log(12-month future price/spot price). Comparison of means is constructed using a *t*-test assuming unequal variances; comparison of medians is constructed by using the non-parametric Wilcoxon rank sum *Z*-score. Two sided *p*-values are reported.

The univariate tests show considerable number differences between firm-quarters with long-term maturities and those with short- or medium-term maturities for oil hedgers and gas hedgers separately. Table 2.4 Panel A reports results pertaining to the subsample of gas hedgers and Panel B presents results for oil hedgers. Results show that oil and gas producers with higher distance-to-default tend to choose longer maturities. Results related to the leverage ratio are mixed. Although the higher leverage ratio is more related to longer maturities for gas hedgers, it seems to be more associated with shorter maturities for oil hedgers. Counter to our predictions, higher distress costs are more related to long-run contracts for gas hedgers. Consistent with our predictions, results further show that oil and gas producers with higher growth opportunities prefer long-run hedging contracts, and that higher correlation between free cash flows and investment expenditures motivates the use of short- and medium-term contracts.

Univariate tests also show that oil and gas producers with higher production uncertainty tend to use long maturity contracts. This is inconsistent with the prediction that higher production uncertainty makes firms reluctant to make a large hedge for more distant exposures. We find that price-quantity correlation is more closely related to medium-term contracts for gas hedgers, and to long-term contracts for oil hedgers. In sum, these findings corroborate our prediction that firms with higher price-quantity correlation tend to use longer maturities because their cash flows are more volatile. Consistent with our prediction, the Wilcoxon test for difference in medians shows that higher CEO stake value in the firm is more related to long maturity contracts. In contrast, higher CEO option-holdings are associated with long-term contracts, which contradicts the prediction that a manager with a convex utility in firm value has a disincentive to undertake corporate hedging.

Univariate tests pertaining to tax incentives indicate that medium-term hedging is related to a higher percentage of tax savings for oil hedgers. Consistent with our prediction, oil and gas producers with higher tax loss carry-forwards tend to use short maturity hedging. In addition, oil and gas producers with remaining longer maturities of debt and proven reserves tend to choose long-run contracts. This corroborates the asset-liability management argument. As predicted, results pertaining to market conditions suggest that higher spot prices and volatilities are more associated with medium-term contracts for gas hedgers and longer contracts for oil hedgers. Conversely, when oil future prices are anticipated to be higher, oil hedgers tend to prefer long maturity contracts.

Table 2.5 presents our results, comparing the moneyness and strike prices of hedging instruments based on their remaining maturities. Table 2.5 Panel A reports results pertaining to gas hedgers and Panel B presents results for oil hedgers. For conciseness, we concentrate our analysis on the three major hedging instruments used by oil and producers: swap contracts, put options and costless collars.[34] For oil hedgers, we find that swap contracts with the longest maturities have the lowest moneyness as measured by the strike price minus the spot price. One explanation would be that firms are reluctant to exit out-of-the-money swaps prior to the agreed-upon termination date due to the termination costs. Consistent with our prediction, results also show that higher strike prices are more related to medium-term swaps for gas hedgers and to long-term swaps for oil hedgers. We further find that higher moneyness and strike prices are more related to medium-term put options in the case of gas hedging. As predicted, longer term put options are more associated with higher strike prices for oil hedgers. Consistent with predictions, longer term collars are related to higher moneyness and strike prices for both oil and gas hedgers.

[34] We skip the observations related to forward/futures contracts because they contribute to only 3.25% of gas hedging activity and 2.78% of oil hedging activity. We also omit observations related to three-way collars because they are used in only 3.42% of cases for gas hedging activity and 3.02% of cases for oil hedging.

Table 2.5 Contract features by hedging maturity

	Short Maturity			Medium Maturity			Long Maturity			Short vs. Long		Medium vs. Long	
Variable	Obs	Mean	Median	Obs	Mean	Median	Obs	Mean	Median	*p*-value (Mean)	*p*-value (Median)	*p*-value (Mean)	*p*-value (Median)
Panel A: Gas hedgers													
Swap contracts													
MONEYNESS	903	-0.187	0	1069	-0.029	0	282	-0.127	0	0.580	0.171	0.344	0.176
STRIKE	903	5.054	5.261	1069	5.506	5.511	282	5.108	5.261	0.744	0.532	0.012	0.011
Put options													
MONEYNESS	306	-0.005	0	184	0.121	0	27	-0.480	0	0.108	0.395	0.043	0.018
STRIKE	306	5.263	5.407	184	5.849	6.114	27	4.865	4.706	0.273	0.369	0.011	0.028
Costless collars													
MONEYNESS	869	0.040	0	859	0.052	0	111	0.777	0	0.002	0.000	0.003	0.000
STRIKE	869	5.491	5.484	859	6.203	6.164	111	7.457	7.161	0.000	0.000	0.000	0.000
Panel B: Oil hedgers													
Swap contracts													
MONEYNESS	794	-2.689	-0.622	706	-2.681	0	211	-5.186	0	0.019	0.300	0.031	0.103
STRIKE	794	41.656	31.155	706	56.059	58.095	211	65.592	64.952	0.000	0.000	0.000	0.000
Put options													
MONEYNESS	230	-1.428	0	188	0.760	0	27	2.043	0	0.389	0.143	0.751	0.514
STRIKE	230	49.356	38.314	188	63.068	60.048	27	66.512	59.956	0.011	0.013	0.599	0.675
Costless collars													
MONEYNESS	663	-2.676	-0.263	589	-3.016	0	151	5.298	0	0.000	0.004	0.000	0.015
STRIKE	663	50.717	48.305	589	60.551	60.048	151	77.451	63.335	0.000	0.000	0.000	0.000

Contract features by hedging maturity

Note:

This table provides the mean and median values of the hedging instruments features (i.e., moneyness and strike price) according to its weighted-average maturity. Hedging instruments are swap contracts, put options, and costless collars. Strike price is measured by the average spot price during the quarter of initiation of the hedging contract. Moneyness is calculated as the contract strike price minus the average spot price during the current quarter. For each instrument, a hedging maturity is classified as short-term maturity if it is below one year ahead, a medium-term maturity if it is between one and two years ahead, and a long-term maturity if it exceeds two years ahead. Comparison of means is constructed using a *t*-test assuming unequal variances; comparison of medians is constructed by using the non-parametric Wilcoxon rank sum *Z*-score. Two sided *p*-values are reported.

2.6 Maturity structure of corporate risk management

To investigate the determinants of hedging maturity choice by oil and gas producers, we estimate the dynamic panel regression using a two-step SYS-GMM[35] model as presented previously. In these regressions, the weighted-average remaining maturity is regressed on variables that measure underinvestment costs, financial distress costs, production function characteristics, managerial risk aversion, tax incentives, market conditions, asset-liability management and contract features. Many specifications of the SYS-GMM are estimated for the subset of oil hedgers and gas hedgers separately and for the following major hedging instruments used: swap contracts, put options and costless collars. We based our analysis on remaining maturity by instrument rather than the whole hedging portfolio to get more insights into the hedging dynamics of oil and gas producers.

[35] Following the good practice guideline suggested by Roodman (2009a and 2009b), we use all available lags of the dependent variables as instruments to retain more information. We also apply a collapsing technique to avoid instrument proliferation that weakens the Hansen test instrument validity. We further report: (i) the number of instruments generated for the regression, (ii) the Hansen J-test statistics and p-value, and (iii) the Arellano-Bond test for a second-order serial correlation in residuals (i.e., AR (2) test).

Table 2.6 Maturity structure by gas hedgers

Variables	(1) Swap contracts	(2) Swap contracts	(3) Swap contracts	(4) Swap contracts	(5) Put options	(6) Put options	(7) Put options	(8) Put options	(9) Costless collars	(10) Costless collars	(11) Costless collars	(12) Costless collars
INV_OPP	0.3292***		0.3468***		0.2735**		0.3192***		0.0695		0.0634	
	(0.089)		(0.082)		(0.114)		(0.108)		(0.086)		(0.079)	
COR_CI_CF		-0.0437		-0.0026		-0.1851**		-0.2055**		-0.0028		0.0599
		(0.042)		(0.048)		(0.081)		(0.099)		(0.044)		(0.043)
LEV	1.3438***			1.4572***	1.3907***			3.2410***	0.8867***			1.0542***
	(0.280)			(0.281)	(0.424)			(0.600)	(0.184)			(0.175)
LEV_SQUARE	-0.9482***			-1.1349***	-1.3725			-5.4469***	-0.5349***			-0.6324***
	(0.360)			(0.402)	(0.866)			(1.456)	(0.130)			(0.170)
DTD			0.0994***				0.0115				0.1499***	
			(0.029)				(0.050)				(0.032)	
DTD_SQUARE			-0.0087*				0.0062				-0.0237***	
			(0.005)				(0.008)				(0.006)	
DIS_COSTS		0.0041		0.0028		0.0069		0.0081*		0.0014		0.0001
		(0.003)		(0.004)		(0.005)		(0.005)		(0.001)		(0.002)
PROD_CV_GAS	0.0734		0.1487**		0.0923		0.0765		0.1273***		0.1439***	
	(0.051)		(0.057)		(0.101)		(0.102)		(0.047)		(0.052)	
COR_PQ_GAS	0.0550		-0.0073		0.0071		0.0110		0.0940**		0.0031	
	(0.051)		(0.045)		(0.083)		(0.078)		(0.042)		(0.039)	
GAS_VOL	0.0555***		0.0541***		0.1128***		0.1287***		0.0482**		0.0425**	
	(0.019)		(0.020)		(0.029)		(0.030)		(0.019)		(0.019)	
GAS_RET	-0.1307*		-0.1572**		-0.4896***		-0.4689***		-0.2587***		-0.2710***	
	(0.070)		(0.069)		(0.142)		(0.130)		(0.070)		(0.076)	
GAS_SPOT		0.1309***				0.1457***				0.0997***		
		(0.016)				(0.029)				(0.017)		
GAS_SPOT_SQUARE		-0.0080***				-0.0074***				-0.0047***		
		(0.001)				(0.002)				(0.001)		
MONEYNESS	0.0144*		0.0209***		0.0158		0.0161		0.0109		0.0142*	
	(0.008)		(0.008)		(0.017)		(0.015)		(0.008)		(0.008)	
STRIKE				0.0299***				0.0384***				0.0222***
				(0.007)				(0.011)				(0.007)
TLCF		-0.3411***		-0.3849***		-0.3462***		-0.4941***		-0.0611*		-0.1061**
		(0.062)		(0.142)		(0.050)		(0.178)		(0.036)		(0.041)
TAX_SAVE	-0.0491		0.2914		0.0389		1.9730**		0.4577		0.7561**	
	(0.140)		(0.235)		(0.848)		(0.764)		(0.409)		(0.340)	
DEBT_MAT		0.0396***		0.0368***		0.0082		-0.0146		0.0307***		0.0337***
		(0.012)		(0.012)		(0.016)		(0.018)		(0.010)		(0.010)
RES_MAT_GAS	0.0184***		0.0188***		0.0212***		0.0208***		0.0228***		0.0200***	
	(0.004)		(0.005)		(0.006)		(0.006)		(0.004)		(0.005)	
CEO_CS		0.1218		0.1756		-0.2095		0.2573		0.1841		0.1322
		(0.114)		(0.154)		(0.330)		(0.326)		(0.148)		(0.121)
CEO_OPT		0.0001		0.0001		-0.0002		0.0001		-0.0002***		-0.0001**
		(0.000)		(0.000)		(0.000)		(0.000)		(0.000)		(0.000)
IMR	0.1829***	0.1002**	0.1202**	0.2569***	0.1225*	0.0851	0.1181*	0.2251***	0.1288***	0.0583	0.0597	0.1734***
	(0.047)	(0.047)	(0.057)	(0.063)	(0.065)	(0.083)	(0.061)	(0.082)	(0.047)	(0.046)	(0.049)	(0.051)
LAG_1	0.5597***	0.5836***	0.5834***	0.5742***	0.4892***	0.5592***	0.5120***	0.4766***	0.5816***	0.6043***	0.5918***	0.6044***
	(0.053)	(0.044)	(0.051)	(0.050)	(0.080)	(0.094)	(0.074)	(0.081)	(0.049)	(0.051)	(0.053)	(0.047)
LAG_2				-0.0289								
				(0.022)								
Observations	2,123	2,129	2,096	2,108	480	485	478	480	1,726	1,746	1,699	1,745
Number of firms	99	100	99	99	44	49	43	44	93	95	93	94
Number of instruments	63.0000	61.0000	63.0000	62.0000	63.0000	61.0000	63.0000	62.0000	63.0000	61.0000	63.0000	62.0000
F statistic	409.4175	705.0217	428.2656	433.7338	173.8287	182.3584	227.4729	200.8200	412.9824	570.3112	601.2629	575.2583
p value F statistic	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Hansen J statistic	63.8114	53.8975	62.5987	59.8964	36.6077	30.6516	36.9887	33.0220	60.9116	52.6989	56.9287	60.2093
p value of Hansen statistic	0.1074	0.3641	0.1279	0.1595	0.9356	0.9893	0.9295	0.9761	0.1613	0.4082	0.2640	0.1769
AR(2) test statistic	-1.4614	-1.3744	-1.6156	-0.7854	-0.6087	-0.9605	-0.3671	-1.4434	-1.3989	-0.8421	-1.3168	-1.5502
p value of AR(2) statistic	0.1439	0.1693	0.1062	0.4322	0.5427	0.3368	0.7136	0.1489	0.1618	0.3997	0.1879	0.1211
Sigma_e	0.3393	0.4425	0.3471	0.3459	0.3049	0.4605	0.3100	0.3164	0.3175	0.4135	0.3194	0.3277

Note:
This table provides the two-step SYS-GMM results for the determinants of the weighted-average remaining maturity for swap contracts, put options and costless collars respectively. The results are for the subsample of gas hedgers. *INV_OPP* for investment opportunities; *COR_CI_CF* for the correlation between free cash flows and cost incurred; *LEV* for the leverage ratio measured by the sum of long-term debt in current liabilities plus one-half long term debt scaled by book value of total assets; *LEV_SQUARED* is the leverage ratio squared; *DTD* for distance-to-default; *DTD_SQUARED* for the distance to default squared; *DIS_COSTS* for distress costs (in $/BOE); *PROD_CV_GAS* measures gas production uncertainty; *COR_PQ_GAS* measures the gas quantity-price correlation; *GAS_VOL* for gas price volatility; *GAS_RET* for gas return as measured by log(gas 12-month future price/gas sport price); *GAS_SPOT* and *GAS_SPOT_SQUARED* are for gas spot price and gas price squared; *MONEYNESS* measured by the contract strike price minus the average spot price during the current quarter; *STRIKE* is the contract's strike price; *TLCF* for tax loss carry-forwards scaled by the book value of total assets; *TAX_SAVE* for the expected percentage of tax saving; *DEBT_MAT* is the long-term debt maturity (in years); *RES_MAT_GAS* are the expected life of proven oil and gas reserves (in years); *CEO_CS* for the market value of common shares held by firm's CEO (in logarithm); *CEO_OPT* for the number of stock options held by firm's CEO (in 000); *IMR* is the inverse Mills Ratio (Table A.2.1); *LAG_1* is the dependent variable first lag; *LAG_2* is the dependent variable second lag (used when there is second-order serial correlation in the error term). Standard errors are clustered by firm and incorporate the Windmeijer (2005) correction, in parentheses. ***Significant at the 1% level, ** Significant at the 5% level, * Significant at the 10% level.

Table 2.7 Maturity structure by oil hedgers

Variables	(1) Swap contracts	(2) Swap contracts	(3) Swap contracts	(4) Swap contracts	(5) Put options	(6) Put options	(7) Put options	(8) Put options	(9) Costless Collars	(10) Costless Collars	(11) Costless Collars	(12) Costless Collars
INV_OPP	0.2623**		0.2200**		0.5839**		0.5923**		0.1001*		0.0916*	
	(0.129)		(0.110)		(0.222)		(0.235)		(0.052)		(0.052)	
COR_CI_CF		-0.1294***		-0.0818*		0.0487		0.0533		0.0213		0.0302
		(0.048)		(0.048)		(0.076)		(0.094)		(0.052)		(0.059)
LEV	0.5090*			0.8594***	1.5182*			1.6283**	1.1577***			0.8237***
	(0.265)			(0.256)	(0.803)			(0.760)	(0.348)			(0.208)
LEV_SQUARE	-0.2940			-0.7017**	-1.5120			-1.3516	-1.4545***			-0.9989***
	(0.402)			(0.349)	(2.053)			(1.702)	(0.522)			(0.292)
DTD			0.0729**				0.2709***				0.1614***	
			(0.029)				(0.075)				(0.055)	
DTD_SQUARE			-0.0049				-0.0474***				-0.0230**	
			(0.003)				(0.015)				(0.010)	
DIS_COSTS		0.0011		-0.0006		0.0146***		0.0103***		0.0003		0.0005
		(0.002)		(0.003)		(0.003)		(0.003)		(0.003)		(0.003)
PROD_CV_OIL	0.1090*		0.1260*		0.0089		0.0109		-0.0404		-0.0797	
	(0.065)		(0.065)		(0.119)		(0.104)		(0.062)		(0.059)	
COR_PQ_OIL	0.0590		0.0001		0.0217		-0.0442		0.0983**		0.0427	
	(0.037)		(0.038)		(0.084)		(0.084)		(0.048)		(0.046)	
OIL_VOL	0.0189***		0.0206***		0.0159**		0.0205**		0.0133**		0.0170***	
	(0.005)		(0.005)		(0.007)		(0.008)		(0.005)		(0.006)	
OIL_RET	-0.0313		0.0165		-0.3799		-0.3938		-0.2188		-0.0051	
	(0.195)		(0.209)		(0.495)		(0.504)		(0.230)		(0.215)	
OIL_SPOT		0.0149***				0.0043				0.0080***		
		(0.002)				(0.003)				(0.002)		
OIL_SPOT_SQUARE		-0.0001***				-0.0000				-0.0000**		
		(0.000)				(0.000)				(0.000)		
MONEYNESS	0.0028**		0.0033***		0.0015		0.0031		0.0037***		0.0044***	
	(0.001)		(0.001)		(0.002)		(0.002)		(0.001)		(0.001)	
STRIKE				0.0057***				0.0037***				0.0033***
				(0.001)				(0.001)				(0.001)
TLCF		-0.3940***		-0.5680***		-0.2640***		-0.4791***		-0.0531		-0.0813
		(0.082)		(0.134)		(0.062)		(0.163)		(0.059)		(0.052)
TAX_SAVE	0.1945		0.1802		0.1319		0.9001		0.1094		0.0787	
	(0.154)		(0.140)		(0.612)		(0.583)		(0.286)		(0.273)	
DEBT_MAT		0.0416***		0.0420***		0.0280		-0.0006		0.0310***		0.0260**
		(0.013)		(0.013)		(0.019)		(0.020)		(0.011)		(0.010)
RES_MAT_OIL	0.0311***		0.0272***		0.0119**		0.0052		0.0182***		0.0161***	
	(0.004)		(0.004)		(0.006)		(0.007)		(0.005)		(0.004)	
CEO_CS		-0.1633		-0.0628		-0.3542		-0.3388		-0.0665		-0.1324
		(0.137)		(0.139)		(0.318)		(0.343)		(0.140)		(0.146)
CEO_OPT		0.0002*		0.0002		-0.0001		0.0001		-0.0001		-0.0001
		(0.000)		(0.000)		(0.000)		(0.000)		(0.000)		(0.000)
IMR	0.1311**	0.1470**	0.1049*	0.2848***	0.1382**	0.2096***	0.0121	0.1800***	0.2054***	0.1265**	0.1797**	0.1946***
	(0.059)	(0.071)	(0.060)	(0.062)	(0.059)	(0.066)	(0.052)	(0.052)	(0.068)	(0.049)	(0.068)	(0.044)
LAG_1	0.5630***	0.5548***	0.5728***	0.5490***	0.4645***	0.5872***	0.4760***	0.5211***	0.5858***	0.6228***	0.5745***	0.6256***
	(0.039)	(0.046)	(0.042)	(0.046)	(0.063)	(0.062)	(0.084)	(0.076)	(0.040)	(0.041)	(0.039)	(0.035)
LAG_2	-0.0496**	-0.0696***	-0.0432**	-0.0529**								
	(0.020)	(0.023)	(0.020)	(0.020)								
Observations	1,593	1,608	1,572	1,608	402	417	393	414	1,331	1,351	1,311	1,351
Number of firms	88	89	88	89	36	40	35	37	81	81	81	81
Number of instruments	63.0000	61.0000	63.0000	62.0000	57.0000	57.0000	57.0000	56.0000	63.0000	61.0000	63.0000	62.0000
F statistic	293.9642	413.6701	255.7297	280.9298	128.4730	176.0464	102.0687	336.8433	280.2979	444.6558	275.8100	318.6617
p value F statistic	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Hansen J statistic	51.8717	51.3504	55.6423	54.2101	29.0451	28.2022	27.3456	35.4909	59.4069	46.4226	56.9199	53.5233
p value of Hansen statistic	0.4007	0.4206	0.2708	0.3170	0.9688	0.9865	0.9825	0.8441	0.1960	0.6558	0.2642	0.3777
AR(2) test statistic	-1.0896	0.1353	-1.2967	-0.7639	0.5991	1.4030	1.0248	1.2104	0.8288	0.2945	0.9272	1.0881
p value of AR(2) statistic	0.2759	0.8923	0.1947	0.4449	0.5491	0.1606	0.3055	0.2261	0.4072	0.7684	0.3538	0.2766
Sigma_e	0.3144	0.4310	0.3160	0.3163	0.3038	0.4969	0.3079	0.3177	0.3374	0.4834	0.3324	0.3533

Note:

This table provides the two-step SYS-GMM results for the determinants of the weighted-average remaining maturity for swap contracts, put options and costless collars respectively. The results are for the subsample of oil hedgers. *INV_OPP* for investment opportunities; *COR_CI_CF* for the correlation between free cash flows and cost incurred; *LEV* for the leverage ratio measured by the sum of long-term debt in current liabilities plus one-half long term debt scaled by book value of total assets; *LEV_SQUARED* is the leverage ratio squared; *DTD* for distance-to-default; *DTD_SQUARED* for distance-to-default squared; *DIS_COSTS* for distress costs (in $/BOE); *PROD_CV_OIL* measures oil production uncertainty; *COR_PQ_OIL* measures the oil quantity-price correlation, *OIL_VOL* for oil price volatility; *OIL_RET* for oil return as measured by log(oil 12-month future price/oil sport price); *OIL_SPOT* and *OIL_SPOT_SQUARED* are for oil spot price and oil price squared; *MONEYNESS* measured by the contract strike price minus the average spot price during the current quarter; *STRIKE* is the contract's strike price; *TLCF* for tax loss carry-forwards scaled by the book value of total assets; *TAX_SAVE* for the expected percentage of tax saving; *DEBT_MAT* is the long-term debt maturity (in years); *RES_MAT_OIL* are the expected life of proven oil and gas reserves (in years); *CEO_CS* for the market value of common shares held by firm's CEO (in logarithm); *CEO_OPT* for the number of stock options held by firm's CEO (in 000); *IMR* is the inverse Mills Ratio (Table A.2.1); *LAG_1* is the dependent variable first lag; *LAG_2* is the dependent variable second lag (used when there are second order serial correlation in the error term). Standard errors are clustered by firm and incorporate the Windmeijer (2005) correction, in parentheses. ***Significant at the 1% level, ** Significant at the 5% level, * Significant at the 10% level.

The results in Tables 2.6 (gas hedgers) and 2.7 (oil hedgers) are generally consistent with hypotheses pertaining to underinvestment costs. In particular, oil and gas producers with higher future investment opportunities (*INV_OPP*) tend to use longer term swap contracts, put options and costless collars. Oil and gas producers with substantial growth opportunities employ hedging contracts with longer maturities to reduce any shortfall in their future cash flows and hence avoid both cutting planned investment programs and costly external financing. We also find a significant negative effect of the correlation between investment expenditures and internally generated cash flows (*COR_CI_CF*) and hedging contract horizon because firms benefit from a natural hedge. We find that the remaining maturities of put options and swap contracts decline with this positive correlation for gas hedgers and oil hedgers respectively. The impacts on costless collars' maturities are mixed and insignificant. Interestingly, results reveal opposite effects of firm's investment specificities on hedging maturity structure: growth options accentuate future funding needs and a positive correlation dampens this need. These opposite effects are essentially driven by the simultaneous positive impacts of current oil and gas prices on future investment opportunities and present cash inflows.

The results pertaining to financial distress give strong evidence of the non-monotonic relationship between hedging horizons and the likelihood of financial distress. In line with Fehle and Tsyplakov's (2005) prediction, we find that the leverage ratio (*LEV*) and the leverage squared (*LEV_SQUARE*) have highly significant positive and negative coefficients respectively for both subsets of gas hedgers and oil hedgers, for the three hedging instruments.[36] These non-monotonic (concave) relationships mean that hedging maturities should first increase and then decrease with the likelihood of financial distress. To further investigate this non-monotonic relationship empirically, we use an alternative robust measure of the likelihood of financial distress, namely, distance-to-default. Interestingly, results show that remaining maturity should increase and decrease with the distance to default. Generally, we find that Distance-to-Default (*DTD*) and its squared value (*DTD_SQUARE*) are respectively significantly positively and negatively related to hedging instrument maturity. The non-monotonic relationship between hedging maturity and leverage ratio is shown, for

[36] As robustness checks, we measure the leverage ratio by: (i) long-term debt in current liabilities plus long-term debt scaled by total assets, (ii) long-term debt scaled by total assets. Results are the same.

each hedging instrument, in Figure 2.1 for gas hedgers and in Figure 2.2 for oil hedgers. These figures show that this non-monotonic relationship is more pronounced for put options for gas hedgers and for costless collars for oil hedgers.

