Selective Hedging in the US Oil and Gas Producers: Determinants and Real Implications

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A supervised project report submitted for the degree of
Master of Science in Financial Engineering

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October, 2023

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Couverture Spéculative chez les Producteurs de Pétrole et de Gaz aux États-Unis: Déterminants et Implications Réelles

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Rapport d'un projet supervisé présenté en vue de l'obtention du grade de *Maîtrise ès sciences en gestion (M.Sc)*, option Ingénierie Financière.

Octobre, 2023

Résumé

La présente étude vise à apporter un nouvel éclairage sur le phénomène de "couverture sélective", une forme de spéculation par laquelle les gestionnaires d'entreprises intègrent activement leurs perspectives personnelles sur les mouvements futurs du marché dans les programmes de gestion de risques des firmes dont ils ont la charge. Nous nous intéressons essentiellement à deux aspects: d'une part, l'identification des principales caractéristiques financières et opérationnelles étroitement liées à la pratique de la couverture sélective et, d'autre part, les effets de ce phénomène sur la valeur, les indicateurs de risque et la performance comptable des entreprises. S'appuyant sur un large ensemble de données de panel sur les activités de couverture d'un échantillon de producteurs de pétrole et de gaz aux États-Unis, notre analyse révèle que la taille de la firme, le potentiel de croissance, la santé financière, la part des investisseurs institutionnels dans l'actionnariat et les opportunités d'investissement sont autant de déterminants significatifs de la décision et de l'étendue de la couverture sélective au sein des firmes. De plus, nous mettons en lumière un important effet d'horizon pour ce qui est de la taille de la firme, variable censée refléter le degré d'absence d'asymétrie d'information. Les activités spéculatives des firmes de petite taille se limitent essentiellement au court terme, alors que les firmes de

taille plus importante se concentrent plutôt sur un horizon de moyen terme. Se basant sur l'approche des modèles d'hétérogénéité essentielle, qui permet de surpasser différents types de biais inhérents au problème d'endogénéité, nous concluons que la spéculation est susceptible d'entrainer des effets délétères non-négligeables sur la valeur et les indicateurs de risques de la firme. Dans le cas présent, la couverture sélective a un effet négatif sur la valeur de la firme sur un horizon de couverture d'une année aussi bien pour le pétrole que pour le gaz, et entraine une augmentation du risque spécifique des firmes sur la même période, pour le pétrole.

Mots-clés: Gestion des risques des firmes non-financières; Couverture sélective; Spéculation; Couverture; Détresse financière; Rémunération des dirigeants; Causalité; Valeur de la firme; Risque idiosyncratique

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Abstract

This study aims to shed light on the phenomenon of "selective hedging," which refers to the prevalent practice among managers of actively incorporating their views about future price movements into their respective firms' risk management programs. We focus on two aspects in particular: What are the primary drivers of this type of speculation in terms of firm characteristics, and what are the real and financial implications of the practice on the firm value, riskiness, and accounting performance? Using a large panel data set of US oil and gas producers, our analysis reveals that firm size, potential for growth, financial health, the stake of institutional investors, and investment opportunities are strongly related to the decision and the extent of selective hedging. Moreover, we uncover an important horizon effect about the firm size, a proxy for informational advantage. Smaller firms tend to engage in short-term speculation, while larger firms aim for longer horizons. Using the essential heterogeneity econometric approach to overcome various types of endogeneity-related issues, we find that selective hedging can yield non-negligible real effects: high-intensity speculation has a negative effect on the firm value and increases the idiosyncratic risk at a one-year horizon.

Keywords: Corporate risk management; Selective hedging; Speculation; Hedging; Financial distress; Managerial compensation; Causality; Firm value; Idiosyncratic risk

Acknowledgements

First and foremost, I would like to express my sincere gratitude to Prof. Georges Dionne, who introduced me to the stimulating field of corporate risk management and kindly accepted to supervise this supervised project.

In addition, I would also like to thank M. Mohamed Mnasri for his unwavering support throughout this project.

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1 Introduction

A considerable number of non-financial firms use derivative instruments to insulate themselves, at least partially, from any risk in future price movements of the commodities at the core of their business. This practice, commonly known as "hedging," has garnered much attention from scholars and professionals and is central to contemporary corporate risk management theory and practice. Many questions about the purpose of hedging activities revolve around one common theme: Do they create any added value for the shareholders?

Indeed, in the frictionless (but fictitious) economy of Modigliani-Miller, with perfect capital markets and full information, hedging is irrelevant as the shareholders can undo any risk management setup put in place by the firm at the same cost. Nevertheless, the real world is replete with many market imperfections. The literature on risk management has identified several rationales that make hedging a value-enhancing strategy, as it helps mitigate several real-world flaws. The most cited motives are:

- the reduction of financial distress costs (Smith and Stulz (1985)),
- the minimization of corporate tax liability (Graham and Smith (1999) and Graham and Rogers (2002)),
- better coordination between financing and investment policies (Froot et al. (1993)),
- the mitigation of conflicts of interest between shareholders and bondholders (Stulz (1996)),
- and agency costs related to corporate governance and the risk-taking behavior of managers (Dionne and Triki (2013)).

Modern risk management theory hinges on two central tenets: market efficiency and diversification. The strong form of market efficiency stipulates that all available public or private information is reflected in market prices, making it impossible to generate sustainable gains through perceived informational advantage. However, many managers who believe in possessing specialized "insights" in some areas often challenge this principle.

Surveys of corporate hedging programs suggest that many managers incorporate their perspectives into their hedging programs by adjusting the size and timing of their derivatives transactions based on their perceptions of the market's future trajectory. Based on a survey of 244 Fortune 500 firms, Dolde (1993) reports that nearly 90% of the surveyed firms determine the size of their hedges considering their market views, at least occasionally. Bodnar et al. (1998)) survey 399 U.S. non-financial firms and find that approximately 50% (10%) of their sample firms confess to frequently (occasionally) altering the size or timing of a hedge due to managers' market perceptions. Stulz (1996) coins the term "selective hedging" to characterize this type of behavior.

The reasons why some managers may believe they can derive meaningful and consistent gains from selective hedging, resulting in shareholder benefits, are unclear. There are a few theoretical lines of reasoning that validate speculation as a 'rational' choice.

On the one hand, Stulz (1996) postulates that this strategy can only be effective if the speculating manager has a comparative advantage in market-specific information. In addition, the strategy is only viable if the company has sufficient financial resources to withstand potential temporary losses without compromising its primary business. Stulz (1996) framed this hypothesis as "the comparative advantage in risk-taking."

On the other hand, the same Stulz (1996) suggests an additional reason why a company might rationally speculate despite knowing it has no comparative advantage in making such a move. When a company is already in financial distress, risk management is ineffective because it increases the likelihood that it will remain in the same condition, ultimately leading to bankruptcy. In this situation, risky bets may be the only way out, as the rise in the underlying volatility of the firm's value enhances the likelihood of favorable events that could get the company out of trouble. This line of reasoning and —and similar ones — are often referred to as "bet-the-ranch" type of arguments.

Campbell and Kracaw (1999) look at the problem of rational speculation from a different perspective. In a model with asymmetric information and a convex investment opportunity set, they show that speculation can be "optimal" for firms that are small relative to their significant investment opportunities, but are hampered by limited financing capabilities.

When external financing costs are prohibitive, mainly due to agency costs inherent to information asymmetry, speculation becomes the last resort to improve the firm's finances and pursue the lucrative investment opportunities at hand.

This study seeks to shed light on the phenomenon of "speculative hedging"[1] in the U.S. oil and gas production industry. Using a rich panel data set of 150 firms spanning a sample period of over a decade, we empirically evaluate the validity of various theoretical propositions put forth to justify firms' speculation within their respective risk management programs. Our research centers on two primary questions: First, we aim to identify the main financial and operational characteristics related to selective hedging to understand the potential drivers of this often-overlooked phenomenon. In addition, we analyze the real and financial implications of speculation on firm value, riskiness, and accounting performance.

After constructing a measure that captures the extent of speculation from the quarterly time series of the firms' hedging ratios, we find that speculative hedging is positively associated with the firm's growth potential and financial health. In addition, institutional ownership discourages speculation significantly. Regarding firm size, a variable thought to proxy for a firm's comparative advantage in acquiring privileged information, our findings suggest an important horizon effect: larger firms prefer to speculate over longer horizons, whereas smaller firms' speculative activities are more focused on the short-term (less than a one-year horizon). Moreover, leveraging the essential heterogeneity econometric approach to overcome different types of endogeneity and selection issues, we confirm that firm size, investment opportunities, financial strength, institutional ownership, and the level of global demand for industrial commodities are all significant determinants of the decision and the extent of high-intensity speculation. The relative importance of each determinant depends on the horizon and the energy commodity under consideration. Importantly, we find that high-intensity speculative hedging causes a statistically significant decrease in the firm value for both oil and gas and raises the idiosyncratic risk at the one-year hedging horizon for oil.

The rest of our paper is organized as follows: In the next section, we provide a broad

[1] In this paper, we use the terms "selective hedging," "speculative hedging," and speculation interchangeably.

overview of our data sample, focusing on the hedging activities. Section 3 constructs our measure of selective hedging and demonstrates how it relates to some key financial and operational characteristics. Section 4 examines the implications of speculative hedging on the firm's value, riskiness, and accounting performance. Finally, Section 5 concludes.

2 Literature review and hypothesis development

The debate around the merits of hedging (or lack thereof) has revolved around two main themes: maximizing the firm value and accommodating managers' risk appetite. Under the traditional "economic value perspective," hedging is only valuable because it helps alleviate market imperfections, allowing the firm to perform better and attain a higher value. Beyond that, derivatives transactions aimed at taking positions over future price fluctuations are deemed worthless as their expected net present value is zero. However, accounts from managers and practitioners seem to challenge the last precept.

Ample survey evidence shows that speculative hedging is widespread, and corporate managers routinely incorporate their views in their risk management schemes. For instance, Glaum (2002) surveys the risk management practices of major non-financial firms in Germany and finds that most employ forecast-based, profit-oriented hedging strategies. Faulkender (2005) finds that managers adjust the exposure of new debt issues to the yield curve in an effort to time interest rates, to mention these two examples. Several quantitative studies also provide evidence of selective hedging across different industries. When examining the North American gold mining industry, Adam and Fernando (2006) show that firms have consistently been able to generate positive, economically significant cash flow gains, thanks to persistent risk premia in the gold futures market. This finding contradicts the zero net present value assumption of derivatives transactions. Besides, the authors do not find a compensating increase in the systematic risk of firms. Taken together, these two facts translate into an increase in the shareholders' value. However, when they decompose the cash flows into those attributable to "fundamental hedging" (justified by the financial and operational characteristics of the firms) and those associated with a residual component of hedging (interpreted as "selective hedging"), they conclude that the cash flow gains from speculation are small at best.

Brown et al. (2006), who focus on the same industry but rely on a much shorter sample period, also find that speculative hedging is widespread in North American gold mining firms. In contrast to predictions that companies hedge to reduce the anticipated costs of financial distress, there is a positive correlation between changes in hedge ratio and concurrent changes in gold prices. The findings are in line with managers' attempts to lock in high prices and to wait out low prices in anticipation of a recovery, an approach similar to "equity market timing." In line with the results of Adam and Fernando (2006), Brown et al. (2006)'s analysis also reveals that economic gains resulting from selective hedging are small, and no evidence suggests this practice results in superior operating or financial performance.

The circumstances under which speculative hedging may be "rationally" justifiable are still points of contention. Stulz (1996) proposes a new theory under which speculation could benefit shareholders. The firm must possess "specialized" information not reflected in the current market conditions. Larger firms are most likely to be in this position because they typically have a sizeable market share, some market power, and a more prominent geographical presence. Moreover, they are able to commit significant resources to acquiring the required expertise to detect and successfully exploit any market inefficiencies. Nonetheless, in an empirical study focusing on North American gold mining firms, Adam et al. (2017) find that though larger firms hedge more of their future production, smaller firms tend to speculate more. This finding is puzzling as it starkly contrasts with Stulz (1996)'s prediction on comparative advantage in risk-taking. Is it a peculiarity of the gold mining industry or a stylized feature of non-financial firms? By examining the US oil and gas producers, our research sheds light on this question and helps distinguish which of the following propositions is supported by empirical evidence.

Hypothesis 1a: All else equal, large firms speculate more than smaller firms.

Hypothesis 1b: All else equal, large firms speculate less than smaller firms.

The relationship between the financial health of a firm and its propensity to selectively hedge is another unsettled issue. On the one hand, Stulz (1996) argues that superior information is necessary but that more is required for effective speculation. The informational advantage may be noisy or inaccurate. Therefore, the firm engaging in selective hedging must be financially solid to absorb transitory losses along the way without jeopardizing its core business. On the other hand, Stulz (1996) further contends that managers of a profoundly distressed firm may be interested in speculating because increasing the underlying volatility of the firm's value distribution makes prospects of getting out of trouble more likely, irrespective of whether they have an informational advantage.

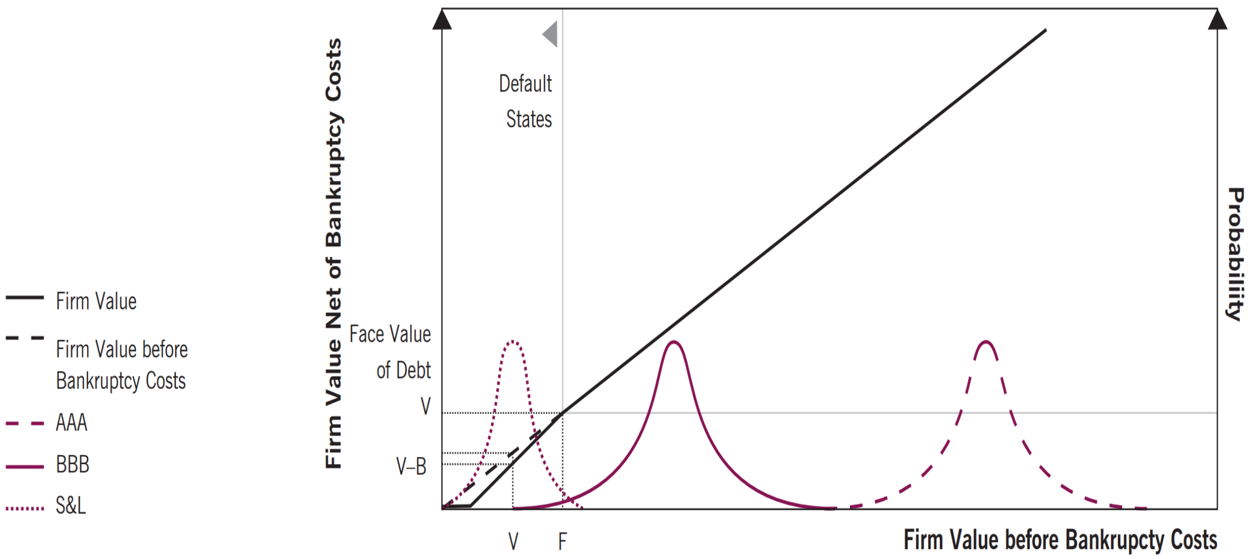
From Figure 1 below, we observe that the firm denoted S&L is in serious trouble as its value's distribution almost entirely lies in the default zone, with the exception of a small portion of its upper tail. In this case, traditional risk management is ineffective because it helps maintain the status quo or worsens the situation by further entrenching the firm value's distribution within the default range. This strategy increases the likelihood that shareholders will wind up with worthless equity, which is the dreaded result. Surprisingly, speculative hedging may be the last meaningful attempt to rescue the company. Indeed, speculation-induced uncertainty increases the volatility of the firm's value, thereby increasing the likelihood of extreme (or tail) events. Technically speaking, the post-speculation firm value distribution is roughly a mean-preserving spread of its pre-speculation counterpart. If, by any chance, a favorable outcome from the upper tail materializes, the firm exits the default range. If not, the situation remains materially unchanged as the state of default prevails. Thus, the expected – though unlikely – benefits from speculation far outweigh its prospective drawbacks.