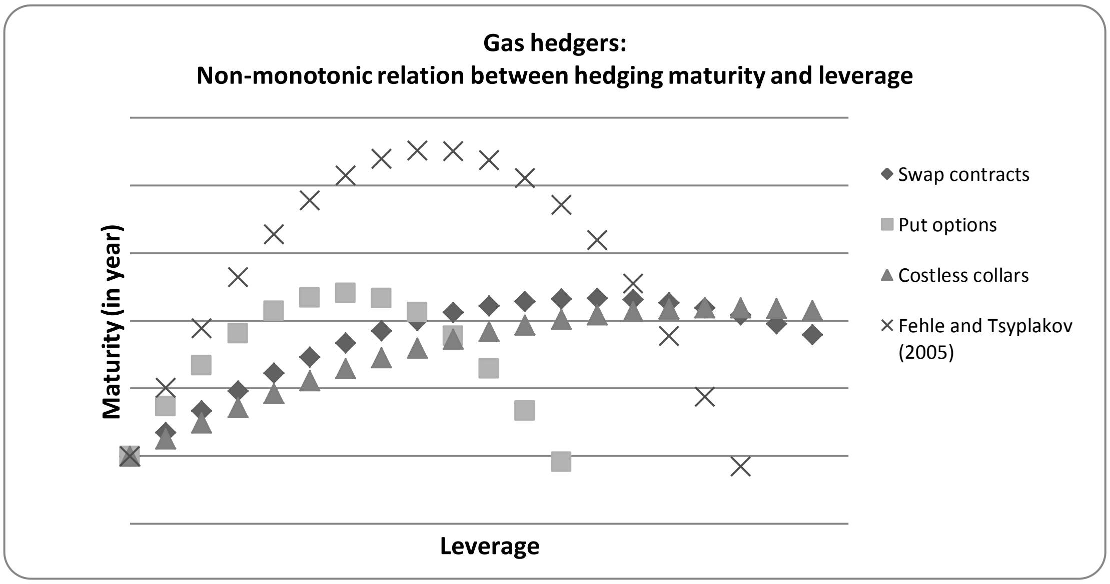

Figure 2.1 Non-monotonic relationship between hedging maturity and leverage for gas hedgers

Note:

This figure illustrates the relation between hedging maturity and leverage ratio by: $Maturity = \alpha \times LEV + \beta \times LEV^2$ with α and β coming from the estimation of our base model SYS-GMM in table 6. The coefficients α and β equal 1.45 and -1.13 for swap contracts, 3.24 and -5.44 for put options, and 1.05 and -0.63 for costless collars (see Table 6 Columns 4, 8 and 12). For Fehle and Tsyplakov (2005), α and β equal 0.70 and -0.69 (see Table 15, pp.40 from Fehle and Tsyplakov, 2005).

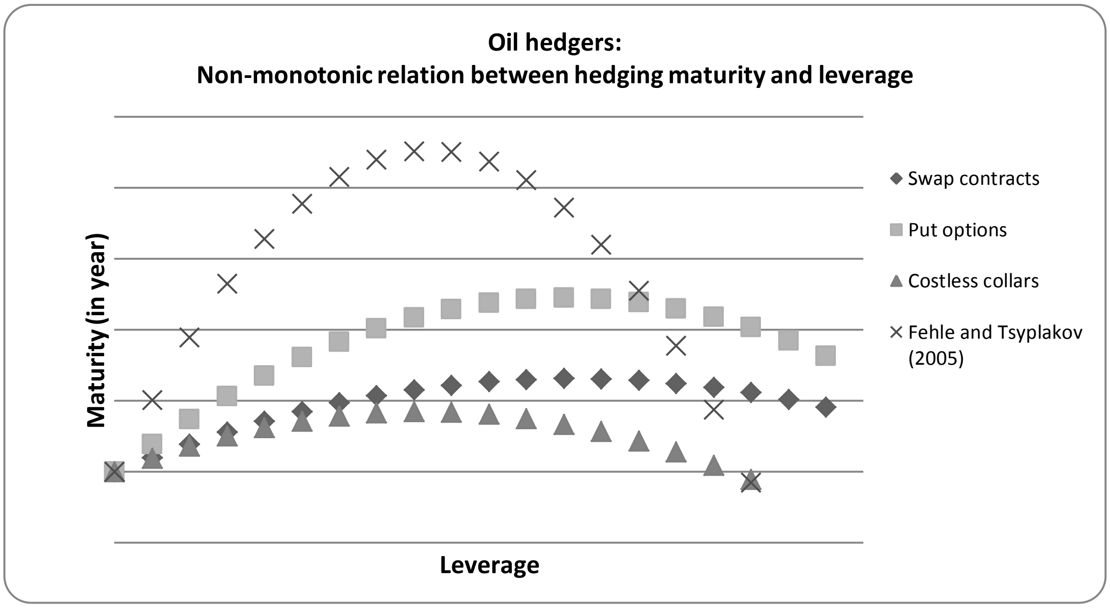

Figure 2.2 Non-monotonic relationship between hedging maturity and leverage for oil hedgers

Note:

This figure illustrates the relation between hedging maturity and leverage ratio by: $Maturity = \alpha \times LEV + \beta \times LEV^2$ with α and β coming from the estimation of our base model SYS-GMM in Table 7. The coefficients α and β equal 0.86 and -0.70 for swap contracts, 1.63 and -1.35 for put options, and 0.82 and -1.00 for costless collars (see Table 7 Columns 4, 8 and 12). For Fehle and Tsyplakov (2005), α and β equal 0.70 and -0.69 (see Table 15, pp.40 from Fehle and Tsyplakov, 2005).

In contrast with our hypotheses, we find that distressed oil and gas producers incurring a higher dollar loss per Barrel of Oil Equivalent (*DIS_COSTS*) tend to use put options with longer maturities. This empirical finding contradicts the simulation results of Fehle and Tsyplakov (2005), who find that firms incurring higher distress costs tend to use short-term hedging contracts. A possible explanation comes from Jensen and Meckling's (1976) risk shifting (or asset substitution) approach. By entering costly long-term put options, distressed oil and gas producers increase rather than eliminate the firm's payoff volatility, decrease assets available for debtholders and preserve any upside potential for shareholders.

Results further indicate that oil and gas producers with higher production uncertainty (*PROD_CV_OIL* and *PROD_CV_GAS*) tend to use long-term swap contracts and costless collars. The impact on put options' maturities is also positive but not significant. This finding contradicts Brown and Toft (2002), who assert that higher production uncertainty makes firms reluctant to hedge farther exposures. As predicted, we find that higher price-quantity correlations (*COR_PQ_OIL* and *COR_PQ_GAS*) motivate oil and gas hedgers to use more distant costless collar positions. A higher price-quantity correlation induces higher firm cash flow volatility because both prices and quantities are moving in the same direction. Altogether, we find that oil and gas producers with higher cash flow volatility, due to higher production uncertainty and/or higher price-quantity correlation, tend to use longer hedging positions to avoid shortfalls in their future revenues.

The results for variables pertaining to market conditions are highly consistent with our predictions. We find that oil and gas price volatilities (*OIL_VOL* and *GAS_VOL*) are significantly positively related to longer maturities for the three hedging instruments. This corroborates the simulation results of Fehle and Tsyplakov (2005), namely that in a higher price fluctuation environment, firms tend to refrain from costly early termination of their outstanding contracts unless spot prices increase significantly. We further find that when future gas prices are expected to be higher, as measured by *GAS_RET*, gas hedgers tend to use short-term hedging. This is consistent with the prediction that when future prices are expected to be higher, firms tend to terminate their outstanding contracts and initiate new hedging contracts with higher exercise prices. In addition, these newly initiated contracts have short maturities to prevent them from being worthless in the future. Surprisingly, expected tendency in future oil prices, as measured by *OIL_RET*, has the predicted negative sign but no significant impact.[37]

Our results also provide strong evidence of a non-monotonic relationship between spot prices and hedging maturities, as conjectured by Fehle and Tsyplakov (2005). We find that oil and gas spot prices (*OIL_SPOT* and *GAS_SPOT*) and the spot prices squared (*OIL_SPOT_SQUARE* and *GAS_SPOT_SQUARE*) have highly significant positive and negative coefficients respectively, yielding a non-monotonic relationship. Accordingly, when spot prices are either very high or very low, firms are more likely to choose short-term hedging contracts. This corroborates the non-monotonic relationship between financial distress likelihood measures (i.e., leverage ratio and distance-to-default) and hedging

[37] We further investigate the effects of anticipated oil and gas prices, as observed in the future contracts market, on hedging maturity choice by using the following Futures terms: three, six, fifteen, eighteen and twenty four months ahead. Our results are unchanged with 12-month future contracts.

maturity. When spot prices are very high or low, firms are more likely to be far from or deep in financial distress respectively. Figures 3 and 4 show the non-monotonic relationship between hedging maturity and spot prices for gas hedgers and oil hedgers separately. The non-monotonic relationship is more evident for swap contracts for oil hedgers.

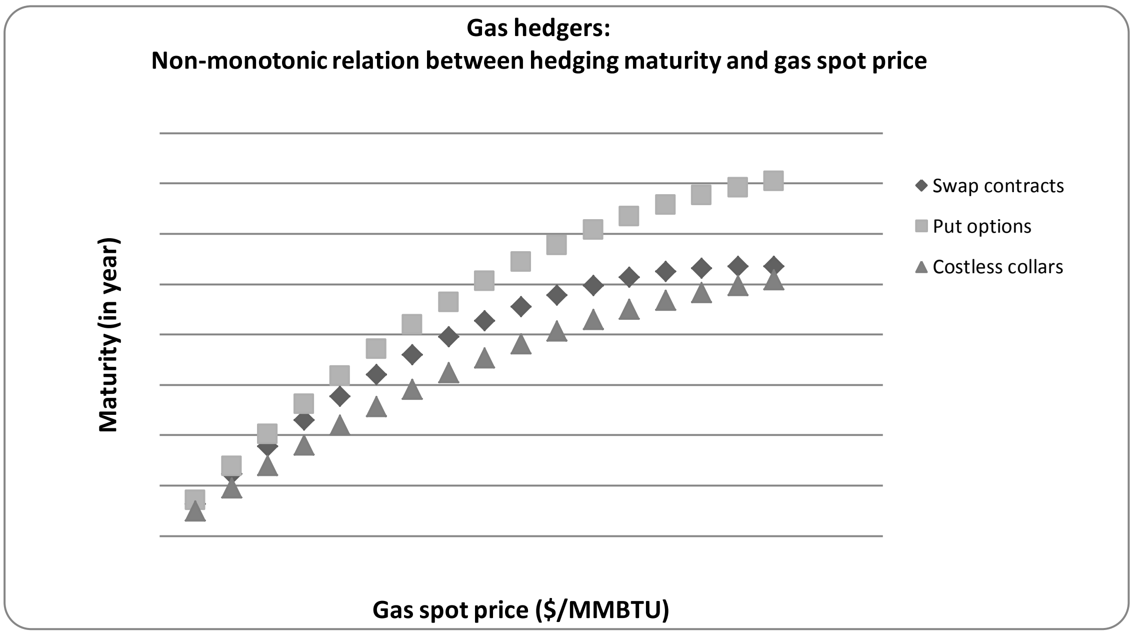

Figure 2.3 Non-monotonic relationship between hedging maturity and gas spot prices for gas hedgers

Note:

This figure illustrates the relation between hedging maturity and leverage ratio by: $Maturity = \alpha \times GAS\_SPOT + \beta \times GAS\_SPOT^{2}$ with α and β coming from the estimation of our base model SYS-GMM in Table 6. The coefficients α and β equal 0.131 and -0.008 for swap contracts, 0.146 and -0.007 for put options, and 0.100 and -0.005 for costless collars (see Table 6 Columns 2, 6 and 10).

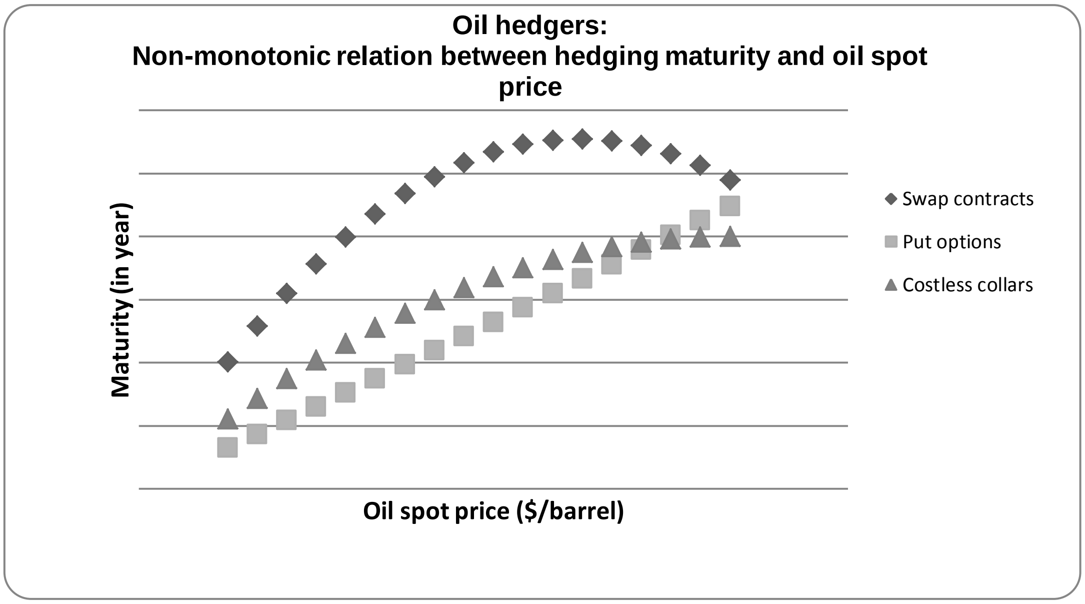

Figure 2.4 Non-monotonic relationship between hedging maturity and oil spot prices for oil hedgers

Note:
This figure illustrates the relation between hedging maturity and leverage ratio by: $Maturity = \alpha \times OIL\_SPOT + \beta \times OIL\_SPOT^2$ with α and β coming from the estimation of our base model SYS-GMM in Table 7. The coefficients α and β equal 0.015 and -0.0001 for swap contracts, 0.0043 and -0.00000185 for put options, and 0.008 and -0.00004 for costless collars (see Table 7 Columns 2, 6 and 10).

Hedging contract features appear to have an evident impact on hedging maturity choice. Results show that swap contracts and costless collars with higher *MONEYNESS* (e.g., strike prices higher than current spot prices) tend to have longer maturities. For put options, moneyness has the predicted sign but no significant impact. As predicted, oil and gas producers keep in-the-money hedging contracts until they mature and early terminate out-of-the-money contracts. Results also indicate that when hedging contracts are initiated at sufficiently higher prices (*STRIKE*) they are more likely to be kept for longer periods.

Consistent with our expectations, we find that oil and gas producers with higher tax loss carry-forwards (*TLCF*) choose short-term hedging maturities. Tax loss carry-forwards thus seem to be a disincentive to hedge longer exposures because they reduce firms' future tax liabilities. This corroborates the argument of Graham and Rogers (2002) that tax loss carry-forwards are uncorrelated with tax function convexity. As predicted, results further show a significant positive association between tax function convexity (*TAX_SAVE*) and put option and costless collar maturities for gas hedgers, in particular. For oil hedgers, the tax function convexity measure has the predicted sign but no significant impact.

Results for variables pertaining to asset-liability management are as predicted. We find that oil and gas producers with longer average debt maturity (*DEBT_MAT*) tend to use more distant swap and collar positions.[38] Average debt maturity appears to have no significant impact on put option maturity. We document strong evidence of a positive impact of the expected life duration of proven oil and gas reserves (*RES_MAT_OIL* and *RES_MAT_GAS*) on maturities of the three hedging instruments. These results suggest that oil and gas producers seek to match the maturities of their hedging and the maturities of their assets and debt. The CEO's stake value in the firm (*CEO_CS*) seems to have no impact on hedging maturity choice. CEO option-holding has a mixed impact. Although CEO option-holding (*CEO_OPT*) is negatively related to collar maturities for gas hedgers, it is positively related to swap maturities for oil hedgers.

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[38] We use an alternative measure of average debt maturity as described by Eisdorfer (2008). The firm's average debt maturity is estimated by: $\hat{T} = \frac{1}{TD}\,(0.5\,STD + 5\,LTD)$ where *TD, STD,* and *LTD* are the book values of total, short-term, and long-term debt. Our results are the same.

2.7 Robustness checks

In this section, we investigate the empirical relevance of our predictions and our previous findings by: (i) studying maturity choice at hedging contract inception, (ii) and investigating the determinants of the early termination of outstanding hedging contracts.

2.7.1 Maturity choice at the inception of the hedging contract

We skim the time series of the weighted-average maturity by hedging instrument and detect initiation dates by choosing observations where the observed maturity at time *T* is superior to the one at time *T-1*. We run a pooled cross-sectional time-series regression of the weighted-average maturities at the inception dates on firm's fundamentals, production function characteristics and oil and gas market conditions. Table 2.8 and 2.9 report the regression results for gas hedgers and oil hedgers separately.

Table 2.8 Maturity choice at the inception of hedging contracts by gas hedgers

Variables	(1) Swap contracts	(2) Swap contracts	(3) Swap contracts	(4) Swap contracts	(5) Put options	(6) Put options	(7) Put options	(8) Put options	(9) Costless collars	(10) Costless collars	(11) Costless collars	(12) Costless collars
INV_OPP	0.0026		0.0146		-0.0512		-0.0371		0.1862**		0.1876**	
	(0.109)		(0.111)		(0.140)		(0.151)		(0.082)		(0.079)	
COR_CI_CF		-0.2297***		-0.2398***		-0.4763***		-0.4721***		-0.0388		-0.0025
		(0.063)		(0.071)		(0.120)		(0.137)		(0.055)		(0.058)
LEV	-0.5737*			-0.9896**	1.9823**			1.5209	0.4274			0.7591**
	(0.343)			(0.408)	(0.784)			(1.168)	(0.329)			(0.357)
LEV_SQUARE	1.0634***			1.1176***	-2.5490**			-2.8874	-0.3952			-0.6584*
	(0.306)			(0.333)	(1.280)			(2.469)	(0.320)			(0.359)
DTD			-0.0023				-0.1624				0.0425	
			(0.040)				(0.119)				(0.064)	
DTD_SQUARE			0.0025				0.0253				-0.0085	
			(0.006)				(0.021)				(0.010)	
DIS_COSTS		0.0057**		0.0055**		0.0036		0.0056		0.0015		0.0010
		(0.003)		(0.002)		(0.005)		(0.005)		(0.002)		(0.002)
PROD_CV_GAS	0.0294		0.0257		0.2925**		0.2413**		0.2699***		0.2538***	
	(0.054)		(0.057)		(0.114)		(0.121)		(0.057)		(0.060)	
COR_PQ_GAS	-0.1624**		-0.1725**		-0.1216		-0.1775*		0.0628		0.0392	
	(0.072)		(0.067)		(0.092)		(0.091)		(0.053)		(0.052)	
GAS_VOL	-0.0259		-0.0364		0.0072		-0.0135		0.0377		0.0317	
	(0.041)		(0.039)		(0.055)		(0.053)		(0.038)		(0.038)	
GAS_RET	0.0015		-0.0392		-0.1774		-0.1942		-0.0055		-0.0033	
	(0.132)		(0.126)		(0.170)		(0.163)		(0.100)		(0.099)	
GAS_SPOT		-0.0159				0.0524				0.0654**		
		(0.035)				(0.040)				(0.027)		
GAS_SPOT_SQUARE		0.0010				-0.0028				-0.0032		
		(0.003)				(0.003)				(0.002)		
STRIKE				-0.0141				0.0260**				0.0278***
				(0.010)				(0.012)				(0.009)
TLCF		-0.5876***		-0.5165***		-0.7963***		-0.6928***		-0.0835		-0.1434
		(0.142)		(0.147)		(0.198)		(0.208)		(0.152)		(0.152)
TAX_SAVE	-1.4783*		-1.5711*		-0.1894		-0.3458		0.2650		0.2519	
	(0.873)		(0.841)		(0.878)		(0.831)		(0.201)		(0.214)	
DEBT_MAT		0.0152		0.0188		0.0068		-0.0029		0.0242**		0.0229**
		(0.013)		(0.013)		(0.020)		(0.020)		(0.011)		(0.012)
RES_MAT_GAS	0.0142***		0.0120***		0.0320***		0.0281***		0.0128**		0.0122**	
	(0.005)		(0.004)		(0.007)		(0.007)		(0.005)		(0.005)	
CEO_CS		0.2019		0.1969		-0.0600		0.1344		0.4796**		0.4417**
		(0.258)		(0.269)		(0.297)		(0.360)		(0.205)		(0.205)
CEO_OPT		0.0007		0.0008		-0.0001		0.0004		0.0001		0.0001
		(0.001)		(0.001)		(0.002)		(0.002)		(0.000)		(0.000)
IMR	-0.3736***	-0.2885***	-0.3237***	-0.3941***	-0.0970	-0.3959***	-0.3236***	-0.2614	-0.3176***	-0.2978***	-0.3778***	-0.2299***
	(0.060)	(0.057)	(0.060)	(0.071)	(0.112)	(0.108)	(0.095)	(0.158)	(0.070)	(0.073)	(0.065)	(0.080)
CONSTANT	1.6506***	1.6762***	1.5977***	1.8711***	0.6523***	1.4443***	1.3201***	1.2623***	1.0725***	1.1194***	1.1399***	1.0577***
	(0.112)	(0.124)	(0.115)	(0.147)	(0.194)	(0.181)	(0.212)	(0.261)	(0.098)	(0.096)	(0.109)	(0.121)
Observations	733	735	726	735	168	168	167	163	603	608	597	607
R-squared	0.0799	0.0825	0.0649	0.0948	0.2083	0.2047	0.1947	0.1898	0.1236	0.0872	0.1220	0.0888

Note:

This table provides pooled cross-sectional time-series regressions of the determinants of the weighted-average remaining maturity for swap contracts, put options and costless collars respectively. The results are for the subsample of gas hedgers. *INV_OPP* for investment opportunities; *COR_CI_CF* for the correlation between free cash flows and cost incurred; *LEV* for the leverage ratio measured by the sum of long-term debt in current liabilities plus one-half long-term debt scaled by book value of total assets; *LEV_SQUARED* is the leverage ratio squared; *DTD* for distance-to-default; *DTD_SQUARED* for distance-to-default squared; *DIS_COSTS* for distress costs (in $/BOE); *PROD_CV_GAS* measures gas production uncertainty; *COR_PQ_GAS* measures the gas quantity-price correlation; *GAS_VOL* for gas price volatility; *GAS_RET* for gas return as measured by log(gas 12-month future price/gas sport price); *GAS_SPOT* and *GAS_SPOT_SQUARED* are for gas spot price and gas price squared; *MONEYNESS* measured by the contract strike price minus the average spot price during the current quarter; *STRIKE* is the contract's strike price; *TLCF* for tax loss carry-forwards scaled by the book value of total assets; *TAX_SAVE* for the expected percentage of tax saving; *DEBT_MAT* is the long-term debt maturity (in years); *RES_MAT_GAS* are the expected life of proven oil and gas reserves (in years); *CEO_CS* for the market value of common shares held by firm's CEO (in logarithm); *CEO_OPT* for the number of stock options held by firm's CEO (in 000); *IMR* is the inverse Mills Ratio (Table A.2.1). Robust standard errors using Huber-White-Sandwich estimator are in parentheses. ***Significant at the 1% level, ** Significant at the 5% level, * Significant at the 10% level.

Table 2.9 Maturity choice at the inception of hedging contracts by oil hedgers

Variables	(1) Swap contracts	(2) Swap contracts	(3) Swap contracts	(4) Swap contracts	(5) Put options	(6) Put options	(7) Put options	(8) Put options	(9) Costless collars	(10) Costless collars	(11) Costless collars	(12) Costless collars
INV_OPP	0.1860		0.2165		0.3426**		0.3949***		0.2728***		0.2879***	
	(0.154)		(0.142)		(0.157)		(0.145)		(0.104)		(0.104)	
COR_CI_CF		-0.2169***		-0.2177***		-0.1492		-0.1486		-0.0184		-0.0360
		(0.063)		(0.065)		(0.124)		(0.125)		(0.075)		(0.086)
LEV	-1.3732***			-0.2853	-1.8256			-0.2747	-0.3317			-0.3262
	(0.403)			(0.378)	(1.277)			(1.569)	(0.425)			(0.478)
LEV_SQUARE	1.0744***			-0.0052	3.5507			1.2990	0.0682			0.1122
	(0.377)			(0.342)	(3.041)			(3.217)	(0.500)			(0.543)
DTD			0.1393***				0.2988***				0.1412**	
			(0.035)				(0.101)				(0.065)	
DTD_SQUARE			-0.0098***				-0.0515***				-0.0200*	
			(0.003)				(0.015)				(0.010)	
DIS_COSTS		0.0018		0.0029*		0.0085*		0.0119***		-0.0003		0.0007
		(0.002)		(0.002)		(0.005)		(0.004)		(0.001)		(0.001)
PROD_CV_OIL	0.3939***		0.3406***		-0.1638		-0.1586		-0.1665*		-0.1750*	
	(0.089)		(0.087)		(0.125)		(0.112)		(0.095)		(0.094)	
COR_PQ_OIL	-0.0259		0.0060		-0.0359		-0.0879		0.1208***		0.1039**	
	(0.042)		(0.037)		(0.088)		(0.079)		(0.047)		(0.048)	
OIL_VOL	0.0126		0.0279**		0.0155		0.0294**		0.0032		0.0094	
	(0.011)		(0.011)		(0.013)		(0.013)		(0.013)		(0.013)	
OIL_RET	1.0026***		0.9922***		-0.1797		0.1297		1.3909***		1.5355***	
	(0.359)		(0.348)		(0.562)		(0.589)		(0.419)		(0.424)	
OIL_SPOT		0.0222***				0.0058				0.0105**		
		(0.003)				(0.005)				(0.004)		
OIL_SPOT_SQUARE		-0.0001***				-0.0000				-0.0000		
		(0.000)				(0.000)				(0.000)		
STRIKE				0.0100***				0.0039**				0.0049***
				(0.001)				(0.002)				(0.001)
TLCF		-0.4943***		-0.4607***		-0.6377***		-0.6094**		-0.2474***		-0.2038***
		(0.133)		(0.136)		(0.215)		(0.261)		(0.079)		(0.077)
TAX_SAVE	0.0044		-0.0476		0.8006		0.6848		-0.1129		-0.7660	
	(0.208)		(0.211)		(1.408)		(1.555)		(1.037)		(1.001)	
DEBT_MAT		0.0212		0.0196		0.0128		0.0093		0.0296*		0.0328**
		(0.014)		(0.014)		(0.025)		(0.026)		(0.015)		(0.016)
RES_MAT_OIL	0.0272***		0.0234***		0.0132**		0.0108**		0.0051		0.0039	
	(0.004)		(0.004)		(0.006)		(0.005)		(0.005)		(0.005)	
CEO_CS		-0.1867		-0.1990		0.0916		-0.0315		0.0717		0.1074
		(0.229)		(0.230)		(0.673)		(0.696)		(0.321)		(0.323)
CEO_OPT		0.0006		0.0007		0.0002		0.0002		0.0004		0.0004
		(0.000)		(0.000)		(0.000)		(0.000)		(0.000)		(0.000)
IMR	-0.2008**	0.0349	-0.0675	0.0230	-0.4435***	-0.3672***	-0.3348***	-0.3689**	-0.2096***	-0.0748	-0.1387*	-0.1324
	(0.091)	(0.087)	(0.083)	(0.094)	(0.121)	(0.105)	(0.086)	(0.147)	(0.077)	(0.080)	(0.081)	(0.083)
CONSTANT	1.2574***	0.6425***	0.6798***	0.9784***	1.5144***	1.3262***	0.9009***	1.3511***	1.4490***	0.8816***	1.1732***	1.1215***
	(0.117)	(0.115)	(0.121)	(0.133)	(0.241)	(0.198)	(0.215)	(0.322)	(0.123)	(0.127)	(0.143)	(0.144)
Observations	562	570	557	570	128	132	126	129	433	436	430	436
R-squared	0.1874	0.2042	0.1950	0.2045	0.2062	0.2111	0.2643	0.2148	0.0952	0.1078	0.1129	0.1046

Note:

This table provides pooled cross-sectional time-series regressions of the determinants of the weighted-average remaining maturity for swap contracts, put options and costless collars respectively. The results are for the subsample of oil hedgers. *INV_OPP* for investment opportunities; *COR_CI_CF* for the correlation between free cash flows and cost incurred; *LEV* for the leverage ratio measured by the sum of long-term debt in current liabilities plus one-half long-term debt scaled by book value of total assets; *LEV_SQUARED* is the leverage ratio squared; *DTD* for distance-to-default; *DTD_SQUARED* for distance-to-default squared; *DIS_COSTS* for distress costs (in $/BOE); *PROD_CV_OIL* measures oil production uncertainty; *COR_PQ_OIL* measures the oil quantity-price correlation; *OIL_VOL* for oil price volatility; *OIL_RET* for oil return as measured by log(oil 12-month future price/oil sport price); *OIL_SPOT* and *OIL_SPOT_SQUARED* are for oil spot price and oil price squared; *MONEYNESS* measured by the contract strike price minus the average spot price during the current quarter; *STRIKE* is the contract's strike price; *TLCF* for tax loss carry-forwards scaled by the book value of total assets; *TAX_SAVE* for the expected percentage of tax saving; *DEBT_MAT* is the long-term debt maturity (in years); *RES_MAT_OIL* are the expected life of proven oil and gas reserves (in years); *CEO_CS* for the market value of common shares held by firm's CEO (in logarithm); *CEO_OPT* for the number of stock options held by firm's CEO (in 000); *IMR* is the inverse Mills Ratio (Table A.2.1). Robust standard errors using Huber-White-Sandwich estimator are in parentheses. ***Significant at the 1% level, ** Significant at the 5% level, * Significant at the 10% level.