Our study will cast light on the empirical relevance of these two hypotheses proposed by Stulz (1996):

Hypothesis 2a: Firms in good financial standing speculate more than financially constrained firms.

Hypothesis 2b: Firms in good financial standing speculate less than financially constrained firms.

Figure 1: Speculation, firm value and financial distress



Firm S&L (most leftward distribution) is in deep financial distress. Speculation would flatten its value distribution, shifting probability mass from the center towards the tails, thus making extreme events more likely. A realization from the upper tail (out of the default range) would rescue the firm. This figure is taken from Stulz (1996).

The issue of investment opportunities and their funding is closely related to the firm's financial standing but with an additional dimension. Campbell and Kracaw (1999) propose a theoretical model demonstrating that, in the presence of asymmetric information, a firm could find it optimal to speculate to be able to undertake promising investment opportunities. In their model, a firm has investment opportunities that are relatively important compared to its initial fund endowment. Moreover, there is an agency cost due to information asymmetry, which is introduced as a cost of state verification due to the lack of observability of the firm's *ex-post* returns. This additional cost makes external financing prohibitive and, hence, unattractive. To circumvent this challenge, the firm might find it optimal to bet on a fair gamble with a zero net present value[2]. In this case, and along the lines of Stulz (1996),

[2]From their no-arbitrage pricing, derivatives transactions for speculative purposes are more or less

the expected benefits of a fortunate draw, which allows the firm to carry out its profitable investment plans, outweigh the adverse consequences of an unfavorable turn of events, which would keep its hands tied.

Based on Campbell and Kracaw (1999)'s intuition, our study seeks to test if observational data support the following assumption:

Hypothesis 3: Investment opportunities, combined with fragile financial health, are drivers of speculation.

Understanding the ties between selective hedging and corporate governance, particularly managers' compensation, is a must in order to have a complete understanding of its driving forces. Indeed, remuneration structures may alter a manager's risk tolerance and lead them to take unwarranted speculative positions. Tufano (1996) shows that stock options make a manager hedge less of the firm's risk exposure. However, managerial ownership is expected to reduce moral hazard costs by aligning manager and shareholder interests. All else being equal, managers with a significant shareholding in their company have "skin in the game" because their wealth is typically not diversified. Therefore, any negative outcomes of the speculative gambles they take will benefit or hurt them equally. We lack access to variables that allow us to capture the speculative aspects of managers' compensation packages, so we rely primarily on the CEO's inside ownership.[3].

Hypothesis 4: CEO shareholding and speculative hedging are negatively related.

Also, the percentage of shares held by institutional investors (institutional ownership) is used as a proxy for (the absence of) information asymmetry (see, for example, Graham and Rogers (2002)). Institutional investors have privileged access to management information

examples of such gambles.

[3]We have the variable "number of CEO options" but nothing about their moneyness. Therefore, this variable carries little information on whether speculation would benefit the CEO. For instance, a CEO with deep in-the-money options should hedge more but refrain from speculation to prevent their stock options from slipping out of the exercise range due to heightened volatility. By the same token, increasing volatility through speculation is in the best interest of a CEO with out-of-the-money options.

and contribute to its dissemination in the financial markets. Consequently, their presence should discourage speculative activities related to information asymmetries.

Hypothesis 5: Institutional ownership prevents speculation.

Lastly, most studies investigating the real and financial implications of speculative hedging find little to no evidence of any significant causal effect. In their study on the gold mining industry in North America, Adam and Fernando (2006) conclude that the cash flow gains from selective hedging are, at best, minimal. At the same time, they could not detect any statistically significant impact of speculation on the firm's systematic risk. Similarly, Brown et al. (2006) conclude that speculative hedging yields no meaningful cash flow gains. In addition, these authors examine the potential impact of this type of activity on the operating and financial performance of the firms. They find no significant effect on the size, operating performance, or market value of equity.

Therefore, we do not anticipate finding any statistically significant real or financial implications of speculative hedging.

Hypothesis 6: Speculative hedging has no significant real or financial implications.

However, we should mention that Adam et al. (2017) find that lagged changes in speculation are positively related to changes in stock return volatility, using different sets of control variables. This result seems to contradict Adam and Fernando (2006)[4]. However, the statistical significance of the coefficient of interest varies greatly across specifications and is not even significant at the usual levels in most of them.

[4] Moreover, using stock return volatility does not reveal if speculation causes an increase in the systematic risk or, instead, if it only affects the idiosyncratic risk, which is diversifiable.

3 Data

3.1 Hedging activities: an overview

Our sample consists of quarterly data on 150 firms operating in the oil and gas production industry in the United States. We have 6324 quarter-firms, spanning the period between 1997Q4 and 2010Q4. It is a rich data set that includes the hedge ratios for both oil and gas at horizons varying from the current fiscal year up to five years ahead, along with several important firm characteristics related to size, financial health, capital structure, and corporate governance. The data also includes key variables that reflect the general outlook of the market conditions for oil and gas. We refer to Dionne et al. (2018) for further details about the sources and the construction of the different variables.