In line with the baseline model (i.e., SYS-GMM), results illustrate the opposite effects of investment program specificities and the non-monotonic relationship between new contracts' maturities and measures of likelihood of financial distress (*LEV* and *DTD*). Distress costs and production uncertainty have the same positive impact on hedging maturities of newly initiated contracts. Results also indicate that the maturities of newly initiated hedging contracts are increasing with strike prices and reserves' expected life duration, and decreasing with tax loss carry-forwards. The coordination between debt maturity and newly initiated collars is again confirmed but it disappears for initiated swaps. Results further show, for gas hedgers, that managers with a higher stake value in the firm prefer long-term collars, as predicted.

However, impacts of leverage ratio and gas price-quantity correlation on maturities of newly initiated swaps contradict our previous findings. Surprisingly, oil and gas market conditions largely lose their effect on hedging contract maturity at initiation. The non-monotonic relationship with spot prices appears to exist only for newly initiated swaps' maturities for oil hedgers. Dissimilar to baseline model results, oil hedgers tend to initiate longer maturity swaps and collars when anticipated oil prices are increasing. One possible explanation for this finding could be that, when oil prices are anticipated to be high in the near term (e.g., we use 12-month future contracts), firms believe that they are more likely to decline in the long run (i.e., mean reversion); hence they tend to initiate long-term hedging contracts to lock-in higher strike prices.[39] Managerial option-holding appears to have no significant impact on maturity choice at the inception of hedging contracts.

2.7.2 Determinants of the early termination decision of hedging contracts

Termination of a hedging contract is considered as an early termination when the outstanding hedging contract has a remaining weighted-average maturity equal to or above six months. For each instrument, we create a dummy variable that takes the value of one when we pick up observations of no-hedging preceded by an outstanding hedging with

[39] We use the following Futures' terms for anticipated oil and gas prices, as observed in the future contracts market: three, six, fifteen, eighteen and twenty-four months ahead. We observe changes only for put option maturities, which become significantly negatively affected by three- and six-month gas future prices, as predicted.

remaining maturity equal to or above six months and zero otherwise. We run pooled cross-sectional time-series probit regressions of these dummy variables on firm fundamentals, production characteristics and oil and gas market conditions. Tables 2.10 and 2.11 report the regression results for gas hedgers and oil hedgers separately.

We find strong evidence of a non-monotonic (convex) relationship between early termination of swap contracts and leverage ratio, in particular.[40] This finding means that early termination of swap contracts decreases then increases with the probability of financial distress. Put options and costless collars also exhibit a non-monotonic (convex) relationship with financial leverage but with lower statistical significance. This empirical evidence corroborates our previous findings. Price-quantity correlations are negatively related to early termination. This is in line with predictions and previous findings that firms with positive price-quantity correlation tend to use longer hedging positions because their generated cash flows are more volatile.

Consistent with our previous findings, higher oil and gas price volatilities prevent the early termination of hedging positions. Results further indicate that when future oil prices are anticipated to be higher, firms tend to early terminate their outstanding swap contracts to profit from the rising prices or to lock in higher strike prices for new contracts. Results again show an evident non-monotonic (convex) relationship between early termination and oil and gas spot prices. When oil and gas prices attain higher levels, outstanding hedging contracts are actively terminated and might be replaced by new contracts with higher strike prices.

[40] We also use distance-to-default and find similar results.

Table 2.10 Determinants of early termination of hedging contracts by gas hedgers

Variables	(1) Swap contracts	(2) Swap contracts	(3) Put options	(4) Put options	(5) Costless collars	(6) Costless collars
OPP_INV	0.2358		-0.3690		0.0856	
	(0.284)		(0.790)		(0.273)	
COR_CI_CF		-0.0556		0.1147		-0.1326
		(0.115)		(0.221)		(0.138)
LEV	-2.9846***		-4.1255*		-0.5718	
	(0.795)		(2.176)		(0.863)	
LEV_SQUARE	1.8096***		4.4556		0.5257	
	(0.664)		(3.985)		(0.628)	
DIS_COSTS		-0.0083		-0.0161		0.0040
		(0.007)		(0.016)		(0.004)
PROD_CV_GAS	0.0479		-0.4728		-0.1927	
	(0.144)		(0.291)		(0.154)	
COR_PQ_GAS	-0.1553		-0.2885		-0.2564*	
	(0.144)		(0.182)		(0.145)	
GAS_VOL	-0.5007***		-0.1973		-0.2868**	
	(0.144)		(0.204)		(0.137)	
GAS_RET	0.1737		-0.1456		0.2358	
	(0.328)		(0.388)		(0.315)	
GAS_SPOT		-0.1848***		-0.3378***		-0.3630***
		(0.068)		(0.108)		(0.081)
GAS_SPOT_SQUARE		0.0061		0.0223***		0.0195***
		(0.005)		(0.007)		(0.006)
MONYNESS		-0.1084		-0.2623		0.2060
		(0.185)		(0.404)		(0.164)
REMAINING_MAT	-0.4496*		-1.2286***		-1.1152***	
	(0.261)		(0.396)		(0.299)	
TAX_SAVE		-0.4619		-0.4984		-0.3618
		(1.036)		(4.009)		(0.834)
DEBT_MAT		-0.0580*		-0.0016		-0.0345
		(0.030)		(0.051)		(0.033)
RES_MAT_GAS	0.0106		-0.0073		0.0146*	
	(0.007)		(0.021)		(0.009)	
CEO_CS		-1.7609		-13.9335*		-3.0740*
		(1.456)		(7.343)		(1.864)
CEO_OPT		-0.0007		0.0009		-0.0039*
		(0.001)		(0.001)		(0.002)
CONSTANT	-1.1494***	-0.7850***	-0.5415	-0.3609	-1.5494***	-0.2803
	(0.167)	(0.210)	(0.354)	(0.385)	(0.232)	(0.251)
Observations	2,312	2,342	559	564	1,865	1,905
Pseudo-R squared	0.0762	0.0569	0.2174	0.0883	0.1527	0.1002
Chi-squared	34.5827	45.6079	44.9633	16.3846	32.6056	45.0865
Significance	0.0001	0.0000	0.0000	0.0593	0.0002	0.0000

Note:
This table provides pooled cross-sectional time-series *PROBIT* regressions of the determinants of the early termination of swap contracts, put options and costless collars respectively. The results are for the subsample of gas hedgers. *INV_OPP* for investment opportunities; *COR_CI_CF* for the correlation between free cash flows and cost incurred; *LEV* for the leverage ratio measured by the sum of long-term debt in current liabilities plus one-half long-term debt scaled by book value of total assets; *LEV_SQUARED* is the leverage ratio squared; *DIS_COSTS* for distress costs (in $/BOE); *PROD_CV_GAS* measures gas production uncertainty; *COR_PQ_GAS* measures the gas quantity-price correlation; *GAS_VOL* for gas price volatility; *GAS_RET* for gas return as measured by log(gas 12-month future price/gas sport price); *GAS_SPOT* and *GAS_SPOT_SQUARED* are for gas spot price and gas price squared; *MONEYNESS* measured by the contract strike price minus the average spot price during the current quarter; *STRIKE* is the contract's strike price; *REMAINING_MAT* is the remaining maturity at the termination date (in years); *TAX_SAVE* for the expected percentage of tax saving; *DEBT_MAT* is the long-term debt maturity (in years); *RES_MAT_GAS* are the expected life of proven oil and gas reserves (in years); *CEO_CS* for the market value of common shares held by firm's CEO (in logarithm); *CEO_OPT* for the number of stock options held by firm's CEO (in 000); Robust standard errors using Huber-White-Sandwich are in parentheses. ***Significant at the 1% level, ** Significant at the 5% level, * Significant at the 10% level.

Table 2.11 Determinants of early termination of hedging contracts by oil hedgers

Variables	(1) Swap contracts	(2) Swap contracts	(3) Put options	(4) Put options	(5) Costless collars	(6) Costless collars
OPP_INV	-0.3025		0.1810		0.2939	
	(0.446)		(0.424)		(0.241)	
COR_CI_CF		-0.0697		0.3345		0.0397
		(0.147)		(0.259)		(0.138)
LEV	-3.2636***		-3.2577		-2.3780**	
	(1.109)		(3.305)		(1.043)	
LEV_SQUARE	2.6593***		2.4391		1.9671	
	(0.931)		(7.625)		(1.219)	
DIS_COSTS		-0.0302		-0.0131		0.0029
		(0.027)		(0.013)		(0.005)
PROD_CV_OIL	0.0381		-0.0322		-0.3278	
	(0.206)		(0.414)		(0.208)	
COR_PQ_OIL	-0.2531**		-0.3286*		-0.3523***	
	(0.127)		(0.183)		(0.116)	
OIL_VOL	-0.1040**		-0.0170		-0.1482**	
	(0.053)		(0.040)		(0.059)	
OIL_RET	3.0460***		1.3630		1.9779	
	(0.921)		(1.426)		(1.214)	
OIL_SPOT		-0.0441***		-0.0290***		-0.0463***
		(0.009)		(0.010)		(0.007)
OIL_SPOT_SQUARE		0.0002***		0.0002**		0.0002***
		(0.000)		(0.000)		(0.000)
MONYNESS		-0.4600***		-0.0167		-0.0452
		(0.097)		(0.027)		(0.030)
REMAINING_MAT	-0.8982***		-1.0269**		-0.8855***	
	(0.285)		(0.456)		(0.282)	
TAX_SAVE		0.9225		6.3143*		1.1954
		(0.890)		(3.477)		(1.130)
DEBT_MAT		-0.0075		-0.2048***		-0.0156
		(0.039)		(0.062)		(0.034)
RES_MAT_OIL	0.0186		-0.0957		-0.0152	
	(0.012)		(0.064)		(0.015)	
CEO_CS		-1.2290		-1.0270		-1.0966
		(1.137)		(2.493)		(0.709)
CEO_OPT		-0.0008		0.0006		-0.0025
		(0.002)		(0.001)		(0.003)
CONSTANT	-1.0042***	-0.4612*	-0.2718	-0.6973*	-0.5360*	-0.1093
	(0.256)	(0.264)	(0.686)	(0.382)	(0.275)	(0.239)
Observations	1,747	1,792	446	471	1,435	1,471
Pseudo-R squared	0.1385	0.3535	0.2079	0.1282	0.1570	0.1770
Chi-squared	37.2153	108.8693	20.0476	25.2569	34.1545	73.2886
Significance	0.0000	0.0000	0.0176	0.0027	0.0001	0.0000

Note:
This table provides pooled cross-sectional time-series *PROBIT* regressions of the determinants of the early termination of swap contracts, put options and costless collars respectively. The results are for the subsample of oil hedgers. *INV_OPP* for investment opportunities; *COR_CI_CF* for the correlation between free cash flows and cost incurred; *LEV* for the leverage ratio measured by the sum of long-term debt in current liabilities plus one-half long-term debt scaled by book value of total assets; *LEV_SQUARED* is the leverage ratio squared; *DIS_COSTS* for distress costs (in $/BOE); *PROD_CV_OIL* measures oil production uncertainty; *COR_PQ_OIL* measures the oil quantity-price correlation; *OIL_VOL* for oil price volatility; *OIL_RET* for oil return as measured by log(oil 12-month futures price/oil sport price); *OIL_SPOT* and *OIL_SPOT_SQUARED* are for oil spot price and oil price squared; *MONEYNESS* measured by the contract strike price minus the average spot price during the current quarter; *STRIKE* is the contract's strike price; *REMAINING_MAT* is the remaining maturity at the termination date (in years); *TAX_SAVE* for the expected percentage of tax saving; *DEBT_MAT* is the long-term debt maturity (in years); *RES_MAT_OIL* is the expected life of proven oil and gas reserves (in years); *CEO_CS* for the market value of common shares held by firm's CEO (in logarithm); *CEO_OPT* for the number of stock options held by firm's CEO (in 000); Robust standard errors using Huber-White-Sandwich are in parentheses. ***Significant at the 1% level, ** Significant at the 5% level, * Significant at the 10% level

.

Results also show that in-the-money swap contracts are less likely to be prematurely terminated by oil hedgers. The remaining maturity of hedging contracts is statistically negatively related to early termination, namely contracts with longer remaining maturity are less likely to be prematurely terminated. Possible explanations could be that the early termination of longer contracts generates higher termination costs, and/or for longer maturities market conditions could improve over the remaining life of the contract, which becomes more beneficial for hedgers. The impact of debt maturity on early termination is negative as predicted but significant only in cases of swap contracts for gas hedgers and put options for oil hedgers. Unexpectedly, higher percentages of tax save motivates the early termination of put options by oil hedgers, and longer gas reserves duration motivates the early termination of collar positions. As predicted, managers with higher stockholding tend to maintain their outstanding hedging contracts, in particular put options and collars.

2.8 Real implications of hedging maturity choice

In this section, we extend the controversial existing literature that focuses on the relationship between corporate hedging and firm risk and value. One strand of this empirical literature finds no support for the risk reduction argument and firm value maximization theory (see for instance Hentschel and Kothari, 2001; Guay and Kothari, 2003; Jin and Jorion, 2006; Fauver and Naranjo, 2010). In contrast, another strand of the literature shows that firm's derivative transactions translate into increases in shareholder value (Allayannis and Weston, 2001; Graham and Rogers, 2002; Carter, Rogers, and Simkins, 2006; Adam and Fernando, 2006; Bartram, Brown, and Conrad, 2011). Other studies give empirical evidence of risk reduction associated with derivative usage (e.g., Guay, 1999; Allayannis and Ofek, 2001; Bartram, Brown, and Conrad, 2011). Aretz and Bartram (2010) review the existing empirical literature on corporate hedging firm value and risk.

We complement the empirical literature by going into further detail and investigating the real implications of the maturity structure of corporate risk management on: (1) firms' stock return sensitivity to changes in oil and gas prices; (2) firms' stock volatility sensitivity to oil and gas price volatilities. In addition, our study does not suffer from the endogeneity concern related to derivatives use as advanced by Jin and Jorion (2006) to explain the controversial results in the literature. This is because we select firms within the same industry; they have the same exposure to commodity risks and they differ vastly in terms of their hedging behaviors. To our knowledge, no empirical study to date gives direct evidence of the effects of maturity structure of corporate hedging on firm value and risk.

2.8.1 Effects of hedging maturity on stock return sensitivity

Our tests expand on that of Jin and Jorion (2006), who run pooled cross-sectional time-series regressions of firms' stock returns on the market and oil and gas price changes, and control for commodity risk hedging and proven oil and gas reserves. We estimate the following models with interaction variables reflecting the impact of hedging maturity in oil beta:

$$R_{i,t} = \alpha_1 + \beta_m \times R_{m,t} + \left(\gamma_{oil} + \sum_{j=1}^{3} \gamma_j \times HM_{i,j,t-1} + \gamma_4 \times \frac{oil\ reserve_{i,t-1}}{MVE_{i,t-1}}\right) \times R_{oil,t} + \beta_{gas} \times R_{gas,t} + \varepsilon_{i,t} \quad (3)$$

and a symmetric equation for gas beta. $R_{i,t}$ is the total stock rate of return for firm *i* in month *t*, $R_{m,t}$ is the monthly return of the S&P 500 index, $R_{oil,t}$ is the monthly rate of change in the price of the NYMEX WTI crude oil near-month futures contract, $R_{gas,t}$ is the monthly rate of change in the price of the NYMEX Henry Hub natural gas near-month futures contract. $HM_{i,j,t-1}$ are three variables reflecting outstanding maturities for swap contracts, put options and costless collars at the end of the previous month for oil (gas) hedgers.[41] Oil reserve/MVE (gas reserve/MVE) are the discounted dollar values of oil (gas) developed reserves divided by the market value of equity.[42] The presented model in (3) allows us to detect the impact of the maturity structure on the sensitivity of firm's stock return to changes in oil and gas prices. We then predict negative signs on the maturities of the three hedging strategies (i.e., swaps, put, and collars). Oil and gas reserves should have

[41] We collect hedging strategy observations on a quarterly basis. For the first two months of each fiscal quarter, we repeat the observations at the end of the previous fiscal quarter. We then suppose that hedging strategies outstanding at the end of the previous fiscal quarter are effective until the end of the current fiscal quarter when we update the observations with the new information reported by firms.

[42] We calculate developed oil and gas reserve quantities on a quarterly basis by considering production, development, and acquisition and exploration activities. For the first two months of each fiscal quarter, we repeat the observations at the end of the previous fiscal quarter. Following SFAS No. 69 and SEC regulations, we calculate a standardized measure of discounted future net cash flows from developed reserves by considering current oil and gas prices, current production quantities and costs, and a discounting rate of 10%. The ratio of reserve/MVE is updated monthly by considering the firm's new stock, oil and gas prices.

positive signs because a greater ratio of reserve/MVE induces greater exposure to oil and gas price fluctuations. We include firm fixed effects and correct standard errors for within-firm correlation (clustering) and heteroskedasticity using the Huber-White-Sandwich estimator. We further include the inverse Mills ratios coming from the Heckman first-step for both subsets of oil hedgers and gas hedgers.

Panel A of Table 2.12 reports the estimations of the model in (3). Columns (1) and (2) of Panel A display the estimation of models with interaction variables between the remaining maturity of the hedging portfolio (i.e., weighted-average maturity of all outstanding hedging instruments) at the end of the previous month and the monthly rate of change in the prices of the NYMEX oil and gas futures contracts for subsets of gas hedging and oil hedging separately. Results show that these interaction variables have the predicted negative sign. However, this negative relationship is statistically significant only for gas hedgers. Longer hedging maturities could lower the sensitivity of stock return to changes in gas prices. Going further in detail, Column (3) of Panel A indicates that swap contracts and costless collars positions with the longest maturities could achieve the lowest sensitivity of stock return to changes in gas prices. Put options have the predicted negative sign but no significant impact. For oil hedgers, the three hedging instruments have no significant impact on the sensitivity of stock return to changes in oil prices as observed for the oil hedging portfolio (Column 4).

Consistent with Rajgopal (1999), and Jin and Jorion (2006), results show that greater oil and gas reserves accentuate a stock’s exposure to oil and gas price fluctuations. We repeat our regressions and replace the ratio of reserve/MVE by the production mix, namely the ratio of the daily gas or oil production quantity divided by the total daily oil and gas production, and find similar results. The coefficients of the production mix ratios are positive, as predicted, and have higher economic significance.

Table 2.12 Effect of hedging maturity on stock return and volatility sensitivity

	Panel A Return Sensitivity				Panel B Volatility Sensitivity			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	Gas	Oil	Gas	Oil	Gas	Oil	Gas	Oil
Variables	Hedgers	Hedgers	Hedgers	Hedgers	Hedgers	Hedgers	Hedgers	Hedgers
(R/SIG)_MKT	1.0155***	1.0723***	1.0143***	1.0700***	1.2699***	1.3036***	1.2679***	1.3037***
	(0.046)	(0.049)	(0.046)	(0.049)	(0.052)	(0.059)	(0.053)	(0.058)
(R/SIG)_OIL	0.2730***	0.3190***	0.2743***	0.2806***	0.2081***	0.1944***	0.2082***	0.2215***
	(0.023)	(0.056)	(0.023)	(0.045)	(0.035)	(0.052)	(0.035)	(0.049)
(R/SIG)_GAS	0.2418***	0.1916***	0.2152***	0.1920***	0.0250	0.0459***	0.0408**	0.0458***
	(0.042)	(0.016)	(0.033)	(0.016)	(0.020)	(0.012)	(0.017)	(0.012)
HEDG_PORT_MAT x	-0.0791***	-0.0562			0.0170	0.0182		
(R/SIG)_(OIL/GAS)	(0.023)	(0.037)			(0.015)	(0.029)		
SWAP_MAT x			-0.0410***	-0.0258			0.0092	0.0125
(R/SIG)_(OIL/GAS)			(0.016)	(0.028)			(0.012)	(0.030)
PUT_MAT x			-0.0273	0.0474			-0.0301	0.0036
(R/SIG)_(OIL/GAS)			(0.027)	(0.061)			(0.022)	(0.045)
COLLAR_MAT x			-0.0401**	-0.0262			0.0015	-0.0230
(R/SIG)_(OIL/GAS)			(0.019)	(0.027)			(0.013)	(0.023)
RES_MVE (OIL/GAS) x	0.0623***	0.0433**	0.0621***	0.0433**				
R_(OIL/GAS)	(0.020)	(0.020)	(0.021)	(0.020)				
MKT_VALUE					0.0000***	0.0000***	0.0000***	0.0000***
					(0.000)	(0.000)	(0.000)	(0.000)
LEV					0.5839***	0.5250***	0.5829***	0.5169***
					(0.084)	(0.106)	(0.084)	(0.105)
DTD					-0.0797***	-0.0823***	-0.0801***	-0.0827***
					(0.009)	(0.009)	(0.009)	(0.009)
Q_RATIO					-0.0213***	-0.0212**	-0.0206***	-0.0207**
					(0.007)	(0.009)	(0.007)	(0.009)
IMR	0.0080	-0.0014	0.0077	-0.0011	0.1145***	0.0895**	0.1112***	0.0826*
	(0.011)	(0.010)	(0.011)	(0.010)	(0.036)	(0.045)	(0.036)	(0.046)
CONSTANT	0.0059	0.0133**	0.0060	0.0131**	0.1920***	0.1976***	0.1952***	0.2030***
	(0.006)	(0.006)	(0.006)	(0.006)	(0.046)	(0.050)	(0.046)	(0.049)
Obs (firm-month)	8,581	7,145	8,581	7,145	8,582	7,150	8,582	7,150
R-squared (within)	0.1840	0.1883	0.1838	0.1884	0.4718	0.4992	0.4720	0.4995
Number of clusters	106	99	106	99	106	99	106	99
F statistic	164.2872	131.2653	125.1299	100.1854	116.2512	114.0222	100.3655	95.3091
Rho	0.0381	0.0325	0.0383	0.0326	0.2148	0.2099	0.2157	0.2103
Sigma_U	0.0300	0.0275	0.0300	0.0275	0.1266	0.1221	0.1269	0.1222
Sigma_E	0.1505	0.1498	0.1506	0.1498	0.2421	0.2369	0.2420	0.2369

Note:

This table reports the coefficient estimates of the fixed effects regressions of the effect of hedging strategy choice on firm's return and risk. The dependent variables are (i) the total stock rate of return for firm *i* in month *t* (Panel A), and (ii) the total stock risk measured by the annualized standard deviation of stock daily returns for firm *i* during month *t* (Panel B). *R_MKT* is the monthly rate of return in the S&P500 index. *R_OIL* is the monthly rate of change of the NYMEX near-month futures contract for oil. *R_GAS* is the monthly rate of change of the NYMEX near-month futures contract for natural gas. *SIG_MKT* is the annualized standard deviation of the market index daily returns during the month *t*. *SIG_OIL* and *SIG_GAS* are the annualized standard deviations of the oil (gas) daily returns during the month *t* (e.g., *R_OIL* and *R_GAS*). *HEDG_PORT_MAT* is the remaining maturity of the hedging portfolio observed at the end of the previous month *T-1*. *SWAP_MAT*, *PUT_MAT*, *COLLAR_MAT* are the remaining maturities observed at the end of the previous month *t-1*. *RES_MVE* stands for the lagged value of the ratio of discounted dollar value of oil (gas) developed reserves divided by the market value of equity *MKT_VALUE* measured by the logarithm of the market value of common shares outstanding (e.g., closing price at the end of the month multiplied by the number of common shares outstanding). *LEV* for the leverage ratio measured by the book value of long-term debt in current liabilities plus one-half long-term debt scaled by the book value of total assets; *Q_RATIO* for the quick ratio measured by the book value of cash and equivalent of cash scaled by the book value of current liabilities; *DTD* for distance-to-default; *IMR* is the Inverse Mills Ratio for oil hedgers and gas hedgers respectively coming from the Heckman first-step (Table A.2.1). Standard errors, corrected for heteroskedasticity and clustering using Huber-White-Sandwich estimator, are in parentheses. ***Significant at the 1% level, ** Significant at the 5% level, * Significant at the 10% leve

2.8.2 Effects of hedging maturity on stock volatility sensitivity

This sub-section provides detailed evidence of the relation of firms' total risk measured by the annualized stock return volatility, and firms' hedging strategies. Our aim is to examine which hedging maturity better mitigates the effects of the exposure to oil (gas) price volatilities on firms' total risk. Following Guay (1999), we partition the total stock return volatility into market risk, oil and gas risks and firm-specific risk. We then estimate the following model with interaction variables for oil hedgers:

$$\sigma_{i,t} = \omega_0 + \omega_m \times \sigma_{m,t} + \left(\omega_{oil} + \sum_{j=1}^{3} \omega_j \times HM_{i,j,t-1}\right) \times \sigma_{oil,t} + \omega_{gas} \times \sigma_{gas,t} + \sum_{j=4}^{8} \omega_j \times Control_{i,t} + \delta_{i,t} \quad (4)$$

and a symmetric equation for gas hedgers where $\sigma_{i,t}$ is the annualized standard deviation of daily stock returns for firm *i* during month *t* to capture the aggregate firm risk, $\sigma_{m,t}$ is the annualized standard deviation of daily S&P 500 index returns during month t, $\sigma_{oil,t}$ are $\sigma_{gas,t}$ are the annualized standard deviations of daily returns of the NYMEX WTI crude oil and Henry Hub natural gas near-month futures contracts during month t. $HM_{i,j,t-1}$ are outstanding remaining maturities as previously defined. $Control_{i,t}$ are a set of exogenous variables related to firms' characteristics. We retain firm size, leverage and liquidity, which Bartram, Brown and Stulz (2012) find to be important determinants of both firm total risk and systematic risk. We also use Distance-to-Default, defined above, and the inverse Mills ratios coming from the Heckman first-step for both subsets of oil hedgers and gas hedgers respectively. This specification partitions total stock return volatility into firm-specific exposures to oil and gas volatilities, global market index risk and firm-specific characteristics. We include firm fixed effects and correct standard errors for within-firm correlation (clustering) and heteroskedasticity using the Huber-White-Sandwich estimator.

Panel B of Table 2.12 reports the estimations of the model in (4). Panel B also shows the estimation of models with interaction variables between the remaining maturity of the hedging portfolio at the end of the previous month and annualized standard deviations for oil and gas NYMEX contracts respectively (Column 5 and 6). Overall, results show that these interaction variables, in all specifications, have no statistically significant effects on the sensitivity of stock volatility to commodity price risk. Results also suggest that larger firms with higher financial leverage have higher return volatility, and firms with higher Distance-to-Default and carrying higher cash balances have lower stock return volatility.

2.9 Concluding Remarks

A substantial body of the corporate risk management literature has increased our understanding of the motivations, virtues and value implications of hedging. This literature derives its theoretical or empirical predictions based on hedging extent or hedging activity participation. Due to the lack of data, the empirical maturity structure of corporate risk management is discussed in a largely descriptive manner. In this study, we go beyond the classical questions in the corporate hedging literature and investigate the following questions: How far ahead do firms hedge? What are the determinants of the maturity structure of firms' hedging programs? and What are the economic effects of hedging maturities on firm value and risk?

Using an extensive and new hand-collected dataset on the risk management activities of 150 U.S. oil and gas producers and the empirical predictions of Fehle and Tsyplakov (2005), we find that the maturity structure of corporate hedging is positively influenced by firms' investment opportunities. Results also show that a positive correlation between investment expenditure and generated cash flows gives firms a natural hedge and motivates the use of short-term contracts. We provide strong evidence that hedging maturities should increase and then decrease with the likelihood of financial distress, as conjectured by Fehle and Tsyplakov (2005). Highly distressed oil and gas producers should enter long-term put options as a risk-shifting strategy. Results indicate that oil and gas producers with higher cash flow volatility tend to use longer maturity hedging to avoid shortfalls in their future cash flows.

Interestingly, we observe strong evidence of the impact of market conditions on hedging maturity choice. We give empirical evidence of a non-monotonic relationship between oil and gas spot prices and hedging maturities, as suggested by Fehle and Tsyplakov (2005). In addition, hedging contract features (i.e., moneyness, strike price) have an evident impact on maturity choice. Regarding asset-liability management, oil and gas producers appear to match the maturities of their hedging positions and the maturities of their assets and debt. Tax function convexity seems to influence the maturity structure of firm's hedging. We also give the first direct evidence of the motivations for early termination of hedging contracts, which appears to be strongly influenced by the likelihood of financial distress, spot prices and their volatilities, price-quantity correlation, and the remaining maturities of contracts. We also find evidence of a non-monotonic (convex) relationship between early termination and financial leverage and spot prices. Table A.2.2 summarizes our predictions and findings arising from the baseline model (i.e., SYS-GMM), maturity choice at inception of the hedging contract, and early termination of contracts. Overall, this table shows that our findings are stable and consistent across these tests. Finally, we explore the real effects of hedging maturity on firm value and risk, and provide empirical evidence that long-term hedging lowers the sensitivity of the stock return to changes in gas prices in particular.

APPENDIX 2.1

FIRST STEP OF THE TWO-STEP HECKMAN REGRESSIONS WITH SAMPLE SELECTION: DETERMINANTS OF THE OIL OR GAS HEDGING DECISION

Table A.2.1: First Step of the Two-Step Heckman regressions with sample selection: Determinants of the oil or gas hedging decision

Variable	**Oil hedge**	**Gas hedge**
TAX_SAVE	0.9005**	0.1232
	(0.366)	(0.428)
LEVERAGE	1.5843***	1.9170***
	(0.091)	(0.096)
CASH_COST	0.0398***	0.0605***
	(0.003)	(0.005)
BVCD	-1.2947***	-1.2417***
	(0.246)	(0.214)
Q_RATIO	-0.1056***	-0.1288***
	(0.014)	(0.014)
RES_(OIL/GAS)	-0.0009***	-0.0001***
	(0.000)	(0.000)
MKT_VALUE	0.3924***	0.5700***
	(0.043)	(0.043)
SALES	0.1994***	0.0894***
	(0.019)	(0.017)
CONSTANT	-2.2678***	-2.1663***
	(0.088)	(0.089)
Observations	5,798	5,798
Pseudo-R squared	0.3025	0.3129
Chi-squared	2399.4838	2512.4946
Significance	0.0000	0.0000

Note:

This table reports the coefficients estimates of the Probit model. The dependent variable is the hedging decision dummy variable that takes the value of 1 if the oil and gas producer have any oil and gas hedging position for the quarter and 0 otherwise. The independent variables are: *TAX_SAVE* for the expected percentage of tax saving; *LEVERAGE* for the leverage ratio measured by the book value of long-term debt scaled by the book value of total assets; *CASH_COST* is the production cost per Barrel of Oil Equivalent (BOE); *BVCD* for the book value of convertible debt scaled by the book value of total assets. *Q_RATIO* for the quick ratio measured by the book value of cash and equivalent of cash scaled by the book value of current liabilities; *RES_OIL* and *RES_GAS* are the quantities of proven reserves for oil (for oil hedgers) and gas (for gas hedgers); *MKT_VALUE* measured by the logarithm of the market value of common shares outstanding (i.e., closing price at the end of the quarter multiplied by the number of common shares outstanding); *SALES* measured by the logarithm of sales at the end of the quarter. Standard errors are in parentheses. ***Significant at the 1% level, ** Significant at the 5% level, * Significant at the 10% level.

APPENDIX 2.2

SUMMARY OF OUR PREDICTIONS AND FINDINGS

Table A.2.2 Summary of our predictions and findings

		Hedging maturity structure Baseline model: SYS-GMM			Maturity choice at the inception of the hedging contract			Early termination of the hedging contract		
Hedging strategies		Swap contracts	Put options	Costless Collars	Swap contracts	Put options	Costless collars	Swaps contracts	Put options	Costless collars
Investment programs and real options										
Investment opportunities	Predicted	+	+	+	+	+	+	-	-	-
	Gas Hedgers	+***	+***	+	+	-	+**	+	-	+
	Oil Hedgers	+**	+**	+*	+	+***	+***	-	+	+
Correlation between internal funds and Investment programs	Predicted	-	-	-	-	-	-	+	+	+
	Gas Hedgers	-	-**	-/+	-***	-***	-	-	+	-
	Oil Hedgers	-***	+	+	-***	-	-	-	+	+
Oil and gas market conditions										
Spot price	Predicted	+	+	+	+	+	+	-	-	-
	Gas Hedgers	+***	+***	+****	-	+	+**	-***	-***	-***
	Oil Hedgers	+***	+	+***	+***	+	+**	-***	-***	-***
Spot price squared	Predicted	-	-	-	-	-	-	+	+	+
	Gas Hedgers	-***	-***	-***	+	-	-	+	+***	+***
	Oil Hedgers	-***	-	-**	-***	-	-	+***	+**	+***
Return	Predicted	-	-	-	-	-	-	+	+	+
	Gas Hedgers	-**	-***	-***	-/+	-	-	+	-	+
	Oil Hedgers	-/+	-	-	+***	-/+	+***	+***	+	+
Price volatility	Predicted	+	+	+	+	+	+	-	-	-
	Gas Hedgers	+***	+***	+**	-	-/+	+	-***	-	-**
	Oil Hedgers	+***	+**	+***	+**	+**	+	-**	-	-**
Oil and gas production function characteristics										
Production uncertainty	Predicted	-	-	-	-	-	-	+	+	+
	Gas Hedgers	+**	+	+***	+	+**	+***	+	-	-
	Oil Hedgers	+*	+	-	+***	-	-*	+	-	-
Price–quantity correlation	Predicted	+	+	+	+	+	+	-	-	-
	Gas Hedgers	+	-/+	+**	-**	-*	+	-	-	-*
	Oil Hedgers	+	-/+	+**	-/+	-	+***	-**	-*	-***

Continued

Table A.2.2-*Contunied*

		Hedging maturity structure Baseline model: SYS-GMM			Maturity choice at the inception of the hedging contract			Early termination of the hedging contract		
Hedging strategies		Swap contracts	Put options	Costless Collars	Swap contracts	Put options	Costless collars	Swaps contracts	Put options	Costless Collars
Financial distress										
Leverage	Predicted	+	+	+	+	+	+	-	-	-
	Gas Hedgers	+***	+***	+***	-**	+**	+**	-***	-*	-
	Oil Hedgers	+***	+**	+***	-***	-	-	-***	-	-**
Leverage squared	Predicted	-	-	-	-	-	-	+	+	+
	Gas Hedgers	-***	-***	-***	+***	-**	-*	+***	+	+
	Oil Hedgers	-**	-	-***	+***	+	+	+***	+	+
Distance to default	Predicted	+	+	+	+	+	+	-	-	-
	Gas Hedgers	+***	+	+***	-	-	+	**n/a**	**n/a**	**n/a**
	Oil Hedgers	+**	+***	+***	+***	+***	+**	**n/a**	**n/a**	**n/a**
Distance to default squared	Predicted	-	-	-	-	-	-	+	+	+
	Gas Hedgers	-*	+	-***	+	+	-	**n/a**	**n/a**	**n/a**
	Oil Hedgers	-	-***	-**	-***	-***	-*	**n/a**	**n/a**	**n/a**
Distress costs	Predicted	-	-	-	-	-	-	+	+	+
	Gas Hedgers	+	+*	+	+**	+**	+	-	-	+
	Oil Hedgers	-/+	+***	+	+*	+***	-/+	-	-	+
Contract features										
Moneyness	Predicted	+	+	+	+	+	+	-	-	-
	Gas Hedgers	+***	+	+*	**n/a**	**n/a**	**n/a**	-	-	+
	Oil Hedgers	+***	+	+***	**n/a**	**n/a**	**n/a**	-***	-	-
Strike price	Predicted	+	+	+	+	+	+	-	-	-
	Gas Hedgers	+***	+***	+***	-	+**	+***	**n/a**	**n/a**	**n/a**
	Oil Hedgers	+***	+***	+***	+***	+**	+***	**n/a**	**n/a**	**n/a**
Remaining maturity	Predicted							-	-	-
	Gas Hedgers							-*	-***	-***
	Oil Hedgers							-***	-**	-***

Continued

Table A.2.2-*Contunied*

Hedging strategies		Hedging maturity structure Baseline model: SYS-GMM			Maturity choice at the inception of the hedging contract			Early termination of the hedging contract		
		Swap contracts	Put options	Costless Collars	Swap contracts	Put options	Costless collars	Swaps contracts	Put options	Costless collars
Tax incentives										
Tax loss carry-forwards	Predicted	-	-	-	-	-	-	+	+	+
	Gas Hedgers	-***	-***	-**	-***	-***	-	**n/a**	**n/a**	**n/a**
	Oil Hedgers	-***	-***	-	-***	-***	-***	**n/a**	**n/a**	**n/a**
Tax save	Predicted	+	+	+	+	+	+	-	-	-
	Gas Hedgers	-/+	+**	+**	-*	-	+	-	-	-
	Oil Hedgers	+	+	+	-/+	+	-	+	+*	+
Asset-liability management										
Debt maturity	Predicted	+	+	+	+	+	+	-	-	-
	Gas Hedgers	+***	-/+	+***	+	-/+	+**	-*	-	-
	Oil Hedgers	+***	-/+	+***	+	+	+**	-	-***	-
Reserve expected life	Predicted	+	+	+	+	+	+	-	-	-
	Gas Hedgers	+***	+***	+***	+***	+***	+**	+	-	+*
	Oil Hedgers	+***	+**	+***	+***	+**	+	+	-	-
Managerial compensation policy										
Managerial shareholding	Predicted	+	+	+	+	+	+	-	-	-
	Gas Hedgers	+	-/+	+	+	-/+	+**	-	-*	-*
	Oil Hedgers	-	-	-	-	-/+	+	-	-	-
Managerial option holding	Predicted	-	-	-	-	-	-	+	+	+
	Gas Hedgers	+	-/+	-***	+	-/+	+	-	+	-*
	Oil Hedgers	+*	-/+	-	+	+	+	-	+	-

Note:
This table presents a summary of our predictions and findings pertaining to the hypotheses tested. The superscripts ***, **, and * mean that the sign is significant at the 1%, 5%, and 10% levels, respectively; -/+ means that the given variable takes the minus sign in some specifications and the plus sign in others, but with no significant effects; n/a stands for non-available and means that the given variable is not included in the regression.

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CHAPITRE III

ARTICLE 3

VALUE AND RISK EFFECTS OF CORPORATE HEDGING:

SOME EVIDENCE FROM THE U.S. OIL AND GAS INDUSTRY

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ABSTRACT

This paper revisits the question of whether derivative use has real implications on firm value and risk. In light of the controversial results of the previous research, this paper revisits the hedging premium question for firms. We control for the endogeneity problem between derivatives use decision and other firm's financial policies. Using a new dataset on the hedging activities of 150 U.S. oil and gas producers, we find that hedging allows firms to realize higher selling prices and therefore higher accounting performance. We also find evidence of a significant risk reduction related to hedging. Finally, results show that hedging eases access to higher debt level, but with no real effects on loan spread. These real implications of hedging should translate into value gains for shareholders.

Keywords: Corporate risk management, real implications, value creation, risk reduction, hedging benefits, oil and gas industry.

JEL classification: D8, G32.

3.1 Introduction

In the frictionless world of Modigliani and Miller (M&M) (1958), there are no rationales for corporate risk management because it does not enhance firm value. However, risk management through derivative instruments becomes increasingly widespread in the imperfect real world where hedging activity has become very important. The Bank of International Settlements (BIS) reports that, by the end of June 2013, notional amounts outstanding of $10.6 trillion and $35.8 trillion for, respectively, over-the-counter foreign exchange (FX) and interest rate (IR) derivatives held by non-financial entities. At the same date, over-the-counter commodity contracts have a notional amount outstanding of about $2 trillion, gold not included. At the beginning of the millennium, these figures were only about $2.8 trillion, $5.5 trillion, and $0.3 trillion for FX, IR and commodity contracts (gold not included). Empirical evidences (e.g., Haushalter, 2000, Jin and Jorion, 2006, Kumar and Rabinovitch, 2013) show increasing fraction of production protected from price fluctuations using derivatives for the petroleum industry, for example.[43]

In the last three decades, growing risk management literature has emerged motivated by data availability and particularly improvements in theoretical backgrounds of corporate demand for protection. Mayers and Smith (1982), Stulz (1984), and Smith and Stulz (1985) are first to build a hedging theory relying on the introduction of frictions into the perfect world of M&M, and show that market frictions (e.g., bankruptcy costs, tax shields, agency costs) enable firms to create value by hedging actively. The subsequent empirical literature extends the knowledge on hedging determinants (e.g., Nance, Smith, and Smithson, 1993, Mian, 1996, Tufano, 1996, Haushalter, 2000). More recent lines in the literature focus on hedging value and risk implications for firms (e.g., Guay, 1999, Allayannis and Weston, 2001, Jin and Jorion, 2006). Yet, empirical findings on value implications of risk management are fairly mixed and inconclusive. Methodological problems related to

[43] Haushalter (2000) reports an average fraction of production hedged of 30% for each year 1992, 1993, and 1994. Jin and Jorion (2006) find that an average firm hedge 33% (41%) of next-year oil (gas) production. Kumar and Rabinovitch (2013) report an average fraction of production hedged of 46% for the current quarter. Their measure combines both oil and gas production. We provide more details on our sample firms' hedging ratios in subsequent section.

endogeneity of derivative use and other firm's decisions, sample selection, sample size, and the existence of other potential hedging mechanisms (e.g., operational hedge) are often blamed for these mixed empirical evidences.

This paper revisits the question of hedging virtues in a more comprehensive and multifaceted manner for a sample of U.S oil and gas producers. To better gauge the real implications of hedging, we examine its effects on the following firm characteristics: 1) *realized* oil and gas prices.[44] Oil and gas prices constitute the primary source of market risk for firms in the petroleum industry. Direct impacts of hedging activities would be materialized in firm's revenues throughout its output prices. To the best of our knowledge, this study gives the first direct evidence of the hedging effects on firm's output selling prices. 2) Firm's accounting performance as measured by the return on equity and the return on asset. We check whether hedging effects translates into higher accounting profits. 3) Firm risk as measured by its total, idiosyncratic, and systematic risk. One would expect that hedging should attenuate firm's exposure to the underlying market risk factor which leads to lower firm riskiness. In doing so, we verify particularly if firms are hedging or speculating by using derivatives. 4) Firm external financing. We assess if hedging eases firm's access to higher debt financing or not. In addition, we check if hedging is valued by lenders. Do hedgers obtain lower loan spread than non-hedgers? Prior literature suggests that hedging should lower the probability of left-tail outcomes which reduces expected costs related to financial distress and bankruptcy, and consequently firm's ability to raise external funds increases (e.g., Smith and Stulz, 1985, Stulz, 1996).

Endogeneity of hedging decision is a major concern for any study in corporate risk management. To overcome this first source of inconsistency in empirical literature, we consider the feedback effects between hedging and other firm's financial decisions. We then use simultaneous equations setting based on three-stage least squares (3-SLS).[45] The 3-SLS

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[44]These *realized* selling prices include the monetary effects of hedging activities, if any. Fortunately, COMPUSTAT database gives historical data on oil and gas selling prices realized by producers on quarterly basis from 2002.

[45] Geczy, Minton, and Schrand (1997) use a two-stage least square (2-SLS) for currency derivative use and capital structure decisions. Graham and Rogers (2002) also use similar approach to link the hedging extent and debt ratio. Dionne and Triki (2013) use a minimum distance procedure to estimate a simultaneous system linking hedging extent and leverage ratio.

estimation has the crucial advantage of considering cross-equation correlation in residuals. Therefore, it leads to more efficient estimations. Moreover, the endogeneity problem is minimized in our tests because the sample selection bias should be alleviated by selecting firms from the same industry; they bear important commodity risk exposures and vastly differ in terms of their hedging behavior as in Jin and Jorion (2006).

Prior literature analyzes either binary variables indicating whether a firm uses derivatives, or sometimes aggregate hedging positions and percentage of production hedged. We go beyond the aggregate feature of the hedging and use detailed information on positions by derivative instrument in use (i.e., swap contracts, put options, and costless collars). We then link the hedging extent by instrument to the retained measure of firm characteristics. To gain further insight, we study the hedging activities of commodities, oil and gas, separately. In doing so, our study identifies more precise mechanism of how hedging affects firm value and risk.

Our evidences suggest that gas hedgers earn noticeably higher gas selling prices. Oil hedging seems to have no real effects on oil prices. For individual instrument, results indicate that costless collars and particularly put options positions are successful hedging strategies. For oil hedging, using swap contracts appears to be loser strategy. Surprisingly, results suggest that oil and gas producers do not frequently adjust their hedging positions in response to their realized prices. More importantly, we find strong evidence that hedging translates into higher accounting performance, as measured by the return on asset and the return on equity, suggesting that hedging enhances the shareholders wealth. The increase in accounting profitability is more attributable to put options. Results show a bi-directional effect signifying that oil and gas producers with higher accounting performance increase swap contracts positions for gas hedging and reduce their collars positions for oil hedging.

Consistent with prior literature (e.g., Guay, 1999; Bartram, Brown, and Conrad, 2011), we find that hedging reduces firm total and idiosyncratic risk. This reduction is statistically and economically significant. The reduction is more attributable to swap contracts for gas hedging and to put options for oil hedging. In addition, interest rate hedging participates in this reduction with significant negative impact on firm risk. Interestingly, firms with higher riskiness tend to cut their swap and collar positions and to increase gas hedging with put options. This finding implies that firms with more volatile value tend to engage in risk-shifting strategies. Pertaining to firm systematic risk, we find that only collars have a negative impact on firm market beta, but with a low statistical significance (10% level). All the other hedging extent measures have no significant effect on firm systematic risk. Overall, this finding suggests that firms' cost of equity does not increase due to hedging as suggested by Adam and Fernando (2006), who do not find a positive effect of gold hedging on firm's market beta. This finding also suggests that any potential positive effects associated with oil and gas hedging should translate into value enhancement for shareholders because there is no off-setting increase in the required cost of equity. Firms with higher systematic risk tend to increase their collar positions and to reduce their put option positions.

Regarding firm debt capacity, we find that oil and gas hedging eases the access to debt financing. The results are statistically and economically significant and consistent with the hypothesis that hedging reduces the expected cost of financial distress and therefore increases firm debt capacity (Stulz, 1984; Smith and Stulz, 1985; Stulz, 1996). Interest rate hedging also has similar positive effects on firm's debt level. The increase in firm access to debt financing should translate into higher firm value throughout the tax-savings related to debt as suggested by Leland (1998), Ross (1996) and Graham and Rogers (2002). We also find strong evidence of a positive feedback effect that runs from leverage to hedging extent. Pertaining to the cost of debt financing, results indicate that oil hedging with collars lowers the loan spread but oil hedging with swaps increases this spread. The net effect of oil hedging portfolio is insignificant. Surprisingly, the hedging of foreign exchange risk noticeably reduces loan spread and interest rate hedging has no real effects. Results further show that higher loan spread implies higher hedging extent by swap contract particularly.

The remainder of this paper is organized as follows. Section 2 reviews related literature. Section 3 describes the sample, explains the construction of variables, and provides summary statistics. Section 4 discusses our univariate and multivariate results. Section 5 concludes the paper.

3.2 Real implications of corporate risk management: a review

3.2.1 Risk management, firm value and risk

One strand of the corporate hedging literature finds no support for the risk reduction argument and firm value maximization theory. Using a sample of 425 large US corporations from 1991 to 1993, Hentschel and Kothari (2001) find that derivative users display economically small difference in their stock return volatility compared with non-users, even for firms with larger derivatives holdings. Guay and Kothari (2003) study the hedging practices of 234 large non-financial firms, and find that the magnitude of the derivative positions is economically small compared to firm-level risk exposures and movements in equity values. Jin and Jorion (2006) revisit the question of the hedging premium for a sample of 119 US oil and gas producers from 1998 to 2001. Although they find that oil and gas betas are negatively related to hedging extent, they show that hedging has no discernible effect on firm value. Fauver and Naranjo (2010) study derivative usage by 1,746 US firms during 1991-2000, and assert that firms with greater agency and monitoring problems exhibit an economically significant negative association of 8.4% between firms' Tobin's Q and derivative usage.

In contrast, Tufano (1998) studies hedging activities of 48 North American gold mining firms from 1990 through March 1994, and finds that gold firm exposures (i.e., gold betas) are negatively related to the firm's hedging production. Guay (1999) looks at a sample of 254 non-financial corporations that began using derivatives in the fiscal year 1991, and reports that new derivative users experience a statistically and economically significant 5% reduction in stock return volatility compared to a control sample of non-users. Using a sample of S&P 500 non-financial firms for 1993, Allayannis and Ofek (2001) find strong evidence that foreign currency hedging reduces firms' exchange-rate exposure. Allayannis and Weston (2001) give the first direct evidence of the positive relation between currency derivative usage and firm value (as defined by Tobin's Q) and show that for a sample of 720 non-financial firms, the market value of foreign currency hedgers is 5% higher on average than for non-hedgers.

Carter, Rogers, and Simkins (2006) investigate jet fuel hedging behavior of firms in the US airline industry during 1993-2003, and find an average hedging premium of 12%-16%. Adam and Fernando (2006) examine the outstanding gold derivative positions for a sample of 92 North American gold mining firms for the period 1989-1999 and obtain that derivatives use translates into value gains for shareholder since there is no offsetting increase in firm's systematic risk. Bartram, Brown, and Conrad (2011) explore the effect of derivative use on firm risk and value for a large sample of 6,888 non-financial firms from 47 countries during 2000-2001. Their evidence suggests that using derivatives reduces both total risk and systematic risk, and is associated with higher firm value, abnormal returns, and larger profits.

Recently, Choi, Mao, and Upadhyay (2013) examine the financial and operational hedging activities of 73 U.S pharmaceutical and biotech firms during 2001-2006. They find that hedging is associated with higher firm value and that this enhancement is larger for firms subject to higher information asymmetry and larger growth options. They estimate that the hedging premium for their sample is about 13.8%. Perez-Gonzales and Yun (2013) exploit the introduction of weather derivatives in 1997 as a natural experiment for a sample of energy firms. They find evidence of positive effects of weather derivative use on firm's value as measured by the market to book ratio.

3.2.2 Risk management and firm cost of capital

Mayers and Smith (1982) and Smith and Stulz (1985) argue that hedging should reduce financial distress costs by lowering the probability of left-tail outcomes, and therefore enhance firm value. The association between hedging and debt financing is examined in many empirical studies. Dolde (1995) and Haushalter (2000) find that leverage ratio increases hedging intensity. On the contrary, another strand in the literature finds no support for this conjecture (e.g., Nance, Smith, and Smithson, 1993, Allayannis and Ofek, 2001). Another line of theory suggests that corporate risk management increases firm's debt capacity. Stulz (1996), Ross (1996), and Leland (1998) assert that corporate risk management enables firm to increase its debt capacity, and therefore firm's value increases due to tax-related benefits of debt (i.e., interest deduction).

To control for potential endogeneity of derivative use and capital structure decisions, some empirical works examine the association between hedging and leverage in a simultaneous equations framework. Gezcy, Minton, and Shrand (1997) run a set of simultaneous equations and find no evidence of feedback effects between firm's derivative use and debt level. On the contrary, Graham and Rogers (2002) also use the same simultaneous equations procedure for a different sample and find strong positive mutual effects between derivatives use and debt capacity of the firm. They also verify that leverage increases due to hedging, which enhances firm value by approximately 1.1% throughout the tax-related savings from debt financing. Dionne and Triki (2013) estimate simultaneously the derivative use and capital structure decisions for a sample of North American gold mining firms. Their findings provide evidence of a positive impact of leverage ratio on gold hedged quantity. However, they find no bi-directional effects because hedging does not increase debt capacity of their sample firms.

Lin, Philips, and Smith (2008) examine theoretically and empirically the interaction between hedging, investment, and financing decisions. From a simultaneous equations setting, their findings are consistent with the debt capacity argument for hedging. That is, there is a significant positive bi-directional effect between firm's hedging and leverage. Regarding the cost of capital, Gay, Lin, and Smith (2011) investigate the relation between derivative use and firm's cost of equity. From a large sample of non-financial firms during the two sub-periods 1992-1996 and 2002-2004, they find that hedgers have lower cost of equity than non-hedgers by about 24-78 basis points. This reduction comes essentially from lower market betas for derivative users. Their results are robust to endogeneity concern related to derivative use and capital structure decisions. Campello, Lin, Ma, and Zou (2011) examine a large sample of 2,718 loan contracts signed by 1,185 firms and find that hedging interest rate and foreign exchange risk noticeably reduces the cost of debt, measured by the loan spread, by about 53 basis points which corresponds to a reduction of 28% of the average loan spread (188 basis points). Recently, Kumar and Rabinovitch (2013) find evidence of cost of debt reduction due to oil and gas hedging for a sample of 41 U.S. oil and gas producers during 1996-2008. Their estimated reduction in cost of borrowing is about 27.3 basis points, which translates into an average reduction of 14.26% in loan spread.