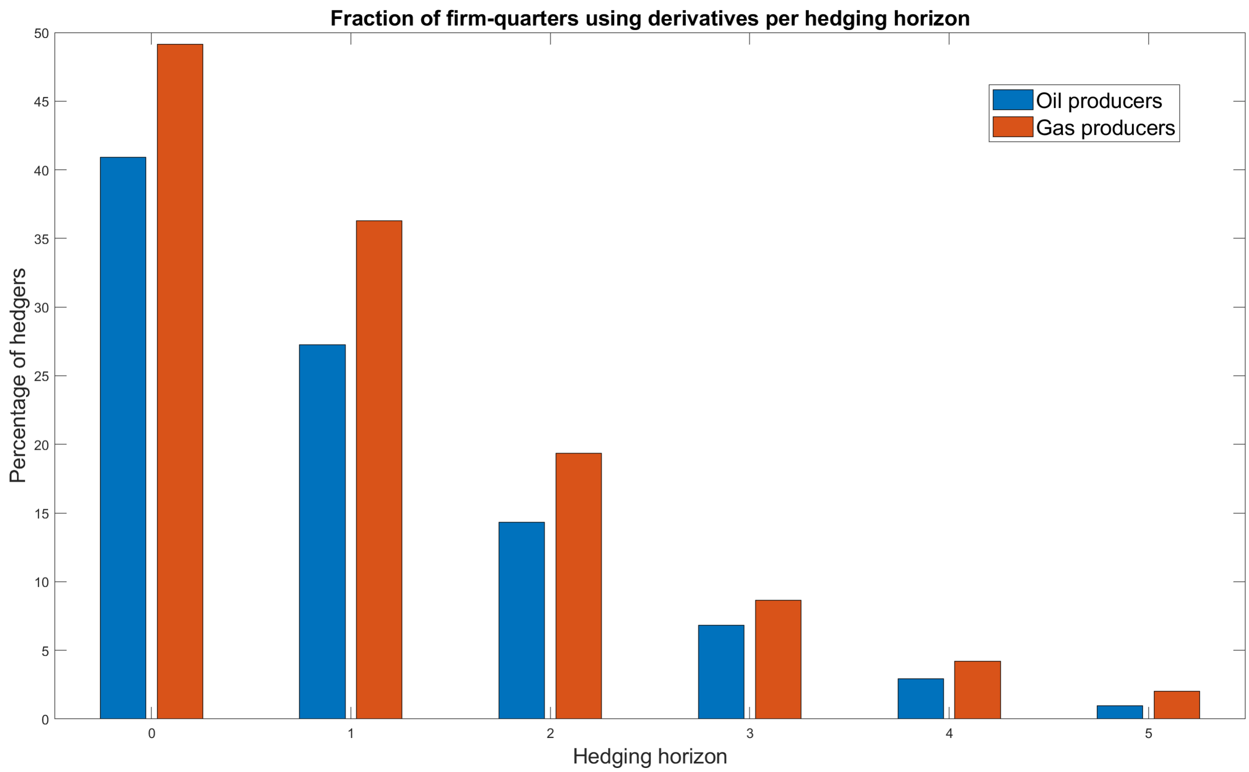
The oil and gas industry is an ideal setting for examining the motivations behind corporate risk management for non-financial firms:

- Oil and gas are globally traded commodities, and firms in this industry broadly face a common market risk: commodity price fluctuations.
- A wide range of oil and gas-specific derivatives are available on the New York Mercantile Exchange and through Over-the-Counter trading, allowing corporations to find instruments that meet their hedging requirements readily.
- There is an explicit metric for determining the extent to which enterprises hedge: the fraction of production shielded from price fluctuations for a given period.

One of the salient characteristics of the oil and gas industry is the pervasive use of derivative instruments for risk management. Figure 2 depicts the fraction of firm-quarters that resort to hedging activities for each horizon ranging from the current fiscal year up to five years in the future.

Almost half (49.1%) of the gas producers hedge part of their production in the current fiscal compared with an equally striking 40.9% of oil producers for the same horizon. However, the proportion of hedgers declines rapidly to the point that less than 9% of producers are

Figure 2: Fraction of firm-quarters using derivatives for risk management by hedging horizon

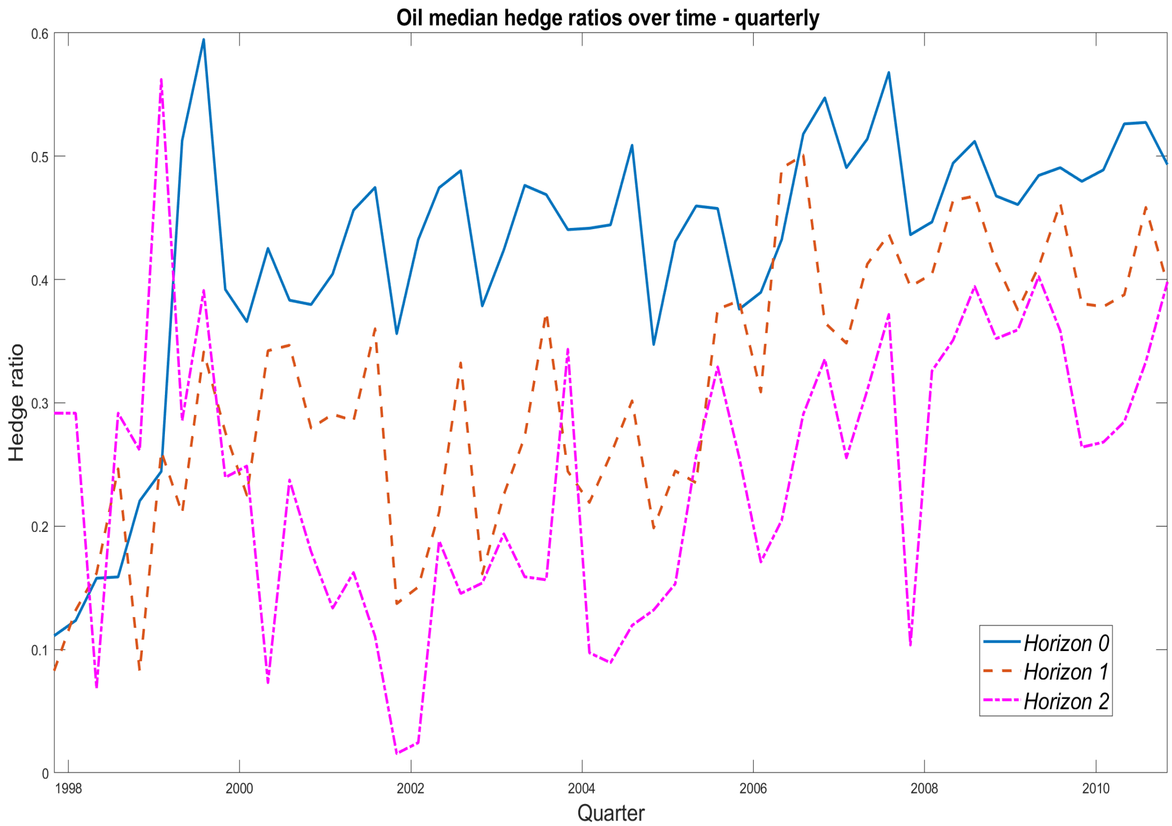


hedgers three years ahead of the current period for either commodity. There appears to be some "shortsightedness" in the risk management schemes of most firms.

There is also considerable variation in the evolution of hedge ratios over time. The median hedge ratios (pooled data) for the current, one-year, and two-year horizons are displayed as a time series in Figure 3. We observe a slight upward trend in the plots, accompanied by significant quarterly changes. Moreover, the farther the horizon, the more pronounced the swings in hedge ratios over time.