3.3 Sample construction and characteristics

3.3.1 Data collection

We begin our sampling by a first list of 413 US oil and gas producers with the primary Standard Industrial Classification (SIC) code 1311.[46] Next, we retain firms which are covered by COMPUSTAT, have at least five years of historical data on oil and gas reserves during the period 1998 to 2010, and have their 10-K and 10-Q reports available from the EDGAR website. Our final sample consists of 150 firms with an unbalanced panel of 6,326 firm–quarter observations.

Data regarding financial characteristics are retrieved from the COMPUSTAT quarterly dataset held by Wharton Research Data Services (WRDS). Operational and geographic segment data are taken from the SEGMENT files of COMPUSTAT. Other items related to institutional shareholdings are from the Thomson Reuters dataset maintained by WRDS. Data related to oil and gas production quantities, cash costs, geographical dispersion in production activities are taken from Bloomberg's annual dataset and verified and completed by hand-collecting data directly from 10-K annual reports. Daily stock return data comes from the CRSP dataset held by WRDS and daily closing prices of oil and gas Future contracts are from the web site of the Energy Information Administration. We obtain loan contracts data for our sample firms from Loan Pricing Corporation's Dealscan database held by WRDS. Characteristics on loan contracts include loan spread, maturity, size, types, and purposes. Our final loan sample contains a total of 694 loan contracts signed by 115 firms. Quarterly data about oil and gas producers' hedging activities were hand-collected from 10-K and 10-Q reports.

3.3.2 Descriptive statistics: Firms and loans' characteristics

Table 3.1 presents summary statistics for firms and loan contracts characteristics in the sample. Statistics show that gas hedging and oil hedging occurred in 49.58% and 41.21% of

[46] The SIC code 1311, Crude Petroleum and Natural Gas, comprises companies primarily involved in the operation of properties for the recovery of hydrocarbon liquids and natural gas.

the firm–quarters in the sample, respectively. 55.15% of the sample firm-quarters hedge gas and/or oil. These proportions are somewhat lower than proportions reported in Jin and Jorion (2006), who examine a sample of 119 U.S oil and gas producers from 1998 to 2001 (their corresponding proportions are 51.12%, 43.33% and 62.42%). In addition, IR and FX risk hedging occurred, respectively, in 17.18% and 4.5% of the firm–quarters.

Table 3.1 also reports summary statistics on firms' financial characteristics such as firm size (market value of assets) and sales. Mean and median values of these characteristics show that our sample comprises relatively small firms and a few large producers. On average, 73.5% of total assets are fixed assets as indicated by the tangibility measure (net PPE scaled by total assets) since oil and gas industry is highly capital intensive. This latter percentage is somewhat lower than the 83% reported in Kumar and Rabinovitch (2013) for a sample of 41 U.S oil and gas producers for the period 1996-2008. Sample firms derive, on average, 87% of their revenues from oil and gas production, with 35% from oil and 52% from gas production, and 87% of their sales are in the U.S market.

Table 3.1 Summary statistics for sample firms

Variables	Obs	Mean	Median	1st quartile	3rd quartile	Std. Dev
Variables that proxy for hedging activity						
GAS_HEDG	6,326	0.496	0	0	1	0.500
OIL_HEDG	6,326	0.412	0	0	1	0.492
OIL/GAS_HEDG	6,326	0.551	1	0	1	0.497
IR_HEDG	6,326	0.172	0	0	0	0.377
FX_HEDG	6,326	0.045	0	0	0	0.207
Variables that proxy for underinvestment costs						
INV_OPP	6,006	0.224	0.075	0.041	0.129	3.619
Variables that proxy for tax advantage						
TLCF	6,066	0.134	0	0	0.064	0.438
TAX_SAVE	6,160	0.052	0.048	0.029	0.070	0.051
Variables that proxy for financial constraints						
DTD	5,686	2.234	2.052	1.323	2.862	1.361
SIGMA_ASSET	5,675	0.492	0.395	0.276	0.588	0.341
LEVERAGE	6,063	0.289	0.263	0.095	0.407	0.261
Q_RATIO	6,069	1.555	0.275	0.079	0.850	5.334
CASH_COST	6,241	9.860	7.527	4.684	12.230	8.441
Variables that proxy for information asymmetry						
%_CS_INST	6,326	0.372	0.299	0.000	0.742	0.353
Variables that proxy for production characteristics						
UNCER_OIL	6,058	0.416	0.313	0.141	0.587	0.388
PQ_COR_OIL	6,119	0.229	0.455	-0.287	0.723	0.587
UNCER_GAS	6,078	0.408	0.303	0.146	0.582	0.359
PQ_COR_GAS	6,112	0.154	0.230	-0.174	0.504	0.419
HERF_GAS	6,180	0.063	0	0	0	0.183
HERF_OIL	6,178	0.100	0	0	0	0.233
Variables that proxy for revenues characteristics						
SALES	6,147	1,419.332	24.062	3.370	170.193	7,880.685
OIL&GAS_REV	6,216	0.864	1	0.981	1	0.284
OIL_REV	6,204	0.351	0.273	0.107	0.526	0.350
GAS_REV	6,204	0.519	0.566	0.242	0.785	0.311
US_SALES	6,304	0.870	1	0.926	1	0.279
OIL_PRICE	3,012	54.658	54.570	33.645	69.225	23.660
GAS_PRICE	3,000	5.653	5.510	4.190	6.925	2.253
Variables that proxy for firm size						
TANGIBILITY	6,033	0.735	0.811	0.644	0.879	0.200
SIZE	5,920	9,782.407	480.944	91.262	2,901.530	44,541.910
Variables that proxy for firm performance and risk						
BETA_MKT	5,097	0.895	0.830	0.272	1.449	1.050
BETA_OIL	5,097	0.201	0.141	-0.045	0.421	0.510
BETA_GAS	5,097	0.086	0.063	-0.054	0.210	0.338
RISK_TOTAL	5,099	0.577	0.467	0.334	0.682	0.384
RISK_SPECIFIC	5,099	3.307	2.769	1.990	1.966	2.071
ROE	6,060	0.024	0.023	-0.014	0.054	2.079
ROA	6,061	-0.002	0.009	-0.007	0.024	0.093
EBITDA	6,053	0.030	0.040	0.014	0.063	0.100

Note:

This table provides financial and operational statistics for the 150 US oil and gas producers for the period 1998 to 2010. All variables' definitions and construction are in Table A.3.1 (Appendix.)

The Table shows that oil and gas producers maintain low leverage levels (book value of debt in current liabilities plus book value of long term debt scaled by total assets), with a mean (median) of 29% (26%), have distance to default with a mean (median) of 2.234 (2.054), and have asset volatility with a mean (median) of 49% (39%). These latter figures are quite similar to those reported by Campello et al. (2011). Table also reports summary statistics on stocks' market betas, and oil and gas betas, calculated on quarterly basis based on three factors market model constituted by daily market returns and daily changes in oil and gas near-month Future contracts prices. Our sample firms have a systematic risk (market beta), oil beta, and gas beta with mean (median) of 0.89 (0.83), 0.20 (0.14), and 0.08 (0.06) respectively. Our sample has higher systematic risk then corresponding market beta reported in Jin and Jorion (2006) and Haushalter, Heron, and Lie (2002). Oil beta estimates are in line with those reported in the two previous studies. On average, gas beta is significantly lower than oil beta indicating that stock returns are more sensitive to fluctuations in oil prices.

Pertaining to firm aggregate risk as measured by annualized standard deviations of daily returns calculated in quarterly basis, statistics indicate a volatility of equity of about 0.58. We also follow previous literature (e.g., Hentschel and Kothari, 2001; Bartram, Brown, and Conrad, 2011) and standardize equity volatility by market index volatility as a measure of the firm's idiosyncratic risk. This measure avoids the potential bias from spurious correlation between risk management activities and overall market volatility. Sample firms appear to have substantial idiosyncratic risks with an average return volatility which is more than three times the market volatility. These two latter figures are relatively similar to those reported in Bartram, Brown, and Conrad (2011) for their international sample. The Table also reports summary statistics on firm profitability as measured by the return on equity (net income scaled by market value of equity) and the return on asset (net income scaled by total assets), and other firm operational characteristics such as production uncertainty (coefficient of variation of daily production), geographical diversification in production activities and the price-quantity correlation.

Table 3.2 reports summary statistics on loan characteristics. The average loan spread, based on DealScan's all in spread drawn[47], is 201 basis points over LIBOR and with a median of 162.5 basis points.. Loan size has a mean (median) of $645 million ($275 million) and the loan maturity has a mean (median) of 1,246 days or about 41.5 months (1,275 days). The average spread loan and maturity is relatively higher than corresponding spreads reported in Kumar and Rabinovitch (2013), who report an average loan spread of 191.67 for a sample of 41 U.S oil and gas producers for the period 1996-2008, and the loan maturity is quite similar to the maturity reported in this same study. In addition, Table 3.2 reports statistics related to loan type and loan primary purpose (dummy variable for each type (5 types) and purpose (6 purposes)). 72.5% of loans in the sample are revolver loans (70.1% are revolvers longer than one year and 2.4% revolvers shorter than one year) and 12.8% are term loans, whereas the remainder is 364-day facilities and others. Regarding loans' purposes, about 41% of loans in the sample are for general corporate purposes, 24% are for working capital financing, 16% are for project financing, and 10.5% are for debt repayment.

[47] All-In Spread Drawn: Describes the amount the borrower pays in basis points over LIBOR for each dollar drawn down. This measure adds the spread of the loan with any annual (or facility) fee paid to the bank group (*Loan Pricing Corporation Deal Scan).*

Table 3.2 Summary statistics for loan characteristics

Variables	Obs	Mean	Median	1st quartile	3rd quartile	Std. Dev
LOAN SPREAD (all-in spread drawn)	615	200.781	162.500	112.500	250	165.566
LOAN SIZE ($Mill)	692	645.662	275	100	600	1,382.889
MATURITY (in days)	654	1,246	1,275	900	1800	570
LOAN TYPES						
REVOLVER (>1 year)	692	0.704	1	0	1	0.456
REVOLVER (<1 year)	692	0.021	0	0	0	0.145
364-DAY FACILITY	692	0.083	0	0	0	0.277
TERM LOAN	692	0.128	0	0	0	0.335
LOAN PURPOSES						
CORPORATE	692	0.406	0	0	1	0.491
WORK CAP	692	0.241	0	0	0	0.428
DEBT REPAY	692	0.105	0	0	0	0.307
PROJECT FINANCE	692	0.161	0	0	0	0.368
BACKUP LINE	692	0.063	0	0	0	0.244
Variables that proxy for macro controls						
CREDIT SPREAD	6,194	1.065	0.91	0.81	1.18	0.494
TERM SPREAD	6,194	1.370	1.56	0.14	2.58	1.218

Note:

This table provides summary statistics on 692 lean contracts in our sample. All variables' definitions and construction are in Table A.3.1.

3.3.3 Descriptive statistics: Oil and gas hedging activities

Table 3.3 shows that oil and gas producers report hedging activity for 3,489 firm–quarters, which represent almost 55% of the whole panel of 6,326 firm–quarters. Gas hedging occurs in 3,137 firm–quarters or almost 50% of the whole sample and oil hedging takes place in 2,607 firm–quarters or almost 41% of the sample. Oil and gas producers report hedging activities for both oil and gas in about 2,255 firm–quarters. Regarding the nature of hedging instruments in use, Table 3.4 shows that the most common hedging vehicles are swap contracts, with 45.58% (45.25%) of use in gas (oil) hedging. The second most frequently used instrument is the costless collar, with 37.19% (37.11%) for gas (oil) hedging. Next are put options, with 10.55% for gas hedging and 11.85% for oil hedging. The least hedging instruments in use are forward or futures contracts, with only 3.25% (2.78%) for gas (oil) hedging, and three-way collars, with only 3.42% (3.02%) for gas (oil) hedging.

Table 3.3 Distribution of hedging decisions by firm–quarter

Hedging activity: Firm–quarter			
	Oil hedgers	Non-oil hedgers	Total
Gas hedgers	2,255	882	3,137
Non-gas hedgers	352	2,837	3,189
Total	2,607	3,719	6,326

Note:

This table breaks down the total sample of 6,326 firm–quarters into observations with and without oil hedging and with and without gas hedging.

Table 3.4 Hedging instruments used by oil and gas producers

	Gas hedging		Oil hedging	
Financial instrument	Number of firm–quarters	Percentage of use	Number of firm–quarters	Percentage of use
Swap contracts	2,255	45.58%	1,711	45.25%
Put options	522	10.55%	448	11.85%
Costless collars	1,840	37.19%	1,403	37.11%
Forwards or futures	161	3.25%	105	2.78%
Three-way collars	169	3.42%	114	3.02%
Total	4,947	100%	3,781	100%

Note:

This table reports the different types of financial instruments used by the sample firms that report oil and gas hedging activities in a given firm–quarter observation. The values for each instrument indicate the number of firm–quarters and the fraction (in percentage) of use.

Table 3.5 shows descriptive statistics for hedging ratios by horizon as measured by the fraction of production hedged.[48] Statistics on aggregate hedging (aggregate hedging portfolio for oil and gas production respectively) ratios by horizon show that firms in the sample hedge their commodity exposures for the current fiscal year to five years ahead. The average hedging ratio for near-term exposures (i.e., hedging ratio for the remaining time of the current fiscal year) is around 51% for gas hedging and 46% for oil hedging. These figures are in line with the corresponding average fraction of production of 46% reported in Kumar and Rabinovitch (2013), who calculate their fractions of production hedged for the current

[48] We follow Haushalter (2000) and use notional quantities to measure the Fraction of Production Hedged (FPH) by horizon.

quarter. Regarding hedging ratios by instrument, we retain observations related to swap contracts, costless collars, and put options because they contribute to more than 93% of cases for gas hedging activity and 94% for oil hedging. We observe that swap contracts are employed to hedge 38% (37%) on average of gas (oil) production for the current fiscal year (i.e., *HR_0*). For the same near-term exposures, we find that oil and gas producers hedge with costless collars around 31% of their gas and oil productions respectively. Put options contribute to the hedging of around 28% (32%) of gas (oil) production during the remaining time of the current fiscal year. Descriptive statistics also show that oil and gas producers undertake quite similar hedging ratios by instrument and horizon for both oil and gas production.

Table A.3.1 gives more details on the construction of variables.

Table 3.5 Summary statistics of hedging ratios by horizon

	Panel A: Gas hedging						Panel B: Oil hedging					
	HR_0	*HR_1*	*HR_2*	*HR_3*	*HR_4*	*HR_5*	*HR_0*	*HR_1*	*HR_2*	*HR_3*	*HR_4*	*HR_5*
Aggregate hedging portfolio												
Mean	0.509	0.376	0.275	0.221	0.180	0.186	0.461	0.383	0.308	0.273	0.233	0.218
Median	0.489	0.309	0.194	0.116	0.076	0.059	0.446	0.360	0.268	0.199	0.147	0.197
Std. Dev	0.300	0.294	0.281	0.272	0.271	0.260	0.279	0.273	0.257	0.258	0.246	0.183
Obs	3,108	2,295	1,225	548	266	127	2,587	1,723	907	431	185	61
Swap contracts												
Mean	0.376	0.294	0.240	0.200	0.164	0.185	0.367	0.302	0.257	0.242	0.204	0.233
Median	0.313	0.213	0.146	0.101	0.070	0.056	0.335	0.242	0.191	0.173	0.144	0.192
Std. Dev	0.290	0.269	0.251	0.228	0.233	0.255	0.253	0.245	0.233	0.227	0.188	0.184
Obs	2,169	1,571	887	472	246	121	1,657	1,092	579	286	134	40
Costless collars												
Mean	0.311	0.251	0.187	0.153	0.115	0.148	0.309	0.251	0.210	0.173	0.122	0.103
Median	0.251	0.191	0.142	0.134	0.100	0.117	0.262	0.203	0.159	0.116	0.065	0.035
Std. Dev	0.244	0.215	0.166	0.126	0.103	0.092	0.231	0.211	0.195	0.160	0.120	0.120
Obs	1,777	1,218	486	130	41	7	1,298	883	410	182	62	18
Put options												
Mean	0.285	0.241	0.260	0.203	0.240	0.125	0.322	0.330	0.298	0.328	0.442	
Median	0.193	0.164	0.188	0.122	0.176	0.125	0.236	0.277	0.221	0.281	0.537	
Std. Dev	0.221	0.227	0.257	0.226	0.220	0.134	0.274	0.264	0.260	0.286	0.319	
Obs	492	248	97	28	10	2	411	241	102	30	9	

3.4 Empirical results

In this section, we first carry out univariate tests to compare firm-quarters with and without oil and/or gas hedging in terms of firm and loan characteristics. We then perform more rigorous multivariate tests to examine the effects of hedging on firm performance, risk, debt capacity, and external financing costs. To account for the potential endogeneity and bi-directional causality between firm's derivative use and other decisions, we conduct all our multivariate tests on a simultaneous equations setting by the three-stage least squares (3-SLS) technique. We also control for the endogeneity problem by examining firms in the same industry; they have the same exposure to commodity price risk and they differ vastly in terms of their hedging behavior. Relative to other empirical studies, we minimize the endogeneity which is a real concern for any study dealing with financial decision-making channels inside firms.

To gain further insight, we decompose the aggregate oil and gas hedging positions and investigate the real implications of each hedging instrument separately, namely swap contracts, costless collars, and put options. We then perform pairwise simultaneous equation regressions. In the first equation, each measure of firm performance, risk, debt capacity, and external financing costs enters as an endogenous variable supplemented by appropriate control variables that have been shown elsewhere to be associated with the retained measure (e.g., Campello et al, 2011). In the second equation, we include the hedge ratio of the aggregate hedging portfolio or by instrument as endogenous variables.[49]

As control variables for the hedge ratio equation, we include the leverage, the quick ratio, sales (in logarithm), variables related to tax incentives (tax save measure and tax loss carry forward), oil and gas spot prices and their volatilities, variables related to production characteristics (price-quantity correlation, quantity risk, and geographical diversification). All control variables enter the regressions in lagged values to better alleviate the endogeneity problem. Finally, all regression have firm and time fixed effects by including dummy variables for each firm and quarter.

[49] We only consider hedging ratios for the remaining period of the current fiscal year (*HR_0*).

3.4.1 Univariate analysis

Table 3.6 presents the results comparing the characteristics of firms and loans for firm-quarters with and without oil and/or gas hedging in place. A Wilcoxon test for difference in medians shows considerable differences between firm-quarters with and without hedging. Consistent with the previous literature, we find that hedgers are much larger than non-hedgers, more leveraged, and have higher asset tangibility, as well as lower asset volatility and higher distance-to-default. We also find that hedgers have higher oil and gas selling prices and higher accounting performance as measured by the *ROE*, *ROA*, and *EBITDA*.

Moreover, hedgers exhibit higher stock return sensitivity to the market index return, and oil and gas price fluctuations as measured by their respective betas. One possible explanation is that hedgers are much larger in terms of size and sales, and then have higher exposure to both market index and commodity price fluctuations. However, this higher sensitivity to market index fluctuations does not translate into higher stock return volatility because hedgers have lower stock return volatility and lower idiosyncratic risk. These findings are quite similar to those in Hentschel and Kothari (2001), who find that hedgers have higher market beta and lower idiosyncratic risk. More importantly, hedgers have access to larger loans with longer maturities. Comparison of medians further indicates that hedgers pay higher spread loan of 25 basis points, which is around 12.5% of the sample mean spread of 200 basis points. However, this difference in median spreads is not significant at conventional levels.

Table 3.6 Univariate tests

Variables	Non-Hedgers Obs	Non-Hedgers Median	Hedgers Obs	Hedgers Median	Wilcoxon *Z*-score	Wilcoxon *p*-Value
SIZE($Mill)	2,505	82.344	3,415	1,256.602	-38.373	0.000
SALES ($Mill)	2,636	3.319	3,448	65.623	-38.225	0.000
TANGIBILITY	2,592	0.684	3,441	0.845	-27.721	0.000
LEVERAGE	2,604	0.122	3,459	0.328	-30.838	0.000
DTD	2,303	1.726	3,383	2.256	-14.713	0.000
SIGMA_ASSET	2,304	0.513	3,371	0.347	24.203	0.000
%_CS_INST	2,837	0.013	3,489	0.633	-39.761	0.000
GAS_PRICE($/Mcf)	898	5.305	2,102	5.615	-5.679	0.000
OIL_PRICE($/bbl)	931	50.670	2,081	56.410	-4.694	0.000
BETA_MKT	1,825	0.637	3,272	0.906	-9.454	0.000
BETA_OIL	1,825	0.115	3,272	0.157	-3.474	0.000
BETA_GAS	1,825	0.033	3,272	0.077	-7.368	0.000
SIG_TOTAL	1,825	0.546	3,274	0.436	11.475	0.000
SIG_SPECIFIC	1,825	3.922	3,274	2.964	12.665	0.000
ROE	2,608	0.014	3,452	0.028	-7.993	0.000
ROA	2,602	0.006	3,459	0.011	-6.040	0.000
EBITDA	2,598	0.029	3,455	0.044	-12.725	0.000
LOAN SPREAD (all-in drawn spread)	126	150	489	175	-1.102	0.276
LOAN SIZE($Mill)	153	200	539	300	-2.098	0.036
MATURITY (in days)	140	1,080	514	1,350	-2.108	0.035

Note :

This table compares medians of firms and loan characteristics for hedgers and non-hedgers. Comparison of medians is constructed using Wilcoxon rank-sum *Z*-test. Two-sided *p*-values are reported. All variables' definitions and construction are in Table A.3.1.

3.4.2 Risk management and firm performance

In this sub-section, we ask whether corporate risk management have real impact on firm operational performance as measured by realized prices of oil and gas, which include the monetary effects of hedging activities, and accounting performance as measured by the return on equity (*ROE*) and the return on assets (*ROA*).

3.4.2.1 Oil and gas realized prices

Table 3.7 reports the results of the 3-SLS estimations where the endogenous variables are hedge ratios and realized prices of oil and gas. As control variables for realized price equation, we include the percentage of sales in the U.S market, the percentage of revenues from oil (gas) production, quantity of oil (gas) daily production, oil (gas) spot prices and volatilities, and oil (gas) production uncertainty.

Panel A of Table 3.7 shows a significant positive impact of the hedging intensity on gas realized prices. Not only is this effect is statistically significant, it is moreover economically important. The estimated coefficient (Table 3.7, Column 1) implies that gas hedgers with an average hedging intensity earn about 1.6$/Mcf (1000 cubic feet) more than non-hedgers (= 3.1212×0.51, where 0.51 is the mean intensity for the aggregate hedging portfolio for gas production reported in Table 3.7). Relative to the average gas realized price of 5.653$/Mcf, this represents an increase of about 28% (=1.6$/5.653$). Regarding hedging intensity by instrument, Panel A of Table 3.7 shows that costless collars and put options have a statistically and economically significant positive impacts on gas realized prices. The average hedging ratio by costless collars contribute to an increase of 1.57$/Mcf (=5.067×0.31, where 0.31 is the mean intensity for costless collars). The average hedging intensity of put options contribute to an increase of 4.4$/Mcf (=15.685×0.285, where 0.285 is the mean intensity for put options). Relative to the average realized price for gas, this represents an increase of about 28% (=1.57$/5.653$) for costless collars and 78% (=4.4$/5.653$) for put options.

Table 3.7 Simultaneous equation analysis of hedging extent and realized selling prices

	Panel A: Gas hedging				Panel B: Oil hedging			
	Hedging portfolio	Swap contracts	Costless collars	Put options	Hedging portfolio	Swap contracts	Costless collars	Put options
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Equation 1: Gas (oil) realized price is the dependent variable								
HEDGE RATIO	3.1212***	1.7610	5.0670***	15.6856***	-1.5077	-13.6491*	31.7962**	37.6445
	(0.636)	(1.086)	(1.052)	(4.532)	(6.240)	(7.815)	(15.433)	(27.412)
US_SALES	-0.1348	0.0299	-0.2277	0.9045*	-0.1479	-0.7447	1.4297	-0.9089
	(0.316)	(0.319)	(0.274)	(0.547)	(1.117)	(0.868)	(2.002)	(0.968)
GAS(OIL)_REV	-0.9514***	-0.8529***	-0.7843**	-1.6267***	-4.8646**	-3.9697**	-7.7759***	-3.0073
	(0.299)	(0.287)	(0.307)	(0.483)	(1.908)	(1.893)	(2.420)	(2.309)
GAS(OIL)_PROD	0.0000	0.0000	-0.0000	-0.0002	0.0050	0.0004	0.0270*	0.0006
	(0.000)	(0.000)	(0.000)	(0.000)	(0.007)	(0.005)	(0.014)	(0.005)
VOL_GAS(OIL)	0.4057***	0.3974***	0.3517***	0.4209**	0.8812***	0.8871***	0.8212***	0.9239***
	(0.127)	(0.121)	(0.132)	(0.179)	(0.104)	(0.105)	(0.119)	(0.117)
SPOT_GAS(OIL)	0.5476***	0.5673***	0.5304***	0.6280***	0.6306***	0.6321***	0.6155***	0.6255***
	(0.021)	(0.019)	(0.023)	(0.033)	(0.012)	(0.011)	(0.014)	(0.012)
UNCER_GAS(OIL)	0.0967	0.4415***	-0.0235	-0.1194	2.2169	3.3285**	1.7319	0.5338
	(0.170)	(0.150)	(0.187)	(0.268)	(1.594)	(1.471)	(1.393)	(1.734)
CONSTANT	1.8708***	1.4943***	2.2458***	0.2226	10.1957***	10.3343***	10.6866***	11.0354***
	(0.461)	(0.452)	(0.438)	(0.774)	(2.357)	(2.208)	(2.995)	(2.342)
Observations	2,880	2,880	2,880	2,880	2,870	2,870	2,870	2,870
R-squared	0.6562	0.6857	0.6194	0.3234	0.8638	0.8593	0.8303	0.8436
Chi_2	5890.2460	6432.0301	5451.4366	2982.9911	18209.7200	17607.2953	14597.0219	15774.1048
p-value	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Equation 2: Hedge ratio is the dependent variable								
GAS(OIL)_PRICE	-0.0470	0.0017	0.0088	-0.0530	-0.0232	-0.0137	-0.0244	0.0087
	(0.062)	(0.048)	(0.048)	(0.032)	(0.020)	(0.015)	(0.015)	(0.010)
TAX_SAVE	0.0064	-0.0526	0.0673	-0.0000	-0.0020	-0.0075	0.0050	0.0050
	(0.070)	(0.053)	(0.045)	(0.037)	(0.063)	(0.035)	(0.075)	(0.014)
TLCF	-0.0366*	-0.0005	-0.0246*	-0.0037	-0.0423	-0.0567**	0.0382	0.0192
	(0.022)	(0.017)	(0.014)	(0.011)	(0.037)	(0.028)	(0.030)	(0.017)
VOL_GAS(OIL)	0.0137	-0.0041	0.0044	0.0206	0.0208	0.0126	0.0217	-0.0094
	(0.031)	(0.024)	(0.025)	(0.016)	(0.017)	(0.013)	(0.013)	(0.008)
SPOT_GAS(OIL)	0.0264	0.0023	-0.0027	0.0231	0.0153	0.0088	0.0156	-0.0054
	(0.033)	(0.026)	(0.026)	(0.017)	(0.013)	(0.009)	(0.010)	(0.006)
Q_RATIO	-0.0017	-0.0007	-0.0011	-0.0009	-0.0010	-0.0011	0.0005	0.0006
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
SALES	0.0665***	0.0128	0.0359***	0.0261***	0.0209	-0.0032	0.0278*	0.0082
	(0.017)	(0.013)	(0.013)	(0.009)	(0.019)	(0.013)	(0.016)	(0.008)
LEVERAGE	0.1009***	0.0939***	-0.0004	-0.0329*	0.0401	0.0611**	-0.0084	-0.0173
	(0.038)	(0.029)	(0.026)	(0.020)	(0.037)	(0.027)	(0.037)	(0.015)
PQ_COR_GAS(OIL)	-0.0795***	-0.0819***	-0.0048	-0.0331**	0.0108	0.0150	-0.0618**	-0.0026
	(0.028)	(0.021)	(0.020)	(0.015)	(0.029)	(0.020)	(0.028)	(0.015)
UNCER_GAS(OIL)	0.0495**	-0.0341*	0.0475**	0.0343***	0.1742***	0.1168***	0.0531	0.0155
	(0.025)	(0.019)	(0.020)	(0.013)	(0.051)	(0.038)	(0.039)	(0.026)
HERF_GAS(OIL)	-0.3132***	-0.1308*	-0.1899***	-0.0422	-0.2708***	-0.1340***	-0.0504	0.0136
	(0.098)	(0.075)	(0.073)	(0.051)	(0.078)	(0.050)	(0.064)	(0.021)
CONSTANT	-0.3636***	-0.1207**	-0.2869***	-0.0379	0.0058	0.1054	0.0531	-0.1266*
	(0.062)	(0.048)	(0.047)	(0.032)	(0.147)	(0.110)	(0.110)	(0.073)
Observations	2,880	2,880	2,880	2,880	2,870	2,870	2,870	2,870
R-squared	0.6381	0.6251	0.5097	0.0523	0.2018	0.2892	-0.7790	0.1042
Chi_2	5480.4338	4807.6629	2985.9036	1126.6518	1569.8011	1287.8327	826.4356	1106.3186
p-value	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

Note:

This table presents the results of 3-SLS simultaneous equations estimation linking hedging extent with oil and gas realized prices to account for endogeneity between the two variables. The dependent variable in *Equation 1* is gas (oil) realized prices. The dependent variable in *Equation 2* is the hedging extent (for the aggregate hedging portfolio and by instrument). The estimation is done for gas hedging (Panel A) and oil hedging (Panel B), separately. All independent variables enter regressions with lagged values. All variables' definitions and construction are detailed in Table A.3.1. All regressions have firm and time fixed effects (not reported for conciseness). The *t-statistics* are into parentheses. ***Significant at the 1% level, ** Significant at the 5% level, * Significant at the 10% level.

Surprisingly, Panel B of Table 3.7 indicates that aggregate hedging portfolio of oil production has no real effects on oil realized prices. However, results further show that hedging oil production by swap contacts leads to a significant reduction in oil realized prices of about 5$/barrel (=-13.649×0.367, where 0.367 is the mean intensity for swap contracts) or equivalently a reduction of about 9.14% of the average realized price of 54.658$/barrel. On the contrary, costless collars contribute to an important increase of about 9.856$/barrel in oil realized prices or 18% of the average oil price. Overall, hedging instruments departing from strict linearity (i.e., put options and costless collars) have the highest positive impacts on realized prices. These instruments allow firms to profit from any potential upside. Although, swap contracts permit firms to fix their selling prices, they deprive them from any important increase in prices.

Results also indicate no bi-directional causality between realized prices and hedging intensities. In fact, oil and gas producers appear to not consider realized prices when adjusting their hedging intensities and strategies. Regarding control variables in price equations, we find that firms deriving most of their revenues from either oil or gas earn lower realized prices. Realized prices also are significantly positively related to spot prices and their volatilities, and to production uncertainty.

3.4.2.2 Accounting performance

We carry out 3-SLS regressions where the endogenous variables are hedge ratios and one of the two measures of firm accounting profit: 1) return on equity (ROE) , and 2) return on asset (ROA). We obtain qualitatively similar results. We focus on the *ROA* results reported in

Table 3.8 to save space (results related to the *ROE* are tabulated in Table A.3.2). As control variables for *ROA* equation, we include the firm size (in logarithm), the leverage ratio, the percentage of revenues from oil and gas production, the percentage of sales in the U.S market, investment expenditures, production cost per barrel of oil equivalent, and institutional shareholding.

Panel A of Table 3.8 shows a significant positive impact of gas hedging intensity on firm *ROA*. Specifically, the *ROA* for gas hedgers increases by a significant 4.99 basis points (0.0499%) for each 1% increase in the aggregate hedging portfolio of gas production. Given the average ratio of 51% for gas hedging portfolio, this translates into a higher *ROA* of about 255 basis points or 2.55%, which places the firm in the top quartile in term of *ROA*. Panel A of Table 3.8, for gas hedging, further indicates that 1% increase in hedging intensity by swap contracts, collars, and put options leads to an increase in *ROA* of 8.28, 7.39, and 23.36 basis points respectively. Results related to oil hedging reported in Panel B also show a significant increase of 9.67 basis points in *ROA* for each 1% increase in the hedged fraction of oil production. The positive impact on *ROA* from oil hedging comes particularly from costless collars and put options with 33.37 and 118.02 basis points respectively. More importantly, we find that most beneficial effects come from put options. This corroborates the results with realized prices. However the impact of put options is statistically insignificant for oil realized prices while it is highly significant for *ROA*. These findings support the hedging premium hypothesis, that is corporate risk management translates into higher firm value and performance.

Table 3.8 Simultaneous equation analysis of hedging extent and the return on asset

	Panel A: Gas hedging				Panel B: Oil hedging			
	Hedging portfolio	Swap contracts	Costless collars	Put options	Hedging portfolio	Swap contracts	Costless collars	Put options
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Equation 1: Return on asset is the dependent variable								
HEDGE RATIO	0.0499***	0.0828**	0.0739**	0.2336***	0.0967***	0.0307	0.3373***	1.1802***
	(0.014)	(0.034)	(0.032)	(0.086)	(0.030)	(0.035)	(0.092)	(0.455)
SIZE	0.0015	0.0025**	0.0026**	0.0025**	-0.0002	0.0025*	0.0003	0.0003
	(0.001)	(0.001)	(0.001)	(0.001)	(0.002)	(0.001)	(0.002)	(0.001)
OIL&GAS_REV	-0.0005	0.0001	0.0001	0.0001	-0.0017	-0.0029	-0.0004	0.0001
	(0.002)	(0.002)	(0.003)	(0.003)	(0.004)	(0.003)	(0.005)	(0.003)
US_SALES	0.0053	0.0102**	0.0059	0.0042	0.0040	0.0030	0.0128	0.0052
	(0.004)	(0.005)	(0.005)	(0.006)	(0.006)	(0.005)	(0.008)	(0.005)
INV_OPP	-0.0009**	-0.0004	-0.0012*	-0.0013*	-0.0012*	-0.0015**	-0.0011	-0.0000
	(0.000)	(0.000)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.002)
%_CS_INST	-0.0128***	-0.0147***	-0.0150***	-0.0126***	-0.0111**	-0.0113***	-0.0242***	-0.0076
	(0.003)	(0.005)	(0.004)	(0.004)	(0.004)	(0.004)	(0.007)	(0.005)
CASH_COST	-0.0005***	-0.0004***	-0.0007***	-0.0007***	-0.0013***	-0.0011***	-0.0016***	-0.0007***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
LEVERAGE	-0.0197***	-0.0227***	-0.0138***	-0.0136***	-0.0138***	-0.0090*	-0.0063	-0.0169*
	(0.005)	(0.006)	(0.004)	(0.004)	(0.005)	(0.005)	(0.006)	(0.010)
CONSTANT	-0.0040	-0.0169	-0.0095	-0.0157	0.0192	-0.0080	0.0160	0.0006
	(0.010)	(0.012)	(0.012)	(0.012)	(0.015)	(0.013)	(0.016)	(0.016)
Observations	5,248	5,248	5,248	5,248	5,256	5,256	5,256	5,256
R-squared	0.3014	0.2638	0.3001	0.2065	0.2302	0.3524	-0.3815	-3.4052
Chi_2	2681.3427	2602.7059	2645.0520	2476.6849	2463.7534	2931.4679	1395.3654	745.4809
p-value	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Equation 2: Hedge ratio is the dependent variable								
ROA	3.4610***	2.8830***	-0.5095	0.3242	-1.8996***	-0.6351	-1.9086***	0.3255
	(0.966)	(0.798)	(0.585)	(0.319)	(0.563)	(0.406)	(0.410)	(0.225)
TAX_SAVE	0.0169	-0.0380	0.0956**	0.0034	0.0351	0.0281	0.0180	-0.0012
	(0.047)	(0.037)	(0.042)	(0.020)	(0.060)	(0.043)	(0.042)	(0.009)
TLCF	-0.0227**	-0.0141	-0.0112	0.0012	-0.0183	-0.0413***	0.0174**	0.0010
	(0.011)	(0.009)	(0.010)	(0.005)	(0.012)	(0.009)	(0.009)	(0.002)
VOL_GAS(OIL)	0.0558***	0.0197	0.0361***	0.0024	-0.0004	0.0022	-0.0064***	0.0011
	(0.018)	(0.015)	(0.011)	(0.006)	(0.003)	(0.002)	(0.002)	(0.001)
SPOT_GAS(OIL)	-0.0014	-0.0057*	0.0073***	-0.0031**	0.0020***	0.0008***	0.0013***	-0.0001
	(0.004)	(0.003)	(0.002)	(0.001)	(0.000)	(0.000)	(0.000)	(0.000)
Q_RATIO	-0.0012**	-0.0008*	-0.0001	-0.0002	-0.0009	-0.0009*	0.0002	0.0001
	(0.001)	(0.000)	(0.000)	(0.000)	(0.001)	(0.001)	(0.000)	(0.000)
SALES	0.0431***	0.0142***	0.0291***	0.0056**	0.0436***	0.0162***	0.0257***	0.0030*
	(0.007)	(0.005)	(0.004)	(0.002)	(0.005)	(0.004)	(0.004)	(0.002)
LEVERAGE	0.2083***	0.1678***	0.0281*	0.0124	0.0552***	0.0873***	-0.0188	0.0103
	(0.026)	(0.022)	(0.016)	(0.009)	(0.021)	(0.015)	(0.015)	(0.008)
PQ_COR_GAS(OIL)	-0.0172*	-0.0144*	0.0028	-0.0094**	-0.0030	-0.0037	-0.0018	0.0000
	(0.009)	(0.007)	(0.008)	(0.004)	(0.009)	(0.006)	(0.006)	(0.002)
UNCER_GAS(OIL)	0.0736***	0.0308**	0.0335***	0.0145**	0.0525***	0.0422***	0.0059	0.0006
	(0.015)	(0.012)	(0.013)	(0.006)	(0.014)	(0.010)	(0.010)	(0.003)
HERF_GAS(OIL)	-0.1624***	-0.0692**	-0.1357***	0.0509***	-0.0707**	-0.0976***	0.0350	0.0055
	(0.038)	(0.029)	(0.031)	(0.015)	(0.035)	(0.025)	(0.024)	(0.005)
CONSTANT	-0.4151***	-0.1337***	-0.2891***	-0.0283	-0.4770***	-0.2185***	-0.2304***	-0.0212
	(0.063)	(0.052)	(0.039)	(0.021)	(0.049)	(0.036)	(0.036)	(0.019)
Observations	5,248	5,248	5,248	5,248	5,256	5,256	5,256	5,256
R-squared	0.4504	0.3531	0.4394	0.2861	0.4937	0.5068	0.1787	0.3964
Chi_2	6255.2466	4760.0622	4189.0354	2253.7585	5861.9751	5548.0440	2528.5586	3618.6994
p-value	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

Note:

This table presents the results of 3-SLS simultaneous equations estimation linking hedging extent with firm's return on asset (*ROA*) to account for endogeneity between the two variables. The dependent variable in *Equation 1* is the *ROA* measured by net income divided by total assets. The dependent variable in *Equation 2* is the hedging extent (for the aggregate hedging portfolio and by instrument). The estimation is done for gas hedging (Panel A) and oil hedging (Panel B), separately. All independent variables enter regressions with lagged values. All variables' definitions and construction are detailed in Table A.3.1. All regressions have firm and time fixed effects (not reported for conciseness). The *t-statistics* are into parentheses. ***Significant at the 1% level, ** Significant at the 5% level, * Significant at the 10% level.

Results also indicate feedback effects between firm *ROA* and hedging intensities. Firms with higher accounting profitability tend to hedge more their gas production. An increase of 1% in *ROA* motivates firms to increase their gas aggregate hedging of about 3.46%. Interestingly, this increase is only significant for swap contracts. This testifies that more profitable firms are under pressure to maintain their accounting performance. Unpredictably, *ROA* appears to have significant negative impacts on oil hedging intensities. In fact, an increase of 1% in *ROA* motivates firms to cut their oil hedging of about 1.90%. This reduction is only significant for costless collars positions. One possible explanation comes from our previous regressions related to oil and gas prices, where we find that oil hedging has negative but insignificant effects on oil realized prices. This may motivate manager, who believes that oil hedging is less appealing, to cut oil hedging to maintain firm performance. Pertaining to control variables in *ROA* equations, we find that larger firms have higher performance. *ROA* appears to be negatively related to the investment expenditures, institutional shareholding, production costs, and leverage.

3.4.3 Risk management and firm risk

This sub-section provides detailed evidence on the mutual effects between firms' hedging activities and firms risk characteristics. Specifically, we check whether firms use derivatives primarily to hedge their exposures. We would expect higher hedging intensity to be associated to lower firm's risk. Conversely, if firms use derivative primarily to speculate, we would expect higher hedging intensity to be related to higher firm's risk. We then examine real implications of firm's hedging on the two following measures of firm risk:1) firm idiosyncratic risk as measured by standardized equity volatility and 2) firm systematic risk as measured by its market beta (Table A.3.1 gives details on the construction of these measures).

3.4.3.1 Firm idiosyncratic risk

We perform simultaneous equations regressions where the endogenous variables are firm's idiosyncratic risk as previously defined and hedge ratios. We make a logarithm transformation for the idiosyncratic risk because of its right-skewed distribution and to ease interpretation of results. Table 3.9 reports the results and show statistically significant estimated coefficients for oil and gas hedging portfolios, with 1% increase in hedging portfolio intensity inducing a reduction in firm's idiosyncratic risk of about 0.41% and 0.48% for gas and oil respectively. However, gas hedging effect has stronger statistical significance. Results related to hedging ratios by instrument indicate that swap contracts are effective vehicles to reduce firm's idiosyncratic risk: 1% increase in swap intensity implies a reduction in idiosyncratic risk of about 1.43% and 1% for gas hedging and oil hedging respectively. More importantly, put options appear to provide firms with the highest reduction in idiosyncratic risk: with 1% increase in intensity leads to a significant reduction of about 4.8% of oil hedging, however with statistical significance at 10% level. For gas hedging, put options also have important negative effects on idiosyncratic risk of about -1.26%. Surprisingly, costless collars appear to be positively associated with firm's risk with an estimated positive coefficient of 1.775. Overall, these findings are consistent with one strand of the literature which testifies that corporations use derivative to hedge and then reduce firm's riskiness (e.g., Stulz, 1996, Bartram, Brown, and Conrad, 2011, among others). Clearly, our results produce evidence that our sample firms do not speculate on commodity market movements.

Table 3.9 Simultaneous equation analysis of hedging extent and firm idiosyncratic risk

	Panel A : Gas hedging				Panel B : Oil hedging			
	Hedging portfolio	Swap contracts	Costless collars	Put options	Hedging portfolio	Swap contracts	Costless collars	Put options
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Equation 1: Firm idiosyncratic risk is the dependent variable								
HEDGE RATIO	-0.4078***	-1.4265***	-0.1899	-1.2604**	-0.4715*	-0.9981***	1.7751*	-4.7894*
	(0.152)	(0.456)	(0.249)	(0.567)	(0.242)	(0.367)	(1.022)	(2.603)
SIZE	-0.0925***	-0.0865***	-0.1078***	-0.1136***	-0.0904***	-0.0924***	-0.1391***	-0.1031***
	(0.012)	(0.018)	(0.011)	(0.009)	(0.014)	(0.012)	(0.018)	(0.014)
ROA	-0.1377**	-0.1103**	-0.1526**	-0.1247*	-0.1112**	-0.1016*	-0.1646**	-0.0964
	(0.057)	(0.050)	(0.060)	(0.068)	(0.052)	(0.055)	(0.073)	(0.109)
OIL&GAS_REV	0.2207***	0.1676***	0.2402***	0.2439***	0.1433***	0.1445***	0.2324***	0.1726***
	(0.045)	(0.041)	(0.045)	(0.047)	(0.039)	(0.043)	(0.056)	(0.049)
US_SALES	0.0287	-0.0197	0.0356	-0.0125	0.0806**	0.0867**	0.1279**	0.0915**
	(0.038)	(0.053)	(0.040)	(0.051)	(0.034)	(0.038)	(0.055)	(0.043)
%_CS_INST	0.0071	0.0376	-0.0147	0.0046	0.0100	-0.0010	-0.0251	-0.0116
	(0.032)	(0.048)	(0.033)	(0.035)	(0.030)	(0.031)	(0.048)	(0.047)
IR_HEDG	-0.0300**	-0.0387	-0.0273*	-0.0371**	-0.0422**	-0.0440*	-0.0466*	-0.0409
	(0.015)	(0.026)	(0.014)	(0.016)	(0.018)	(0.026)	(0.027)	(0.059)
FX_HEDG	-0.0011	0.0114	-0.0054	0.0057	0.0076	0.0110	0.0095	0.0227
	(0.027)	(0.027)	(0.029)	(0.031)	(0.026)	(0.029)	(0.037)	(0.082)
Q_RATIO	-0.0037***	-0.0051***	-0.0027**	-0.0030**	-0.0033**	-0.0037**	-0.0016	-0.0027
	(0.001)	(0.002)	(0.001)	(0.001)	(0.001)	(0.001)	(0.002)	(0.002)
LEVERAGE	0.4204***	0.5592***	0.3470***	0.3683***	0.3746***	0.4364***	0.3333***	0.4454***
	(0.045)	(0.075)	(0.036)	(0.040)	(0.039)	(0.049)	(0.042)	(0.099)
CONSTANT	1.5832***	1.5802***	1.6979***	1.7935***	1.5138***	1.5048***	1.8976***	1.6222***
	(0.105)	(0.159)	(0.093)	(0.089)	(0.120)	(0.111)	(0.138)	(0.111)
Observations	4,762	4,762	4,762	4,762	4,773	4,773	4,773	4,773
R-squared	0.6557	0.4635	0.6708	0.6390	0.6441	0.5809	0.4473	0.0522
Chi_2	9256.8758	5434.2655	9715.4624	8899.1446	8864.4590	7217.6559	6114.3380	4150.6213
p-value	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Equation 2: Hedge ratio is the dependent variable								
IDIOSYNC_RISK	-0.1709***	-0.1514***	-0.0488	0.0471*	-0.2192***	-0.0778*	-0.1334***	-0.0085
	(0.057)	(0.043)	(0.043)	(0.024)	(0.055)	(0.040)	(0.038)	(0.022)
TAX_SAVE	0.0158	-0.0026	0.0677	0.0137	0.0177	0.0289	-0.0191	0.0166
	(0.055)	(0.031)	(0.044)	(0.025)	(0.050)	(0.037)	(0.038)	(0.017)
TLCF	-0.0688***	-0.0268**	-0.0460***	-0.0009	-0.0062	-0.0192**	0.0203**	-0.0035
	(0.017)	(0.011)	(0.013)	(0.008)	(0.011)	(0.008)	(0.009)	(0.004)
VOL_GAS(OIL)	0.0456**	0.0019	0.0326**	0.0132*	0.0028	0.0029	-0.0009	-0.0002
	(0.019)	(0.015)	(0.014)	(0.008)	(0.003)	(0.002)	(0.002)	(0.001)
SPOT_GAS(OIL)	0.0079***	0.0021	0.0071***	-0.0013	0.0010***	0.0006***	0.0002	0.0002
	(0.003)	(0.003)	(0.002)	(0.001)	(0.000)	(0.000)	(0.000)	(0.000)
Q_RATIO	-0.0027***	-0.0022***	-0.0004	-0.0001	-0.0020**	-0.0014**	-0.0006	-0.0001
	(0.001)	(0.001)	(0.001)	(0.000)	(0.001)	(0.001)	(0.001)	(0.000)
SALES	0.0294***	0.0016	0.0176***	0.0066***	0.0171***	0.0057*	0.0081**	-0.0005
	(0.006)	(0.003)	(0.004)	(0.002)	(0.005)	(0.003)	(0.004)	(0.002)
LEVERAGE	0.2534***	0.1968***	0.0675***	-0.0028	0.1501***	0.1203***	0.0402**	0.0247**
	(0.030)	(0.024)	(0.022)	(0.013)	(0.028)	(0.021)	(0.019)	(0.012)
PQ_COR_GAS(OIL)	-0.0253**	-0.0286***	0.0122	-0.0179***	-0.0000	-0.0059	0.0103*	-0.0055
	(0.012)	(0.009)	(0.010)	(0.005)	(0.008)	(0.006)	(0.006)	(0.003)
UNCER_GAS(OIL)	0.0873***	0.0438***	0.0198	0.0332***	0.0695***	0.0587***	-0.0231**	0.0137**
	(0.019)	(0.013)	(0.015)	(0.008)	(0.016)	(0.012)	(0.011)	(0.006)
HERF_GAS(OIL)	-0.2187***	-0.0663***	-0.1642***	0.0582***	-0.1066***	-0.0938***	0.0225	-0.0113
	(0.041)	(0.025)	(0.032)	(0.018)	(0.029)	(0.022)	(0.021)	(0.009)
CONSTANT	-0.1725	0.0922	-0.1605**	-0.1083**	-0.0364	-0.0594	0.0623	0.0024
	(0.106)	(0.076)	(0.080)	(0.046)	(0.098)	(0.071)	(0.068)	(0.038)
Observations	4,762	4,762	4,762	4,762	4,773	4,773	4,773	4,773
R-squared	0.6213	0.5476	0.4530	0.2800	0.5257	0.5181	0.3632	0.4167
Chi_2	8135.3652	6283.1136	3955.9155	2026.8951	5959.9473	5394.5600	3020.7439	3438.9627
p-value	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

Note:

This table presents the results of 3-SLS simultaneous equations estimation linking hedging extent with firm idiosyncratic risk to account for endogeneity between the two variables. The dependent variable in *Equation 1* is the firm idiosyncratic risk measured by stock return volatility divided by market return volatility. The dependent variable in Equation 2 is the hedging extent (for the aggregate hedging portfolio and by instrument). The estimation is done for gas hedging (Panel A) and oil hedging (Panel B), separately. All independent variables enter regressions with lagged values. All variables' definitions and construction are detailed in Table A.3.1. All regressions have firm and time fixed effects (not reported for conciseness). The *t-statistics* are into parentheses. ***Significant at the 1% level, ** Significant at the 5% level, * Significant at the 10% level.

Surprisingly, results show significant negative effects of idiosyncratic risk on hedging intensities. These negative effects are about 17 and 22 basis points for gas and oil hedging portfolios, respectively. For individual instruments, we find that firms with higher levels of idiosyncratic risks tend to reduce their swap and collar positions particularly: 1% increase in firm's idiosyncratic risk commits gas hedgers to reduce their swap positions by about 15 basis points. More importantly, gas hedgers increase their put options positions by about 5 basis points for each 1% increase in firm's idiosyncratic risk. Similarly, oil hedgers reduce their swap positions by about 8 basis points and their collar positions by about 13 basis points for each 1% increase in idiosyncratic risk.

Two plausible explanations, for the intriguing reduction in swap positions and increase in put option positions as firm's risk increases, come from the risk-shifting theory (e.g., Jensen and Meckling, 1976; Myers, 1977). In fact, as the idiosyncratic risk increases, firm's value becomes more volatile (and more leveraged) and the option character of stocks (e.g., Merton, 1974) becomes more important. Shareholders, then, have incentives to let firm value under exposure by reducing swap positions to increase firm's riskiness and to transfer wealth from debt holders to equity owners. In addition, as firms' risk increases, managers tend to enter in costly non-linear hedging positions (put options) as risk-shifting behavior.

Regarding control variables, IR hedging seems to have a significant negative effect on firm's idiosyncratic risk. This finding reiterates the hypothesis that risk management could reduce firm's idiosyncratic risk (e.g., Guay, 1999). Finally, firm's idiosyncratic risk seems to be significantly negatively related to firm's size, profitability, and liquidity. On the contrary, more leveraged firms with lower diversification (industrial and geographical) exhibit higher idiosyncratic risk. Finally, we repeat the same regressions with the annualized standard deviations of stock returns (with logarithmic transformation because of its distribution is strongly right-skewed). Results are qualitatively the same.

3.4.3.2 Firm systematic risk

Univariate tests show higher market betas for oil and gas hedgers. At first glance, one would suspect that derivative use causes firm systematic risk to increase and consequently firm cost of equity to be higher. As Adam and Fernando (2006) point out, any positive link between hedging and firm's systematic risk implies higher cost of equity implying that the potential positive cash flows related to hedging would not translate into higher value gains for shareholders. Therefore, we inspect in a more rigorous manner the potential effects between hedging intensity and firm's systematic risk. First, we follow previous studies (e.g., Jin and Jorion, 2006) and estimate a market model that includes the market index and the rates of change in NYMEX near-month Future contracts for oil and gas respectively. The model is estimated in a quarterly frequency using daily returns of firms' stocks and of market index. We use the CRSP NYSE/AMEX/Nasdaq composite value-weighted index as a market measure. We use also daily rates of change in near-month contract prices for oil and gas. To avoid the non-trading biases related to daily data (Scholes and Williams, 1977), we supplement the contemporaneous daily return by one lead and lag return for the market index, oil, and gas returns.[50] Beta for each factor (market, oil, and gas) is obtained by summing the estimated coefficients on the contemporaneous, lead, and lagged return.