Although there is seasonality in the demand for energy commodities, these substantial variations in the hedging ratios are not supported by commensurate changes in the firms' fundamentals. Thus, the frequent shifts we observe in the hedge ratios are regarded as

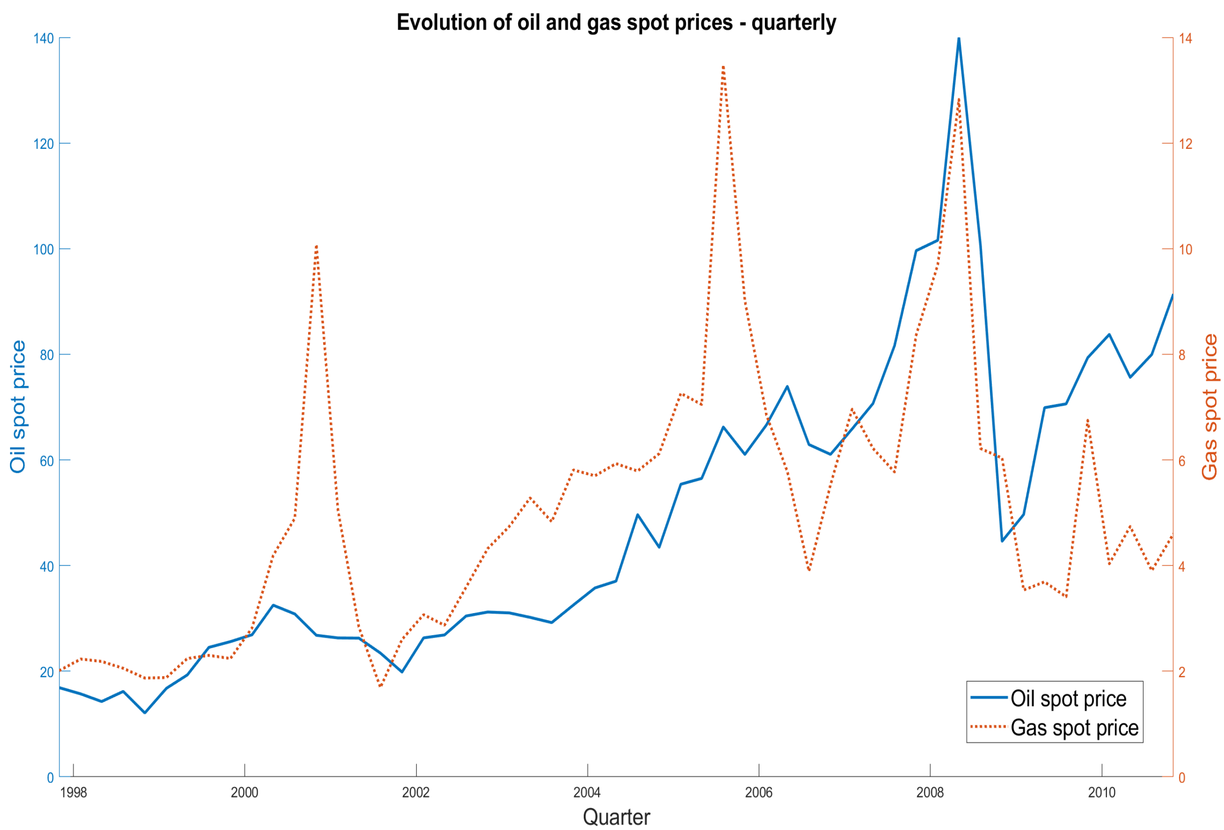
Figure 3: Evolution of the median hedge ratios at different hedging horizons: Oil industry



informal evidence of speculation within the hedging programs of firms.

Moreover, market conditions seem to play a considerable role in the evolution of hedge ratios through time. Figure 4 depicts the quarterly evolution of oil and gas spot prices. A careful inspection of this figure, jointly with Figure 3, reveals positive comovement between the oil spot price and the hedge ratios, particularly in the short run (current and one-year ahead horizons). For instance, the contemporaneous correlation between the oil price spot and the one-year median hedge ratio (among the users of derivatives) is 0.747, which is significant.

Figure 4: Evolution of the oil spot price at quarterly frequency



Evolution of spot prices for both energy commodities: left y-axis for oil and right y-axis for gas

This striking aspect indicates that firms tend to hedge more when oil prices rise and hedge less when the oil market is bearish. The previous observation is counterintuitive at first, as one would expect the opposite if hedging were viewed as a substitute for insurance, and it is viewed as another sign pointing to speculation. If the price is believed to be mean-reverting, a speculator will attempt to 'lock in' high future prices when the market is bullish and avoid committing to low expected prices when market conditions are bearish. This is especially true when the oil market is in "contango" ("normal backwardation"), which occurs when the futures contract trades above (below) the expected spot price at contract maturity.

3.2 Firms characteristics at a glance

Table 1 provides summary statistics for the variables used to characterize the population of firms in our data sample. The descriptive statistics are computed on the original population of the firm-quarters (pooled data). The market-to-book value of assets (Tobin's Q) indicates that most US oil and gas firms in our sample have high growth potential, with an average of 1.812 and a distribution skewed to the right, as the median is only 1.426. Just over a quarter of our sample firm-quarters pay a dividend (26.5%).

Table 1: Summary statistics for the sample firms' financial and operational characteristics.

Variable	Obs.	Mean	Standard deviation	Median	1st quartile	3rd quartile
Firm size[5]	5913	6.289	2.480	6.171	4.513	7.970
Market-to-book value of assets	5910	1.812	1.426	1.442	1.131	1.935
Dividend payout	6324	0.265	0.442	0.000	0.000	1.000
Liquidity	6067	1.556	5.335	0.274	0.079	0.850
Leverage	6042	0.516	0.285	0.523	0.342	0.659
Tax savings	6158	0.052	0.051	0.048	0.029	0.070
Investment opportunities	6293	0.129	2.333	0.062	0.035	0.107
CEO shareholding	6026	0.004	0.017	0.000	0.000	0.002
Institutional ownership	6324	0.337	0.345	0.216	0.000	0.687
Number of CEO options	6324	17.444	68.186	0.000	0.000	12.000
Number of analysts	6324	5.109	6.914	0.000	2.000	8.000
Oil production risk	6244	0.272	0.302	0.169	0.080	0.344
Gas production risk	6220	0.272	0.280	0.181	0.092	0.360

[5]We construct the variable "firm size" ourselves as it does not feature in the original data. Firm size is defined as the natural logarithm of the market value of assets. The market value of assets equals the book value of assets minus the book value of common stock plus the market value of equity.

We generally observe firms with low levels of liquidity. Half of them have a quick ratio below 0.274, and the third quartile is only 0.850. This indicates that most firms may face difficulties honoring their short-term liabilities. Despite this, the average level of liquidity is a whopping 1.56. Put together, all these statistics point to the fact that while the general population of firms is short of liquidity, there are a handful of major players with vast amounts of liquidity, leading to a massively positively skewed distribution. Also, we note a relatively high leverage (51.6%) and an outstanding presence of institutional investors: their average stake in the firms is slightly over a third of total ownership.

4 Selective hedging and the fundamentals of the firms

4.1 Methodology

Following Haushalter (2000) and Adam and Fernando (2006), we first determine the level of hedging consistent with the fundamentals of the firm. The thought process follows sequential reasoning: First, firms decide whether to hedge and, conditional on deciding to hedge, to what extent to do it.

We rely on the Heckman two-stage econometric model, which embodies the above sequential decisions. In the first step, we estimate a probit regression to model the decision of hedging or not (selection equation).

$$Prob(D = 1|Z) = \Phi(Z\gamma) \tag{1}$$

where D indicates the hedging decision ($D = 1$ if the firm uses derivatives for risk management and $D = 0$ otherwise), Z is a vector of explanatory variables, γ is a vector of unknown parameters, and Φ is the cumulative distribution function of the standard normal distribution.

In the second step (outcome equation), we regress the observed (non-zero) hedge ratios on the main determinants of firms' hedging policies. We add the inverse Mills ratio as an additional explanatory variable to capture the selection bias induced by the decision to hedge or not (selection equation).

$$E\left[h, D=1|Z\right] = X\beta + \rho\sigma_u\lambda(Z\gamma) \tag{2}$$

where ρ is the correlation between unobserved determinants of the propensity to hedge ε (error term in the selection equation) and unobserved determinants of the hedge intensity u (error term in the outcome equation), σ_u being the standard deviation of u, and λ is the inverse Mills ratio evaluated at $Z\gamma$. This equation demonstrates Heckman's insight that sample selection can be viewed as a form of omitted-variables bias.

From the second stage of Heckman's estimation, we obtain predicted hedge ratios $\hat{h}_{it}$ for each firm i and time t. This is the extent of the hedge attributable to the firm financial and operational characteristics, according to the model specification.

For a given year, we measure the degree of selective hedging for firm i as the yearly root-mean-square deviation of the quarterly hedge ratios h_{it}.

$$\textit{Speculative hedging}_i = \sqrt{\frac{1}{4}\sum_{t=1}^{4}\left(h_{it} - \hat{h}_{it}\right)^2} = \sqrt{\frac{1}{4}\sum_{t=1}^{4} e_{it}^2} \tag{3}$$

This procedure provides a measure of speculative hedging for each hedging firm and each year. Our measure takes into account both the differences in hedging levels $(h_{it} - \hat{h}_{it})$, but also the temporal variations of these differences throughout the year. The exercise is conducted separately for each commodity: oil and gas.

We then regress the derived indicators on several firm characteristics to assess the associations between speculation and informational asymmetries, financial distress, managerial and institutional shareholdings, market conditions, and growth potential.

4.2 Empirical results

4.2.1 Hedging decision and magnitude

We follow Adam et al. (2017) and build a parsimonious model for hedging based on a limited set of explanatory variables that the literature identified as reliable determinants of hedging decision and magnitude. At this stage, the purpose is not to be exhaustive in terms of available independent variables[6]; rather, the focus is on the fundamental aspects that justify the use of derivatives for risk management across all firms, setting aside peculiarities.

Adam et al. (2017) use firm size, market-to-book ratio of assets (Tobin's Q), dividend payout dummy, liquidity, and leverage only.

We extend their specification to include tax savings, investment opportunities, institutional shareholding, market conditions (oil and gas respective spot price and volatility), as well as CEO shareholding to account for other motives that may justify the decision to hedge. The last variable is of particular interest as it allows us to consider, although partially, the other class of arguments that justify hedging, namely, accommodating managers' risk aversion.

Our estimation is conducted for three horizons: the current fiscal year, the one-year ahead, and the two-year ahead. Beyond the two-year horizon, hedging incidence declines markedly, making the estimation impossible over the whole sample period. For instance, no single firm hedges oil at the four or five-year horizon between 1997 and 2002, and we only have 20 out of 2426 firm-quarters that hedge at the three-year horizon over the same period.

Table 2 and Table 3 summarize the results of the Heckman two-stage regression for oil and gas, respectively. A few remarks are in order.

We include firm-specific 'oil production risk' and 'gas-production risk' variables in the selection equation (first stage) but not in the outcome equation (second stage) to satisfy the exclusion restriction required to generate credible estimates.

There appears to be a strong horizon effect in the results. Indeed, for each energy commodity type, the statistical significance of most variables varies across horizons. However, the sign is generally the same and consistent with the general consensus in the literature. Also, we notice that the explanatory power of the fundamentals of the firms, as captured by

[6] We note that some of our potential independent variables are highly collinear too. For instance, firm size has a 0.8182 correlation with oil reserves, 0.8648 correlation with gas reserves and a 0.7808 correlation with the number of analysts. See the matrix of correlation Table 12 in the appendix.

Table 2: Results for Heckman two-stage regression analysis: Oil

	0-year hedge ratio		1-year hedge ratio		2-year hedge ratio	
Variable	Selection	Hedge ratio	Selection	Hedge ratio	Selection	Hedge ratio
Firm size	0.1500**	0.0495***	0.1500***	0.0529***	0.1333**	0.0066
	(0.067)	(0.019)	(0.056)	(0.018)	(0.054)	(0.021)
Market	−0.3441***	−0.1161***	−0.3416***	−0.1063***	−0.3437***	0.0090
to book	(0.079)	(0.025)	(0.073)	(0.028)	(0.076)	(0.031)
Dividend	−0.3800**	−0.0825**	−0.3074*	−0.0599	−0.0393	0.0042
payout	(0.191)	(0.039)	(0.176)	(0.057)	(0.195)	(0.030)
Liquidity	−0.1716***	−0.0475***	−0.2141***	−0.0543***	−0.1919**	0.0100
	(0.053)	(0.015)	(0.056)	(0.019)	(0.077)	(0.010)
Leverage	0.6420***	0.2142***	0.5550***	0.2791***	0.7287***	0.0754
	(0.213)	(0.069)	(0.202)	(0.078)	(0.195)	(0.072)
Tax savings	0.9043	0.3977**	1.2433**	0.3802**	0.8792*	0.0026
	(0.572)	(0.179)	(0.586)	(0.160)	(0.453)	(0.101)
Investment	0.0150**	0.0436**	0.0225***	0.0671***	0.0193*	0.0690*
opportunities	(0.007)	(0.017)	(0.008)	(0.016)	(0.010)	(0.040)
CEO	4.7154	1.5480***	5.0504*	1.3778**	2.5146*	−0.2271
shareholding	(4.614)	(0.465)	(2.764)	(0.556)	(1.343)	(0.284)
Institutional	0.7015**	0.0956	0.3795	0.0149	0.0938	−0.0505
ownership	(0.307)	(0.074)	(0.288)	(0.084)	(0.279)	(0.048)
Oil	0.0068***	0.0019***	0.0120***	0.0040***	0.0145***	0.0009
spot price	(0.002)	(0.001)	(0.002)	(0.001)	(0.002)	(0.001)
Oil price	−0.0037	−0.0041*	−0.0098	−0.0038	0.0027	−0.0021
volatility	(0.009)	(0.002)	(0.008)	(0.003)	(0.009)	(0.003)
Gas	0.0101	0.0027	−0.0006	−0.0022	0.0034	−0.0069
spot price	(0.015)	(0.004)	(0.015)	(0.004)	(0.017)	(0.004)
Gas price	0.0461*	0.0269***	0.0130	0.0136	−0.0148	0.0236*
volatility	(0.028)	(0.009)	(0.033)	(0.012)	(0.032)	(0.013)
Production	−0.0444		0.0770		0.1670	0.1765
risk - Oil	(0.179)		(0.139)		(0.215)	
Production	0.2436		0.3680*		0.6851***	
risk - Gas	(0.208)		(0.198)		(0.257)	
Intercept	−1.4661***	−0.2126***	−2.0341***	−0.5714***	−2.8295***	0.1820
	(0.300)	(0.108)	(0.263)	(0.123)	(0.288)	(0.138)
Observations	5685	2499	5685	1668	5685	872
χ^2		208.81		254.20		69.96
Prob. $> \chi^2$		> 0.001		> 0.001		> 0.001

Figures in parentheses denote robust standard errors clustered at the firm level. Superscripts ***, ** and * indicate significance at the 1%, 5% and 10% levels, respectively. The second-stage regressions include quarterly dummies to capture any seasonality effect, in addition to the inverse Mills ratio, whose coefficients are not reported here for the sake of space.