Next, we estimate simultaneous equations where the endogenous variables are firm's systematic risk (quarterly stock market betas) and hedge ratios to control for possible simultaneity. Results are reported in Table 3.10. Interestingly, estimated coefficients for both hedging portfolios of oil and gas productions have negative signs but with no statistical significance at conventional levels. We find no evidence that oil and gas hedging increases systematic risk for our sample firms. Therefore, the positive effects, in terms of realized prices and *ROA* found in the previous section, should translate into value gains for

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[50] See Dimson (1979) and Fowler and Rorke (1984) for more details.

shareholders. More importantly, Panel A of Table 3.10 indicates that hedging gas production by costless collars has a significant (at the level of 10%) negative impact on firm's systematic risk. This finding suggests that hedging gas production by collars would attenuate cost of equity for oil and gas producers. Results further show no evident effects for swap contracts or put options.

Regarding the feedback effects, results reveal that 1% increase in systematic risk commits firms to increase their collar positions by about 6 basis points for oil hedging and gas hedging respectively. This increase in collar intensity should be interpreted in light of the previously documented negative effect of collars on systematic risk. Similarly, 1% increase in systematic risk leads to a reduction of 4 basis points in put option positions for oil hedging. One possible explanation is that by cutting option positions, managers are trying to attenuate the volatility effects of such non-linear hedging instruments.

For control variables in the systematic risk equation, we find that IR hedging reduces systematic risk which confirms that financial hedging has risk reduction virtues as claimed by one strand of the related literature (see Panel A, Column 1 and 2). We also find that more profitable oil and gas producers bear noticeably lower systematic risk. On the contrary, systematic risk appears to be significantly positively related to firm size, leverage and more noticeably to the percentage of institutional shareholding. These latter findings give evidence that the higher systematic risk observed for oil and gas hedgers comes essentially form their larger size, higher leverage ratio, and more importantly their higher percentage of institutional shareholding (see univariate tests).

Similarly, we assess whether derivative use is positively related to firm's exposure to oil and gas price fluctuations. Univariate results show that hedgers have significantly higher exposure to oil and gas price fluctuations as measured by their respective betas from the market model estimated previously. That is, if firms in our sample use derivative to speculate, and then to increase their commodity exposures, we should expect a significant positive effects of hedging on oil and gas betas.

Table 3.10 Simultaneous equation analysis of hedging extent and firm systematic risk

	Panel A : Gas hedging				Panel B : Oil hedging			
	Hedging portfolio	Swap contracts	Costless collars	Put options	Hedging portfolio	Swap contracts	Costless collars	Put options
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Equation 1: Firm systematic risk is the dependent variable								
HEDGE RATIO	-0.3490	-0.7219	-1.1071*	-0.9299	-0.1881	-0.7111	1.1821	3.5165
	(0.350)	(0.828)	(0.620)	(1.325)	(0.589)	(0.795)	(1.999)	(4.793)
SIZE	0.0898***	0.0701**	0.1141***	0.1028***	0.0765**	0.0809***	0.0658**	0.0742***
	(0.028)	(0.033)	(0.026)	(0.021)	(0.033)	(0.025)	(0.032)	(0.024)
ROA	-0.5143***	-0.4836***	-0.5489***	-0.5734***	-0.3939***	-0.3443**	-0.2851**	-0.4452**
	(0.136)	(0.133)	(0.145)	(0.146)	(0.138)	(0.136)	(0.136)	(0.219)
OIL&GAS_REV	0.1318	0.0887	0.1053	0.0944	0.0440	0.0052	0.0268	0.0718
	(0.104)	(0.096)	(0.108)	(0.100)	(0.102)	(0.103)	(0.101)	(0.111)
US_SALES	0.0083	-0.1019	0.0085	0.1116	-0.1031	-0.1138	-0.1461	-0.1042
	(0.088)	(0.114)	(0.095)	(0.111)	(0.089)	(0.091)	(0.100)	(0.096)
%_CS_INST	0.3181***	0.3738***	0.3135***	0.2225***	0.2911***	0.2782***	0.2927***	0.2957***
	(0.076)	(0.100)	(0.080)	(0.075)	(0.079)	(0.076)	(0.097)	(0.092)
IR_HEDG	-0.0689*	-0.1063**	-0.0256	-0.0110	-0.0680	-0.0948	-0.0038	-0.0223
	(0.035)	(0.053)	(0.035)	(0.035)	(0.047)	(0.059)	(0.046)	(0.107)
FX_HEDG	0.0103	0.0456	0.0116	-0.0069	0.0033	0.0209	-0.0312	-0.0386
	(0.064)	(0.067)	(0.071)	(0.065)	(0.069)	(0.070)	(0.065)	(0.158)
Q_RATIO	0.0031	0.0027	0.0034	0.0038	0.0030	0.0025	0.0040	0.0035
	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)
LEVERAGE	0.1484	0.2095	0.1145	0.0613	0.1733*	0.2434**	0.1482*	0.0677
	(0.104)	(0.131)	(0.089)	(0.089)	(0.089)	(0.102)	(0.084)	(0.159)
CONSTANT	0.5563**	0.7600**	0.3915*	0.4707**	0.7158**	0.6664***	0.9274***	0.7890***
	(0.243)	(0.298)	(0.226)	(0.199)	(0.296)	(0.246)	(0.260)	(0.200)
Observations	4,673	4,673	4,673	4,673	4,684	4,684	4,684	4,684
R-squared	0.3712	0.3557	0.3438	0.3700	0.3739	0.3605	0.3413	0.2503
Chi_2	2750.1957	2565.1182	2682.2338	2820.6103	2781.0386	2687.9323	2523.1622	2441.6563
p-value	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Equation 2: Hedge ratio is the dependent variable								
BETA_MKT	-0.0609	-0.0486	0.0649**	-0.0387**	-0.0268	-0.0255	0.0540*	-0.0115
	(0.040)	(0.033)	(0.031)	(0.017)	(0.044)	(0.034)	(0.031)	(0.019)
TAX_SAVE	0.0144	-0.0245	0.0776	0.0092	0.0052	0.0151	-0.0003	0.0015
	(0.058)	(0.045)	(0.047)	(0.025)	(0.058)	(0.043)	(0.035)	(0.025)
TLCF	-0.0883***	-0.0492***	-0.0536***	0.0027	-0.0124	-0.0241**	0.0142	0.0052
	(0.018)	(0.014)	(0.015)	(0.008)	(0.013)	(0.010)	(0.009)	(0.006)
VOL_GAS(OIL)	0.0546**	0.0133	0.0654***	-0.0102	0.0087***	0.0053***	0.0013	0.0000
	(0.022)	(0.018)	(0.017)	(0.009)	(0.002)	(0.002)	(0.002)	(0.001)
SPOT_GAS(OIL)	0.0063	0.0011	0.0121***	-0.0047***	0.0010**	0.0004	0.0009**	0.0000
	(0.004)	(0.003)	(0.003)	(0.002)	(0.000)	(0.000)	(0.000)	(0.000)
Q_RATIO	-0.0017**	-0.0014**	-0.0006	-0.0001	-0.0010	-0.0010	-0.0004	0.0001
	(0.001)	(0.001)	(0.001)	(0.000)	(0.001)	(0.001)	(0.001)	(0.000)
SALES	0.0431***	0.0121***	0.0163***	0.0063***	0.0317***	0.0107***	0.0114***	0.0032
	(0.006)	(0.004)	(0.004)	(0.002)	(0.005)	(0.004)	(0.004)	(0.002)
LEVERAGE	0.2005***	0.1465***	0.0442**	0.0181*	0.0792***	0.0994***	-0.0146	0.0199**
	(0.024)	(0.020)	(0.018)	(0.010)	(0.023)	(0.018)	(0.016)	(0.010)
PQ_COR_GAS(OIL)	-0.0127	-0.0182*	0.0147	-0.0101**	0.0069	0.0019	0.0000	-0.0039
	(0.012)	(0.009)	(0.010)	(0.005)	(0.009)	(0.007)	(0.005)	(0.004)
UNCER_GAS(OIL)	0.0990***	0.0649***	0.0233	0.0260***	0.0757***	0.0565***	0.0052	0.0045
	(0.018)	(0.014)	(0.014)	(0.008)	(0.015)	(0.011)	(0.009)	(0.006)
HERF_GAS(OIL)	-0.2429***	-0.1110***	-0.1723***	0.0477***	-0.1189***	-0.1095***	0.0091	0.0104
	(0.043)	(0.033)	(0.034)	(0.018)	(0.033)	(0.025)	(0.020)	(0.014)
CONSTANT	-0.3931***	-0.1051**	-0.2974***	0.0092	-0.3752***	-0.1593***	-0.2008***	-0.0125
	(0.059)	(0.049)	(0.045)	(0.025)	(0.057)	(0.044)	(0.040)	(0.025)
Observations	4,673	4,673	4,673	4,673	4,684	4,684	4,684	4,684
R-squared	0.6206	0.5620	0.4010	0.2456	0.5686	0.5296	0.3477	0.4252
Chi_2	7734.6309	6059.0298	3530.4441	1929.6447	6178.7115	5290.8280	2890.6784	3490.3474
p-value	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

Note:

This table presents the results of 3-SLS simultaneous equations estimation linking hedging extent with firm systematic risk to account for endogeneity between the two variables. The dependent variable in *Equation 1* is the firm systematic risk measured by stock market beta. The dependent variable in Equation 2 is the hedging extent (for the aggregate hedging portfolio and by instrument). The estimation is done for gas hedging (Panel A) and oil hedging (Panel B), separately. All independent variables enter regressions with lagged values. All variables' definitions and construction are detailed in Table A.3.1. All regressions have firm and time fixed effects (not reported for conciseness). The *t-statistics* are into parentheses. ***Significant at the 1% level, ** Significant at the 5% level, * Significant at the 10% level.

In unreported results, we repeat the same simultaneous equations estimation with oil and gas betas as endogenous variables with hedge ratios. Results reveal insignificant feedback effects between oil and gas betas and hedging intensity. Although, these findings are inconsistent with the hypothesis that hedging should reduce firm's exposure to the underlying risk (e.g., Tufano, 1998, Allayannis and Ofek, 2001, Jin and Jorion, 2006), they do not provide evidence of a speculative behavior of our sample firms.

3.4.4 Risk management and external financing

In this sub-section, we examine the potential feedback effects between corporate risk management and 1) capital structure decisions, and 2) external financing costs.

3.4.4.1 Firm debt capacity

In line with the existing literature (e.g., Froot, Stein, and Sharfstein, 1993, Stulz. 1996, Leland, 1998, Graham and Rogers, 2002, Dionne and Triki, 2013, Bartram, Brown, and Fehle, 2009), we investigate jointly commodity hedging and debt level of firms. We, then, estimate simultaneous regressions where the endogenous variables are hedge ratio and leverage ratio as measured by the book value of long term debt plus debt in current liabilities scaled by book value of assets. We supplement the leverage equations by the following control variables: firm size (in logarithm), asset volatility, asset tangibility measuring the firm's collateral value, firm profitability measured by the *EBITDA*, and dummy variables for IR hedging and FX hedging.

Interestingly, Table 3.11 shows statistically and economically significant effects of oil and gas hedging on firms' leverage ratios. The estimated coefficients indicate that a 1% increase in the aggregate hedging ratio of gas (oil) production translates into a 13 (25.51) basis points in leverage ratio. These figures are larger than the 3 basis points reported in Bartram, Brown, and Fehle (2009) for commodity hedging, and are relatively smaller than 32 basis points documented in Graham and Rogers (2002) for IR and FX hedging. For gas hedging, a 1% increase in swap contract and put option intensity leads to an increase of about 28 and 97 basis points in leverage ratio.

For oil hedging, a 1% increase in swap contract, costless collar, and put option intensity allows firms to attain higher leverage ratios of about 29, 62, and 218 basis points. More importantly, put options appear to allow firms to access higher levels of external financing. One explanation of this finding could be that put option users are often wealthy firms having better access to debts. Relative to the average hedging ratio, a firm can attain higher leverage levels of about 6.63% (=13 basis points × 51%) and about 12% (=25.51 basis points × 47%) for gas hedging and oil hedging respectively. This explains the important gap between median leverage of hedgers and non-hedgers (33% versus 12%).

These documented findings corroborate earlier empirical results and theoretical conjectures by Smith and Stulz (1985), Froot, Stein, and Sharfstein (1993), Stulz (1996), Ross (1996), Leland (1998), and Graham and Rogers (2002), namely financial hedging improves firm's debt capacity by reducing the probability of left-tail (lower-tail) outcomes and expected costs of bankruptcy. In doing so, corporate risk management increases firm value throughout the following three channels: 1) tax advantages of interest deduction (Ross, 1996, Leland, 1998, Graham and Rogers, 2002), 2) project financing (Froot, Stein, Sharfstein, 1993, Stulz, 1996, Graham and Rogers, 2002), and 3) firm monitoring provided by debt financing which commits manager to improve efficiency (Stulz, 1996).

Table 3.11 Simultaneous equation analysis of hedging extent and firm leverage

	Panel A: Gas hedging				Panel B: Oil hedging			
	Hedging portfolio	Swap contracts	Costless collars	Put options	Hedging portfolio	Swap contracts	Costless collars	Put options
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Equation 1: Leverage ratio is the dependent variable								
HEDGE RATIO	0.1301**	0.2769**	0.1457	0.9701***	0.2551**	0.2847**	0.6235**	2.1793**
	(0.063)	(0.138)	(0.132)	(0.287)	(0.114)	(0.136)	(0.284)	(0.872)
SIZE	0.0159***	0.0175***	0.0189***	0.0186***	0.0166***	0.0171***	0.0160***	0.0197***
	(0.004)	(0.004)	(0.004)	(0.004)	(0.005)	(0.004)	(0.005)	(0.004)
SIGMA_ASSET	-0.0775***	-0.0699***	-0.0868***	-0.0917***	-0.0707***	-0.0679***	-0.0867***	-0.0937***
	(0.008)	(0.008)	(0.010)	(0.009)	(0.008)	(0.008)	(0.009)	(0.012)
TANGIBILITY	0.1559***	0.1497***	0.1459***	0.1497***	0.1775***	0.1828***	0.1812***	0.1906***
	(0.023)	(0.028)	(0.021)	(0.021)	(0.024)	(0.026)	(0.021)	(0.032)
EBITDA	-0.2672***	-0.2583***	-0.2853***	-0.3314***	-0.2351***	-0.2321***	-0.2894***	-0.3216***
	(0.022)	(0.023)	(0.023)	(0.027)	(0.022)	(0.022)	(0.026)	(0.034)
IR_HEDG	0.0440***	0.0461***	0.0407***	0.0474***	0.0466***	0.0473***	0.0397***	0.0469**
	(0.007)	(0.010)	(0.006)	(0.008)	(0.009)	(0.010)	(0.009)	(0.020)
FX_HEDG	-0.0062	-0.0115	-0.0002	-0.0115	-0.0049	-0.0086	-0.0041	-0.0104
	(0.012)	(0.012)	(0.012)	(0.014)	(0.011)	(0.011)	(0.013)	(0.028)
CONSTANT	-0.0035	-0.0167	-0.0188	-0.0330	0.0126	-0.0105	0.0151	-0.0284
	(0.037)	(0.038)	(0.038)	(0.033)	(0.051)	(0.040)	(0.048)	(0.045)
Observations	5,233	5,233	5,233	5,233	5,215	5,215	5,215	5,215
R-squared	0.6567	0.6362	0.6529	0.5537	0.6197	0.6305	0.5393	0.0812
Chi_2	9940.8560	9051.6243	9874.4309	7739.2906	7650.2938	9007.0146	6805.6163	3921.8942
p-value	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Equation 2: Hedge ratio is the dependent variable								
LEVERAGE	0.5294***	0.3714***	0.2401***	-0.0810***	0.3660***	0.4140***	-0.0038	-0.0523*
	(0.077)	(0.063)	(0.054)	(0.030)	(0.071)	(0.056)	(0.048)	(0.030)
TAX_SAVE	0.0263	-0.0081	0.0894**	0.0302	0.0586	0.0420	0.0519	0.0337*
	(0.054)	(0.041)	(0.041)	(0.022)	(0.042)	(0.036)	(0.032)	(0.017)
TLCF	-0.0351***	-0.0246**	-0.0087	0.0052	-0.0101	-0.0281***	0.0173***	0.0065*
	(0.012)	(0.010)	(0.009)	(0.005)	(0.008)	(0.008)	(0.007)	(0.003)
VOL_GAS(OIL)	0.0751***	0.0317**	0.0391***	0.0042	0.0068***	0.0032**	0.0024*	0.0000
	(0.016)	(0.013)	(0.011)	(0.006)	(0.002)	(0.002)	(0.001)	(0.001)
SPOT_GAS(OIL)	0.0124***	0.0068***	0.0081***	-0.0029**	0.0014***	0.0009***	0.0004**	0.0001
	(0.003)	(0.002)	(0.002)	(0.001)	(0.000)	(0.000)	(0.000)	(0.000)
Q_RATIO	-0.0020***	-0.0016***	-0.0004	-0.0007**	-0.0017***	-0.0012**	-0.0009**	-0.0007***
	(0.001)	(0.001)	(0.000)	(0.000)	(0.001)	(0.000)	(0.000)	(0.000)
SALES	0.0398***	0.0089***	0.0198***	0.0069***	0.0270***	0.0086***	0.0138***	0.0033**
	(0.004)	(0.003)	(0.003)	(0.002)	(0.004)	(0.003)	(0.003)	(0.002)
PQ_COR_GAS(OIL)	-0.0129	-0.0195**	0.0036	-0.0147***	-0.0018	-0.0032	-0.0005	-0.0043
	(0.010)	(0.008)	(0.008)	(0.004)	(0.006)	(0.005)	(0.005)	(0.003)
UNCER_GAS(OIL)	0.0825***	0.0565***	0.0232*	0.0279***	0.0524***	0.0387***	0.0119	0.0111**
	(0.017)	(0.013)	(0.012)	(0.007)	(0.011)	(0.009)	(0.008)	(0.005)
HERF_GAS(OIL)	-0.1734***	-0.0874***	-0.1242***	0.0502***	-0.1058***	-0.0924***	-0.0228	-0.0226**
	(0.038)	(0.030)	(0.029)	(0.016)	(0.025)	(0.021)	(0.017)	(0.010)
CONSTANT	-0.4580***	-0.1640***	-0.2419***	-0.0411**	-0.3866***	-0.1874***	-0.1534***	-0.0260
	(0.046)	(0.037)	(0.033)	(0.018)	(0.041)	(0.032)	(0.028)	(0.018)
Observations	5,233	5,233	5,233	5,233	5,215	5,215	5,215	5,215
R-squared	0.6040	0.5451	0.4309	0.2921	0.5482	0.4749	0.3893	0.4194
Chi_2	8335.7023	6528.0162	4160.4057	2287.3198	6591.0687	5228.4476	3347.3579	3862.3846
p-value	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

Note:

This table presents the results of 3-SLS simultaneous equations estimation linking hedging extent with firm leverage to account for endogeneity between the two variables. The dependent variable in *Equation 1* is the firm leverage ratio measured by the book value of long-term debt + debt in current liabilities divided by total assets. The dependent variable in Equation 2 is the hedging extent (for the aggregate hedging portfolio and by instrument). The estimation is done for gas hedging (Panel A) and oil hedging (Panel B), separately. All independent variables enter regressions with lagged values. All variables' definitions and construction are detailed in Table A.3.1. All regressions have firm and time fixed effects (not reported for conciseness). The *t-statistics* are into parentheses. ***Significant at the 1% level, ** Significant at the 5% level, * Significant at the 10% level.

Results also show statistically and economically significant positive impacts of leverage ratio on hedging intensity as suggested by the previous literature and particularly Haushalter (2000) for oil and gas industry. As leverage increases, firms tend to intensify their hedging by swap contracts and collars, and to reduce put option intensity. In light of the median leverage of 33% for hedgers, these latter findings are consistent with Adam (2002) prediction, namely when credit premium is moderately large, firms tend to use linear approximation of their hedging strategies. Control variables in leverage equations have predicted signs. Leverage is positively related to firm size and collateral value (asset tangibility), and negatively related to asset volatility and firm profitability. More importantly, we find that IR hedging has a significant positive effect on leverage ratio as predicted (Graham and Rogers, 2002). This latter finding reiterates the conjecture that financial hedging improves firm's debt capacity.

3.4.4.2 Cost of external financing

In the previous sub-section, we find that hedging eases the access to external funds. We now turn our attention to the cost of external financing. We do this by explicitly connecting hedging and loan spread. It is expected that hedging by reducing the probability of left-tail realizations and preventing agency costs related to risk-shifting, should improve loans contracting terms. We then estimate simultaneous regressions where the endogenous variables are hedge ratios and loan spreads. We largely follow the empirical specification adopted by Campello et al (2011) and take the logarithm of loan spread to alleviate the effects of extreme values in the spread sample. We also control for loan characteristics (logarithm of loan size (in *Mill* $), logarithm of loan maturity (in days), types, and purposes), macroeconomic variables (credit and term spreads), and firm specific characteristics (firm size (in logarithm), firm profitability, leverage, asset tangibility, asset volatility, dummy variables for IR hedging and FX hedging).

Results reported in Panel A of Table 3.12 show insignificant effects of gas hedging on loan spreads. Contrary to our prediction, results in Panel B indicate that loan spread is positively related to swap contract intensity for oil hedging. In fact, average (oil) hedgers with swap contracts are charged loan spreads that are 35.23% higher than those charged to non-hedgers (= 0.96×0.367, where 0.367 is the mean intensity for swap contracts for oil hedging). This finding contradicts the estimated reduction of 28% in loan spread reported by Campello et al (2011) for average IR/FX hedgers. It also contradicts spread reduction of 17.5% documented in Kumar and Rabinovitch (2013) for average oil and gas hedgers.

As predicted, average oil hedgers with costless collars are charged loan spreads that are 42.87% lower than those charged to non-hedgers. Relative to the average loan spread of about 201 basis points, swap contracts lead to an increase of about 71 basis points in loan spread and collars reduce this spread by about 86 basis points. Collar effects corroborate Campello et al (2011) and Kumar and Rabinovitch (2013) findings, with a higher figure. Due to these conflicting effects of swap and collars, the aggregate hedging portfolio of oil production has a negative but insignificant effect on loan spread.

Results further indicate a significant positive effect of loan spread on oil and gas hedging ratios: a 1% increase in loan spread implies an increase of about 10 and 17 basis points in the aggregate hedging portfolio of gas and oil production, respectively. Concerning hedging intensity by instrument, we find that loan spread have a particular positive impact on the extent of swap contracts for both panels of gas hedgers and oil hedgers, and a negative effect on put options for gas hedgers. Interestingly, these findings are consistent with our previous results related to leverage effects on hedging instruments that is leverage impacts in a positive manner swap contracts and in a negative manner put options. Regarding control variables in the loan spread equation, we find that firms with farther loan maturities are charged higher spread because banks require liquidity premium for long-term debts. The loan size has a negative impact on spreads which might reflect economies of scale in bank lending (Campello et al., 2011).

Table 3.12 Simultaneous equation analysis of hedging extent and loan spread

	Panel A: Gas hedging				Panel B: Oil hedging			
	Hedging portfolio	Swap contracts	Costless collars	Put options	Hedging portfolio	Swap contracts	Costless collars	Put options
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Equation 1: Loan spread (in log) is the dependent variable								
HEDGE RATIO	0.0024	0.3610	-0.4071	-0.9874	-1.1985	0.9601*	-1.3829**	-2.6801
	(0.455)	(0.383)	(0.637)	(1.186)	(1.102)	(0.520)	(0.592)	(2.592)
MATURITY	0.0722*	0.0717*	0.0773**	0.0729**	0.1033*	0.0697**	0.0835**	0.0889
	(0.037)	(0.038)	(0.037)	(0.035)	(0.054)	(0.035)	(0.042)	(0.056)
LOAN SIZE	-0.1193***	-0.1165***	-0.1227***	-0.1199***	-0.1463***	-0.1132***	-0.1264***	-0.1267***
	(0.020)	(0.019)	(0.020)	(0.022)	(0.026)	(0.019)	(0.022)	(0.045)
CREDIT_SPREAD	-0.0705	-0.0827	-0.0611	-0.0546	-0.0665	-0.0641	-0.0595	-0.0426
	(0.120)	(0.126)	(0.173)	(0.136)	(0.158)	(0.113)	(0.150)	(0.212)
TERM_SPREAD	0.0924	0.0917	0.0748	0.0744	0.0801	0.0912	0.0780	0.0660
	(0.145)	(0.146)	(0.179)	(0.158)	(0.208)	(0.138)	(0.157)	(0.312)
SIZE	-0.0516	-0.0528	-0.0489	-0.0471	-0.0193	-0.0573	-0.0501	-0.0278
	(0.054)	(0.042)	(0.038)	(0.043)	(0.074)	(0.037)	(0.041)	(0.101)
EBITDA	0.0606	0.0560	0.0869	0.1072	0.3584	0.0955	0.1710	0.2582
	(0.317)	(0.307)	(0.332)	(0.314)	(0.506)	(0.304)	(0.348)	(0.395)
TANGIBILITY	0.1611	0.1401	0.1171	0.0363	0.1260	0.1149	0.2032	0.0344
	(0.314)	(0.254)	(0.224)	(0.277)	(0.484)	(0.210)	(0.240)	(0.528)
LEVERAGE	0.9767***	0.9433***	1.0255***	1.0404***	1.3803***	0.7802***	1.0516***	1.3125***
	(0.181)	(0.142)	(0.161)	(0.145)	(0.420)	(0.172)	(0.168)	(0.450)
SIGMA_ASSET	0.2650*	0.2782**	0.2555*	0.2341*	0.2739	0.2236*	0.2646*	0.2283
	(0.137)	(0.141)	(0.136)	(0.137)	(0.193)	(0.127)	(0.145)	(0.272)
IR_HEDG	-0.0156	-0.0137	-0.0113	-0.0113	-0.0030	-0.0110	-0.0105	0.0005
	(0.041)	(0.040)	(0.043)	(0.039)	(0.054)	(0.039)	(0.043)	(0.111)
FX_HEDG	-0.2069**	-0.1912**	-0.1969**	-0.1792**	-0.2329**	-0.1782**	-0.1940**	-0.2091*
	(0.091)	(0.086)	(0.086)	(0.082)	(0.107)	(0.082)	(0.089)	(0.122)
CONSTANT	5.2432***	5.1720***	5.1791***	5.1801***	4.8489***	5.1269***	5.0058***	4.7316***
	(0.687)	(0.509)	(0.544)	(0.675)	(1.097)	(0.510)	(0.571)	(1.623)
Observations	541	541	541	541	534	534	534	534
R-squared	0.8494	0.8441	0.8399	0.8406	0.7055	0.8107	0.7681	0.6975
Chi_2	3047.9566	3011.8708	2872.3926	2905.3416	1181.2056	2519.4797	2033.2960	1339.3020
p-value	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Equation 2: Hedge ratio is the dependent variable								
LOAN SPREAD	0.1044**	0.0718*	0.0409	-0.0311*	0.1712***	0.0671*	0.0408	0.0154
	(0.044)	(0.037)	(0.032)	(0.018)	(0.052)	(0.037)	(0.032)	(0.026)
LEVERAGE	0.1986**	0.0555	0.0948	0.0860**	0.1169	0.1295*	-0.0091	0.1058**
	(0.090)	(0.076)	(0.066)	(0.036)	(0.107)	(0.076)	(0.066)	(0.053)
TAX_SAVE	0.3760	-0.1202	0.8059**	-0.0992	0.5504	-0.1226	0.7335***	0.0629
	(0.426)	(0.354)	(0.314)	(0.163)	(0.401)	(0.301)	(0.277)	(0.187)
TLCF	-0.3438***	-0.3322***	0.0134	-0.0405	-0.0330	-0.0615	0.0871	-0.0289
	(0.111)	(0.093)	(0.081)	(0.042)	(0.103)	(0.079)	(0.069)	(0.051)
VOL_GAS(OIL)	0.0635	0.0391	-0.0291	0.0328	0.0177	0.0116	-0.0009	-0.0039
	(0.052)	(0.044)	(0.038)	(0.021)	(0.015)	(0.011)	(0.009)	(0.008)
SPOT_GAS(OIL)	0.0215**	0.0021	0.0210***	-0.0014	0.0019	0.0022***	0.0006	0.0003
	(0.010)	(0.008)	(0.007)	(0.004)	(0.001)	(0.001)	(0.001)	(0.001)
Q_RATIO	-0.0032	-0.0030	0.0004	-0.0004	0.0049	-0.0041	0.0023	0.0033
	(0.004)	(0.004)	(0.003)	(0.002)	(0.005)	(0.003)	(0.003)	(0.002)
SALES	0.0303	-0.0137	0.0307**	0.0047	0.0666***	-0.0070	0.0270**	0.0215**
	(0.019)	(0.016)	(0.014)	(0.008)	(0.019)	(0.014)	(0.012)	(0.009)
PQ_COR_GAS(OIL)	0.0465	0.0221	0.0390	-0.0043	-0.0699**	-0.0416	-0.0092	-0.0195
	(0.048)	(0.040)	(0.035)	(0.018)	(0.035)	(0.025)	(0.021)	(0.015)
UNCER_GAS(OIL)	-0.0251	-0.1263**	0.0129	0.0617**	0.1594***	-0.0690*	0.0987***	0.0458*
	(0.073)	(0.061)	(0.053)	(0.028)	(0.058)	(0.041)	(0.036)	(0.024)
HERF_GAS(OIL)	-0.1714	-0.0225	-0.2496**	0.1397**	0.2155*	-0.2045**	0.2473***	0.1170**
	(0.151)	(0.125)	(0.111)	(0.059)	(0.121)	(0.093)	(0.082)	(0.059)
CONSTANT	-0.7495***	-0.0690	-0.4682**	-0.0622	-1.4643***	-0.0667	-0.6226***	-0.3800**
	(0.291)	(0.246)	(0.214)	(0.116)	(0.337)	(0.241)	(0.211)	(0.164)
Observations	541	541	541	541	534	534	534	534
R-squared	0.7027	0.6844	0.6288	0.5313	0.5981	0.6135	0.5887	0.5630
Chi_2	1280.2745	1181.1841	914.8622	620.2128	807.5248	863.8695	761.5915	700.2860
p-value	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

Note:

This table presents the results of 3-SLS simultaneous equations estimation linking hedging extent with loan spread to account for endogeneity between the two variables. The dependent variable in *Equation 1* is the loan spread (in logarithm). The dependent variable in Equation 2 is the hedging extent (for the aggregate hedging portfolio and by instrument). The estimation is done for gas hedging (Panel A) and oil hedging (Panel B), separately. All independent variables enter regressions with lagged values. All variables' definitions and construction are detailed in Table A.3.1. All regressions have firm and time fixed effects (not reported for conciseness). The *t-statistics* are into parentheses. ***Significant at the 1% level, ** Significant at the 5% level, * Significant at the 10% level.