Table 3: Results for Heckman two-stage regression analysis: Gas

	0-year hedge ratio		1-year hedge ratio		2-year hedge ratio	
Variable	Selection	Hedge ratio	Selection	Hedge ratio	Selection	Hedge ratio
Firm size	0.1393**	0.0382*	0.1578***	0.0666***	0.1516***	0.0075
	(0.069)	(0.021)	(0.061)	(0.021)	(0.056)	(0.018)
Market	−0.2613***	−0.0864***	−0.2211***	−0.0825***	−0.2665***	−0.0100
to book	(0.066)	(0.019)	(0.054)	(0.018)	(0.067)	(0.023)
Dividend	−0.4330**	−0.0988***	−0.3485**	−0.1369**	0.1074	−0.0070
payout	(0.169)	(0.037)	(0.155)	(0.055)	(0.163)	(0.027)
Liquidity	−0.1762**	−0.0522***	−0.2638***	−0.0929***	−0.2224***	−0.0012
	(0.069)	(0.018)	(0.059)	(0.019)	(0.084)	(0.012)
Leverage	0.7964***	0.1161*	0.7155***	0.2695***	0.8764***	−0.0091
	(0.254)	(0.070)	(0.204)	(0.079)	(0.203)	(0.055)
Tax savings	0.5072	0.1369	0.997*	0.1502	1.2629***	0.1187
	(0.654)	(0.144)	(0.512)	(0.184)	(0.460)	(0.143)
Investment	0.0158*	0.0167	0.0304***	0.0383*	0.0225**	0.0584*
opportunities	(0.009)	(0.030)	(0.008)	(0.020)	(0.011)	(0.030)
CEO	5.3051	−0.0952	4.2623*	0.4761	2.0233	−0.5022*
shareholding	(4.554)	(0.499)	(2.311)	(0.646)	(1.811)	(0.271)
Institutional	0.6470**	0.0301	0.1494	−0.0332	0.0430	−0.1929***
ownership	(0.316)	(0.082)	(0.296)	(0.092)	(0.296)	(0.070)
Oil	0.0042**	0.0016**	0.0103***	0.0037***	0.0110***	0.0012***
spot price	(0.002)	(0.001)	(0.002)	(0.001)	(0.002)	(0.000)
Oil price	−0.0068	0.0029	0.0021	0.0011	0.0034	−0.0014
volatility	(0.008)	(0.002)	(0.007)	(0.003)	(0.009)	(0.003)
Gas	0.0118	0.0004	−0.0144	−0.0059	−0.0256*	−0.0038
spot price	(0.013)	(0.004)	(0.011)	(0.004)	(0.013)	(0.004)
Gas price	0.0326	0.0137	−0.0290	−0.0134	−0.0369	0.0165*
volatility	(0.026)	(0.010)	(0.028)	(0.009)	(0.032)	(0.012)
Production	0.1471		0.1032		0.3275*	
risk - Oil	(0.186)		(0.110)		(0.183)	
Production	−0.0626		0.0954*		0.3761****	
risk - Gas	(0.214)		(0.126)		(0.214)	
Intercept	−1.1183***	0.1040	−1.7044***	−0.5336***	−2.5724***	0.2449**
	(0.337)	(0.126)	(0.283)	(0.108)	(0.284)	(0.124)
Observations	5685	2940	5685	2167	5685	1,143
χ^2		88.87		252.16		100.68
$Prob. > \chi^2$		> 0.001		> 0.001		> 0.001

NOTES: See notes to Table 2.

the Wald statistic[7], is highest at the one-year horizon for oil and gas, respectively, and lowest at the two-year horizon for oil and the zero-year horizon for gas.

Firm size is a strong driver of both the decision to use derivatives and the scope of the hedging program. Except for the second stage (outcome equation) of the two-year horizon for both commodities, firm size is otherwise statistically significant at the 5% level at most, in all other cases, in line with prior studies. The primary justification is that larger firms have sufficient resources to commit to a risk management program requiring hefty fixed costs.

The market-to-book value of assets (Tobin's Q) is also highly statistically significant (1% level) in almost all cases, with a negative sign. We interpret this to reflect that firms with significant growth potential are less exposed to price uncertainty than more "mature" firms.

Liquidity and dividend payout, when statistically significant, are negatively correlated with the decision to hedge and the magnitude of the hedging intensity. Firms in good financial health (those that announce dividends or have high levels of available liquidity) are less concerned about the risk of financial distress because they have an extra layer of cushion to help face uncertainty in future price movements.

Leverage, tax savings, investment opportunities, and CEO shareholding all have a positive marginal impact of the magnitude on hedging whenever statistically significant.

4.2.2 Speculation measures: descriptive statistics

Table 4 shows summary statistics for the speculative hedging measures we have constructed. At a given horizon, the statistics are very similar for both commodities.

Two stark observations stand out: First, we notice that the distributions of speculative measures are consistently positively skewed for all horizons and commodities, with the mean greater than the median in all cases. This remark suggests that, for a given horizon, there is a minority of firms that speculate significantly more than the rest of the sample firms[8]. Second, even though hedging is more prevalent in the current fiscal year and gradually decreases along

[7]The degrees of freedom are the same across horizons.

[8]But not necessarily the same firms for all horizons.

Table 4: Summary statistics for the constructed yearly measure of selective hedging

Speculation Measure	Obs	Mean	Standard deviation	Median	1st quartile	3rd quartile
			Oil			
SH0	759	0.2725	0.1882	0.2376	0.1273	0.3713
SH1	573	0.3253	0.2347	0.2889	0.1433	0.4633
SH2	316	0.2122	0.1368	0.2055	0.1209	0.2723
			Gas			
SH0	879	0.2716	0.1812	0.2345	0.1430	0.3524
SH1	714	0.3210	0.2597	0.2538	0.1278	0.4508
SH2	425	0.2002	0.1435	0.1750	0.1211	0.2394

SH0, SH1, and SH2 are the speculative hedging measures for horizon 0 (current fiscal year), horizon 1 (one year ahead), and horizon 2 (two years ahead), respectively.

the temporal horizon, we observe higher values of speculative hedging for the one-year ahead horizon. This observation may indicate that standard risk management rationales (correction of market imperfections) predominate in the current fiscal year relative to the one-year ahead hedging activities, which give rise to relatively more speculation.

4.2.3 Selective hedging, firm size, and asymmetry of information

As argued in Section 2, if the "efficient market hypothesis" is violated, larger firms are more likely to possess superior information due to their market size, substantial footprint in the industry, and ability to devote substantial resources to an active risk management program. Table 5 and Table 6 reveal intriguing aspects of the relationship between firm size and the degree of speculation. Notably, there appears to be a horizon pattern between the two variables. Smaller firms speculate more at shorter horizons (current and one-year ahead hedging), while larger firms are more likely to hedge selectively at the two-year horizon. This pattern is strikingly similar between the two energy commodities, and for the current and one-year horizons, the effects are all statistically significant at the 1% level in most cases.

These results reveal that for speculation, small firms tend to restrict themselves to shorter horizons where they might think risks of major and detrimental market swings are limited. On the other hand, larger firms may be more willing to commit to longer horizons in the hope of reaping substantial benefits in case of success. Furthermore, larger firms are more likely to have greater financial strength to cope with potential adverse events, much in the spirit of Stulz (1996)'s hypothesis about speculation.