In addition, more leveraged firms with higher asset volatility are charged higher loan spread to account for the incremental credit risk related to newly issued loans. More importantly, firms with FX hedging are charged lower loan spreads. The reduction due to FX hedging ranges from 18 to 23 basis points, which implies a reduction of about 9% to 11.5% of the average loan spread (201 basis points). Surprisingly, IR hedging has negative but insignificant estimated coefficients. These latter findings are consistent with findings in Campello et al (2011) for IR/FX hedging, however these authors do not consider IR hedging and FX hedging separately in their model. These findings also could explain the divergence of our results from those in Kumar and Rabinovitch (2013), who do not control for IR and/or FX hedging in their regressions.

3.5 Concluding Remarks

Many empirical studies on corporate risk management explore the question of whether derivatives have value and risk implication on firms. Results have been largely controversial. Using a new dataset of detailed information on the hedging activities of 150 U.S. oil and gas producers during the period from 1998 to 2010, this papers revisits the hedging premium question. We use simultaneous equation regressions to control for the endogeneity feature of derivative use decision. This study examines the links between oil and gas hedging and multiple measures of firm performance, risk and debt characteristics. Furthermore, we go beyond the aggregate feature of hedging activity and examine the real implications by derivative instrument used by our sample firms.

On the whole, we provide novel evidence of the real impact of hedging on firm' output realized selling prices, and show that hedging significantly increases gas realized prices. In addition, we find that higher realized prices are more related to costless collars and put options. Hedging also appears to be positively associated with firm's accounting performance. Our results also show that oil and gas hedging is significantly negatively related to total and idiosyncratic risk suggesting that our sample firms hedge and not speculate with derivatives. We further find insignificant effects of hedging on systematic risk suggesting that hedging does not increase the cost of equity for hedgers. Interestingly, we find that oil and gas hedging facilitates the access to more debt financing but not at a lower cost. In fact, we find a significant positive association between hedging and debt but there are no real impacts on loan spread. Finally, the welfare effects of hedging on realized prices, accounting performance, risk, and debt capacity of firms should translate into value gains for shareholders.

APPENDIX 3.1

VARIABLES' DEFINITIONS, CONSTRUCTION AND DATA SOURCES

Table A.3.1 Variables' definitions, construction and sources

Variable definition	Variable name	Construction	Data source
Variables that proxy for hedging activity			
Hedging dummy	*GAS_HEDG, OIL_HEDG IR_HEDG, FX_HEDG*	For Commodity Risk, FX, and IR hedging activities for a specified fiscal quarter. This variable is coded as follows: 0 (no hedging), 1(hedging).	10-K and 10-Q reports
	OIL/GAS_HEDG	Equals one if firm engages in oil and/or gas hedging and 0 otherwise	10-K and 10-Q reports
Variables that proxy for tax advantage of hedging			
Tax loss carry forwards	*TLCF*	Book value of the TLCF scaled by the book value of total assets	Compustat
Tax save	*TAX_SAVE*	Tax liability saving arising from a reduction of 5% of taxable income (Graham and Smith, 1999).	Manually constructed
Variables that proxy for financial distress			
Leverage	*LEV*	Book value of long-term debt in current liabilities and long-term debt scaled by the book value of total assets.	Compustat
Distance to default	*DTD*	Market-based measure of default risk based on Merton's (1974) approach and used by Moody's KMV. The DTD is equal to $\frac{V_a - D}{V_a \sigma_a}$, where D is defined as long-term debt in current liabilities plus one-half of long-term debts, V_a is the market value of assets, and σ_a is one-year asset volatility. The quantities V_a and σ_a are unobservable and are approximated from Merton's (1974) model by using the market value and volatility of equity, the three-month Treasury bill rate, and debts (D). See Crosbie and Bohn (2003) for more details on the construction of the DTD.	Manually constructed
Asset volatility	*SIGMA_ASSET*	Defined as in the calculation of distance-tot-default	
Cash cost	*CASH_COST*	Production cost of a BOE	Bloomberg and 10-K reports
Quick ratio	*Q_RATIO*	Cash and cash equivalents scaled by current liabilities.	Compustat
Variables that proxy for underinvestment costs			
Investment opportunities (IOs)	*INV_OPP*	Total costs incurred in oil and gas property acquisition, exploration, and development, scaled by net property, plant, and equipment at the beginning of the quarter.	Bloomberg and 10-K reports
Variables that proxy for revenues characteristics			
Sales	*SALES*	The logarithm of firm's total revenues	Compustat
Sales in U.S markets	*US_SALES*	Fraction of sales in U.S markets divided by firm's total sales	Compustat
Fraction of revenues from oil and gas production	*OIL&GAS_REV*	Oil and gas revenues divided by the firm's total revenues.	Bloomberg and 10-K reports
Fraction of revenues from oil production	*OIL_REV*	Equals the fraction of oil production (i.e., oil daily production in BOEs, divided by daily oil and gas production in BOEs) multiplied by the fraction of oil and gas revenues (*OIL&GAS_REV*).	Bloomberg and 10-K reports
Fraction of revenues from gas production	*GAS_REV*	Equals the fraction of gas production (i.e., gas daily production in BOEs, divided by daily oil and gas production in BOEs) multiplied by the fraction of oil and gas revenues (*OIL&GAS_REV*).	Bloomberg and 10-K reports
Variables that proxy for production characteristics			
Herfindahl index (oil production)	*HERF_OIL*	Equals 1- $\sum_{i=1}^{N}\left(\frac{q_i}{q}\right)^2$, where q_i is the daily oil production in region i (Africa, Latin America, North America, Europe, and the Middle East) and q is total daily oil production.	Bloomberg and 10-K reports

Continued

Table A.3.1-*Continued*

Variable definition	Variable name	Construction	Data source
Herfindahl index (gas production)	*HERF_GAS*	Equals 1- $\sum_{i=1}^{N}\left(\frac{g_i}{g}\right)^2$, where g_i is the daily gas production in region i (Africa, Latin America, North America, Europe, and the Middle East) and g_i is total daily gas production.	Bloomberg and 10-K reports
Oil production uncertainty	*UNCER_OIL*	Coefficient of variation of daily oil production. This coefficient is calculated for each firm by using all the observations of daily oil production until the current quarter.	Bloomberg and 10-K reports
Gas production uncertainty	*UNCER_GAS*	Coefficient of variation of daily gas production. This coefficient is calculated for each firm by using all the observations of daily gas production until the current quarter.	Bloomberg and 10-K reports
Price–quantity correlation (oil)	*PQ_COR_OIL*	Correlation coefficient between daily oil productions and oil spot prices.	Bloomberg and 10-K reports
Price–quantity correlation (gas)	*PQ_COR_GAS*	Correlation coefficient between daily gas productions and gas spot prices.	Bloomberg and 10-K reports
Gas daily production	*GAS_PROD*	Measured in millions of cubic feet. The observations are given on an annual basis. We repeat the annual observations for each quarter of the same fiscal year	Bloomberg and 10-K reports
Oil daily production	*OIL_PROD*	Measured In thousands of barrels. The observations are given on an annual basis. We repeat the annual observations for each quarter of the same fiscal year	Bloomberg and 10-K reports
Variables that proxy for firm size			
Firm size	*SIZE*	The logarithm of (number of common shares outstanding * end-of-quarter per share price) + book value of asset – book value of equity.	Compustat
Tangibility	*TANGIBILITY*	Net property, plant, and equipment scaled by book value of asset.	Compustat
Profitability	*EBITDA*	Earnings before interest, tax, depreciation, and amortization scaled by book value of total asset.	Compustat
Variables that proxy for information asymmetry			
% Institutions shareholding	*%_CS_INST*	Percentage of institutions' common shares held.	Thomson Reuters
Variables that proxy for market conditions			
Oil spot price	*SPOT_OIL*	Oil spot price represented by the WTI in the NYMEX.	Bloomberg
Gas spot price	*SPOT_GAS*	Constructed as an average index established from principal locations' indices in the United States (Gulf Coast, Henry Hub, etc.)	Bloomberg
Oil price volatility	*VOL_OIL*	Historical volatility (standard deviation) using the spot price of the previous 60 days.	Bloomberg
Gas price volatility	*VOL_GAS*	Historical volatility (standard deviation) using the spot price of the previous 60 days.	Bloomberg
Firm's stock return characteristics			
Stock market beta, oil beta, and gas beta	*BETA_MKT, BETA_OIL, BETA_GAS*	Calculated from the market model supplemented by changes in near-month NYMEX future contracts for gas and oil. The model is estimated on quarterly basis using daily return of firm's stock and market index as measured by the CRSP value weighted index.	CRSP and US energy information administration
Total volatility	*SIG_TOTAL*	Standard deviation of daily stock return calculated on quarterly basis	CRSP
Idiosyncratic risk	*SIG_SPECIFIC*	Equals the ratio of stock return volatility divided by market index volatility calculated from daily returns and on quarterly frequency.	CRSP

Continued

Table A.3.1-*Continued*

Variable definition	Variable name	Construction	Data source
Loan characteristics			
Loan spread	*LOAN SPREAD*	All-in spread drawn over the LIBOR charged by the bank for the drawn fraction of the facility.	DealScan
Loan size	*LOAN SIZE*	The logarithm of loan size, measured in $ million	DealScan
Loan maturity	*MATURITY*	The logarithm of lean maturity, measured in days	DealScan
Loan types dummies		Dummy variable for each loan type: including revolver greater than one year, revolver less than one year, term loan, and 364-day facility	DealScan
Loan purposes dummies		Dummy variable for each loan purpose, including general corporate purposes, debt repayment, project financing, and back-up line for commercial papers	DealScan
economic control variables			
Term spread	*TERM SPREAD*	The difference between 10-year Treasury bonds and 1-year Treasury bonds	Federal Reserve
Credit spread	*CREDIT SPREAD*	The difference between the yields on BAA corporate bond and AAA corporate bond	Federal Reserve

APPENDIX 3.2

SIMULTANEOUS EQUATION ANALYSIS OF HEDGING EXTENT AND THE RETURN ON EQUITY

Table A3.2 Simultaneous equation analysis of hedging extent and the return on equity

	Panel A: Gas hedging				Panel B: Oil hedging			
	Hedging portfolio	Swap contracts	Costless collars	Put options	Hedging portfolio	Swap contracts	Costless collars	Put options
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Equation 1: Return on equity is the dependent variable								
HEDGE RATIO	0.1287**	0.1511	0.2389**	0.6130*	0.1732*	-0.1195	1.1123***	3.5196**
	(0.056)	(0.135)	(0.115)	(0.333)	(0.101)	(0.133)	(0.326)	(1.369)
SIZE	0.0019	0.0073	0.0007	0.0026	-0.0031	0.0049	-0.0037	-0.0014
	(0.004)	(0.005)	(0.004)	(0.004)	(0.005)	(0.005)	(0.006)	(0.004)
OIL&GAS_REV	0.0168	0.0166	0.0290**	0.0252**	0.0306**	0.0285**	0.0447***	0.0291**
	(0.011)	(0.010)	(0.012)	(0.012)	(0.012)	(0.012)	(0.017)	(0.014)
US_SALES	0.0255	0.0529***	0.0284	0.0215	0.0364*	0.0345*	0.0679**	0.0329
	(0.017)	(0.020)	(0.020)	(0.027)	(0.019)	(0.019)	(0.029)	(0.022)
INV_OPP	0.0024	0.0023	0.0008	0.0008	-0.0006	-0.0001	0.0017	0.0006
	(0.002)	(0.002)	(0.003)	(0.002)	(0.003)	(0.003)	(0.004)	(0.002)
%_CS_INST	-0.0359***	-0.0481***	-0.0266*	-0.0228	-0.0225	-0.0289*	-0.0741***	-0.0180
	(0.013)	(0.016)	(0.016)	(0.015)	(0.015)	(0.015)	(0.024)	(0.019)
CASH_COST	-0.0018***	-0.0014***	-0.0019***	-0.0020***	-0.0027***	-0.0021***	-0.0041***	-0.0012*
	(0.000)	(0.000)	(0.001)	(0.001)	(0.000)	(0.000)	(0.001)	(0.001)
LEVERAGE	-0.0340*	-0.0332	-0.0232	-0.0212	-0.0060	0.0167	0.0035	-0.0155
	(0.018)	(0.023)	(0.016)	(0.016)	(0.016)	(0.019)	(0.020)	(0.027)
CONSTANT	-0.0332	-0.0979*	-0.0281	-0.0556	-0.0051	-0.0867*	0.0213	-0.0321
	(0.041)	(0.050)	(0.043)	(0.044)	(0.051)	(0.046)	(0.057)	(0.051)
Observations	5,237	5,237	5,237	5,237	5,243	5,243	5,243	5,243
R-squared	0.1439	0.1432	0.1237	0.0990	0.1483	0.1563	-0.5663	-2.8136
Chi_2	1074.4425	1065.2208	1050.0986	1049.0043	1078.8284	1069.5052	601.7645	405.3583
p-value	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Equation 2: Hedge ratio is the dependent variable								
ROE	0.7946***	0.7271***	-0.0613	0.1230	-0.6089***	-0.1689	-0.6758***	0.1090
	(0.285)	(0.238)	(0.184)	(0.102)	(0.219)	(0.152)	(0.171)	(0.084)
TAX_SAVE	0.0254	-0.0442	0.1009**	0.0049	0.0566	0.0302	0.0418	0.0024
	(0.051)	(0.041)	(0.041)	(0.021)	(0.060)	(0.041)	(0.048)	(0.011)
TLCF	-0.0259**	-0.0189**	-0.0077	-0.0007	-0.0244**	-0.0428***	0.0250**	0.0022
	(0.012)	(0.009)	(0.009)	(0.005)	(0.012)	(0.009)	(0.010)	(0.002)
VOL_GAS(OIL)	0.0523***	0.0158	0.0360***	0.0011	0.0043	0.0041**	-0.0027	0.0006
	(0.018)	(0.015)	(0.012)	(0.006)	(0.003)	(0.002)	(0.002)	(0.001)
SPOT_GAS(OIL)	-0.0015	-0.0063*	0.0069***	-0.0033**	0.0019***	0.0008***	0.0013***	-0.0001
	(0.004)	(0.003)	(0.003)	(0.001)	(0.000)	(0.000)	(0.000)	(0.000)
Q_RATIO	-0.0015**	-0.0011**	-0.0001	-0.0002	-0.0010	-0.0009*	0.0002	0.0001
	(0.001)	(0.001)	(0.000)	(0.000)	(0.001)	(0.000)	(0.001)	(0.000)
SALES	0.0471***	0.0166***	0.0268***	0.0040*	0.0366***	0.0119***	0.0232***	0.0029
	(0.006)	(0.005)	(0.004)	(0.002)	(0.005)	(0.004)	(0.004)	(0.002)
LEVERAGE	0.1606***	0.1285***	0.0315**	0.0107	0.0626***	0.0859***	0.0005	0.0047
	(0.022)	(0.019)	(0.014)	(0.008)	(0.021)	(0.014)	(0.016)	(0.008)
PQ_COR_GAS(OIL)	-0.0133	-0.0145*	0.0052	-0.0084**	-0.0003	-0.0035	0.0010	0.0001
	(0.010)	(0.008)	(0.008)	(0.004)	(0.009)	(0.006)	(0.007)	(0.002)
UNCER_GAS(OIL)	0.0815***	0.0381***	0.0358***	0.0146**	0.0433***	0.0373***	-0.0100	-0.0035
	(0.017)	(0.014)	(0.013)	(0.007)	(0.014)	(0.010)	(0.011)	(0.003)
HERF_GAS(OIL)	-0.1938***	-0.0966***	-0.1402***	0.0537***	-0.0893**	-0.1068***	0.0447	0.0085
	(0.040)	(0.032)	(0.031)	(0.016)	(0.036)	(0.025)	(0.028)	(0.007)
CONSTANT	-0.4248***	-0.1340***	-0.2753***	-0.0160	-0.4538***	-0.1972***	-0.2352***	-0.0163
	(0.060)	(0.050)	(0.039)	(0.021)	(0.053)	(0.037)	(0.041)	(0.020)
Observations	5,237	5,237	5,237	5,237	5,243	5,243	5,243	5,243
R-squared	0.5002	0.3687	0.4472	0.2802	0.4473	0.4962	0.0099	0.4060
Chi_2	7119.2985	5188.3519	4236.8553	2279.4582	5446.2599	5464.6774	2066.6122	3863.1885
p-value	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

Note:

This table presents the results of 3-SLS simultaneous equations estimation linking hedging extent with firm's return on equity (*ROE*) to account for endogeneity between the two variables. The dependent variable in *Equation 1* is the *ROE* measured by net income divided by book value of equity. The dependent variable in *Equation 2* is the hedging extent (for the aggregate hedging portfolio and by instrument). The estimation is done for gas hedging (Panel A) and oil hedging (Panel B), separately. All independent variables enter regressions with lagged values. All variables' definitions and construction are detailed in Table A.3.1. All regressions have firm and time fixed effects (not reported for conciseness). The *t-statistics* are into parentheses. ***Significant at the 1% level, ** Significant at the 5% level, * Significant at the 10% level.

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CONCLUSION

Malgré son impertinence dans le monde parfait de Modigliani et Miller (1958), la gestion des risques financiers est devenue une pratique usuelle dans un grand nombre d'entreprises non-financières (Bartram, Brown, et Fehle, 2009). La littérature a bien amélioré notre compréhension des motivations de la gestion des risques et de ses vertus potentielles en termes de création de la valeur pour l'entreprise et, par conséquent, pour les actionnaires. Toutefois, il importe de remarquer que cette littérature, surtout celle empirique, nous éclaire peu sur les déterminants du choix de la stratégie de couverture à adopter par les entreprises. De surcroit, cette littérature ne dit presque rien sur la manière de choisir les maturités des positions de couverture et leur évolution dans le temps. À ce niveau, le manque de modèle théorique a été comblé par Fehle et Tsyplakov (2005). Finalement, les résultats empiriques relatifs aux implications et retombées de la gestion des risques sur l'entreprise restent largement controversés et non-concluants.

Parmi les raisons déjà avancées par Aretz et Bartram (2010) pour expliquer ces controverses, on trouve les difficultés à déterminer avec précision l'étendue de la couverture vu que les entreprises utilisent des portefeuilles complexes incorporant une multitude d'instruments qui diffèrent en termes des coûts d'initiation, profil de gain (*payoff*), maturité, comptabilisation, etc. Grâce aux données très détaillées, collectées manuellement, sur les positions de couverture d'un échantillon de 150 compagnies pétrolières américaines, le but de cette thèse est de contribuer à la littérature en préconisant des réponses surtout au regard des déterminants du choix de la stratégie et de la maturité de la couverture. Vu le manque d'évidences empiriques portant sur ces deux aspects, nous croyons qu'il n'est pas inutile d'apporter une nouvelle contribution à la littérature dans ce sujet. Encore, nous croyons que, revisiter la question de la prime liée à la gestion des risques est toujours indispensable, surtout à la lumière des différentes critiques méthodologiques et les limitations au niveau des données qui restreignent la pertinence des résultats empiriques obtenus.

Dans le premier chapitre, nous avons examiné la validité empirique de certaines prédictions émanant des travaux théoriques en rapport avec les déterminants du choix des stratégies de couverture. Un défi d'ordre méthodologique s'est posé vu la persistance dans le choix des stratégies. Cette persistance a motivé le recours à une modélisation économétrique dynamique appliquée aux modèles aux choix discrets. Dans l'ensemble, les résultats obtenus montrent que les entreprises qui font face à plus de dépenses d'investissement utilisent plus les stratégies non-linéaires. Toutefois, une corrélation positive entre ces dépenses d'investissement et les flux monétaires générés à l'interne incite davantage l'utilisation des stratégies linéaires. Les stratégies non-linéaires sont aussi positivement corrélées avec la diversification géographique et l'incertitude dans la production. Cependant, une corrélation positive entre les prix de vente et les quantités produites motive le déploiement des stratégies linéaires pour stabiliser les flux monétaires.

Les résultats donnent aussi une première évidence empirique de l'impact du problème de surinvestissement qui favorise l'utilisation des stratégies linéaires. La fonction d'utilité du gestionnaire averse au risque joue un rôle important dans la détermination de la stratégie de couverture. Si sa fonction d'utilité est concave (plus d'actions), le gestionnaire choisirait les stratégies linéaires. Si sa fonction d'utilité est convexe (plus d'options d'achat), il aurait tendance à préférer les stratégies ayant un *payoff* convexe. Les entreprises les plus endettées, mais pas encore en détresse financière, cherchent à stabiliser leurs flux monétaires avec particulièrement les contrats swap. Les entreprises en détresse financière font plutôt du transfert de risque avec les options de vente.

Le deuxième chapitre investigue particulièrement la validité empirique des prédictions théoriques émanant du modèle de Fehle et Tsyplakov (2005) ainsi que d'autres hypothèses liées au programme d'investissement de l'entreprise, à la maturité de ses actifs et ses dettes, aux taxes, et à l'aversion au risque du gestionnaire. Le constat le plus important révélé par les résultats est celui de la relation non-monotone qui existe entre la maturité de la couverture et la probabilité de la détresse financière. Cette non-monotonicité existe aussi entre la maturité et les prix au comptant du pétrole et du gaz. Les résultats montrent aussi que la maturité de la couverture est positivement corrélée à l'incertitude dans la production, à la corrélation entre les prix de vente et les quantités produites, et à la volatilité des prix au comptant.

Les entreprises ayant de grandes dépenses d'investissement privilégient les couvertures avec de longues maturités pour aboutir à une meilleure coordination des dépenses en capital et du financement. Toutefois, une corrélation positive entre les dépenses d'investissement et les flux monétaires, incite les entreprises à utiliser des couvertures plus courtes. Les résultats montrent encore que les entreprises alignent la maturité de leurs positions de couverture avec celles de leurs actifs et leurs dettes. Enfin, une première investigation empirique des effets de la maturité de la couverture sur la valeur et le risque de l'entreprise, démontre que les positions de couverture avec des échéances plus lointaines assurent une meilleure réduction de la sensibilité des rendements de l'action aux fluctuations des prix du pétrole et du gaz.

Dans le troisième chapitre, nous réexaminons l'hypothèse de la prime liée à la gestion des risques financiers. Pour pallier aux critiques adressées aux résultats déjà obtenus dans la littérature, nous prenons en compte particulièrement le problème d'endogénéité de la décision de couverture avec d'autres aspects de la politique financière de l'entreprise via une estimation en équations simultanées par la méthode des triples moindres carrés. Nous avons aussi contrôlé pour l'existence d'autres couvertures telles que celles relatives aux taux d'intérêt et aux taux de change, et aussi l'existence d'autres types de couverture opérationnelle sous forme de diversification géographique, par exemple.

Les résultats révèlent que la gestion des risques a des effets positifs particulièrement sur les prix de vente du gaz. Ces effets positifs se répercutent favorablement sur la performance comptable de l'entreprise. De plus, la couverture permet de réduire significativement la volatilité des rendements des actions de l'entreprise ainsi que son risque résiduel. La couverture n'est pas associée à une augmentation du risque systématique. Cela signifie que la présence de la gestion des risques financiers n'incite pas les investisseurs à demander un taux de rendement plus élevé pour détenir l'action de l'entreprise. De surcroit, la gestion des risques augmente la capacité de l'entreprise à contracter des dettes mais sans effets directs (positif ou négatif) sur le coût de cet endettement.

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