Therefore, our approach helps disentangle important horizon effects in the association between speculation and the firm's size that would otherwise be overlooked when considering a single aggregate portfolio of all derivatives covering a given period. Given that most hedging activities are short-term, it is no surprise that a single portfolio approach would be driven by the effects in the short run, resulting in the seemingly puzzling results of a negative relationship between the extent of speculation and the size of the firm as in Adam et al. (2017).

4.2.4 Speculation, financial health and the potential for growth

In this subsection, we focus on the variables that can be considered proxies for firms' financial health: liquidity and leverage.These two variables are not direct measures of financial distress. Nonetheless, they provide insightful information regarding the relationship between speculation and the company's financial condition.

Table 5 and Table 6 reveal that liquidity is positively related to speculation for both commodities and is statistically significant at the 5% level for the current and one-year ahead horizons for gas. As for leverage, when statistically significant (5% level at most), it exhibits a negative relationship with the extent of selective hedging. This is true for both the one-year (oil and gas) and two-year (gas only) horizons.

Together, these two effects suggest that firms with secure financial standing are more likely to engage in speculation. As noted in Section 2, the theoretical relationship between selective hedging and the likelihood of financial distress is ambiguous. Stulz (1996) argues

Table 5: Selective hedging as a function of firms' attributes: Oil

Variable	0-year speculation	1-year speculation	2-year speculation
Firm size	−0.0085	−0.0316***	0.0225***
	(0.006)	(0.009)	(0.006)
Market to book value of assets	0.0606***	0.0891***	−0.0121
	(0.018)	(0.025)	(0.014)
Liquidity	0.0081	0.0100	0.0210
	(0.011)	(0.015)	(0.013)
Leverage	0.0060	−0.1351**	0.0124
	(0.043	(0.067)	(0.030)
Institutional ownership	−0.0980***	−0.1081**	−0.0342
	(0.036)	(0.045)	(0.043)
CEO shareholding	−0.3667**	−0.3703**	0.0833
	(0.173)	(0.183)	(0.093)
Oil spot price	0.0011*	0.0000	0.0009
	(0.001)	(0.001)	(0.001)
Oil price volatility	−0.0015	0.0027	−0.0041
	(0.003)	(0.004)	(0.004)
Gas spot price	−0.0120*	−0.0193**	−0.0062
	(0.007)	(0.008)	(0.007)
Gas price volatility	0.0294	0.0922**	−0.0120
	(0.031)	(0.042)	(0.033)
Intercept	0.2731***	0.5794***	0.0706
	(0.059)	(0.080)	(0.043)
Observations	759	573	316
R-squared	0.0942	0.1874	0.0672

Figures in parentheses denote robust standard errors clustered at the firm level. Superscripts ***, ** and * indicate significance at the 1%, 5% and 10% levels, respectively.

Table 6: Selective hedging as a function of firms' attributes: Gas

Variable	0-year speculation	1-year speculation	2-year speculation
Firm size	-0.0022	-0.0361^{***}	0.0133^{**}
	(0.008)	(0.010)	(0.006)
Market to book	0.0059	0.0499^{**}	-0.0080
value of assets	(0.012)	(0.021)	(0.010)
Liquidity	0.0286^{**}	0.0564^{**}	0.0038
	(0.014)	(0.022)	(0.012)
Leverage	-0.0685^{**}	-0.2404^{**}	-0.0979^{**}
	(0.032)	(0.050)	(0.049)
Institutional	-0.0888^{**}	-0.1544^{***}	-0.1520^{***}
ownership	(0.041)	(0.058)	(0.033)
CEO	-0.0799	-0.8924^{***}	-0.4559^{***}
shareholding	(0.267)	(0.276)	(0.134)
Oil	0.0006	0.0005	0.0006
spot price	(0.001)	(0.001)	(0.001)
Oil price	-0.0018	0.0021	0.0019
volatility	(0.003)	(0.004)	(0.004)
Gas	-0.0071	-0.0108	0.0004
spot price	(0.006)	(0.008)	(0.005)
Gas price	0.0510^{*}	0.0556	0.0039
volatility	(0.027)	(0.038)	(0.038)
Intercept	0.3243^{***}	0.6899^{***}	0.1996^{***}
	(0.047)	(0.071)	(0.053)
Observations	879	714	425
R-squared	0.0738	0.2433	0.1310

Figures in parentheses denote robust standard errors clustered at the firm level. Superscripts ***, ** and * indicate significance at the 1%, 5% and 10% levels, respectively.

both ways: On the one hand, firms have a comparative advantage in risk-bearing when they have access to information not reflected fully in market prices, but, on top of that, they must have sufficient financial strength to withstand the potentially dire consequences of any speculative gambles. On the other hand, he provides a compelling argument for why firms in financial distress might 'rationally' speculate: The objective is to "spread out" the probability distribution of the firm value, increasing the possibility of extreme outcomes and thereby the likelihood of escaping financial distress.

Moreover, Campbell and Kracaw (1999) assert that the cost of raising external funds is higher for relatively small firms due to information asymmetry. Therefore, speculation might be a worthwhile attempt hoping to get substantial positive cash flows to supplement limited internal resources for investment endeavors.

For the two-year horizon, our findings corroborate the first claim of Stulz (1996). Larger firms with favorable indicators of financial health (relatively high level of liquidity and low leverage) are more prone to speculative hedging. Moreover, "real considerations" (such as the firm's value) seem irrelevant when speculation is dominated by larger firms as the sign of the market-to-book value of assets is negative, though not statistically significant at the usual levels. Our findings contrast with those of Adam et al. (2017), who use direct measures of firms' financial distress (Altman (1968)'s Z-score or Ohlson (1980)'s O-score but omit liquidity and leverage in their regression specification while studying speculative hedging in North American gold mining firms.

For the one-year horizon, our empirical evidence tips the balance in favor of Campbell and Kracaw (1999)'s line of thinking: Speculation is associated with relatively small firms with higher potential for growth (as captured by Tobin's Q). Even though these firms also exhibit solid financial indicators, it is hard to gauge whether their financial standing is enough to fulfill all their potential for growth through investment[9].

These observations indicate that model specification, including judicious choice of the

[9]We attempted to include 'investment opportunities' as an explanatory variable in our specification, but the results were less neat due to the variable's apparent collinearity with other regressors. In our reasoning, we suppose that fulfilling the massive potential for growth requires important investments.

dependent variable, is paramount to drawing accurate conclusions.

4.2.5 Speculative hedging, CEO inside ownership, and capital structure

As alluded to in Section 2, empirical research addressing selective hedging and its potential effects on the firm value has found no evidence of any meaningful impact (see, for instance, Adam and Fernando (2006) and Brown et al. (2006)). Therefore, it is worthwhile to analyze the specific attributes of managers who attempt to "time the market" in order to understand why they would engage in seemingly futile activities.

We acknowledge beforehand that the analysis we provide here is limited because we do not have access to a complete characterization of managers' compensation packages in our sample data, especially their most speculative components. Our findings reveal a strong and consistently inverse relationship between the size of the CEO's equity and the level of speculation. This relationship is statistically significant (at the 5% level at most) for most horizons and both energy commodities. This result is consistent with financial theory: Managers with a substantial stake in the firm are comparatively less diversified. Therefore, their risk aversion is predominant in the firm's hedging activities. To the extent that the managers understand or believe the ineffectiveness of speculation in increasing the firm value (and, by extension, their wealth), they should refrain from actively incorporating their personal views in any of the firm's risk management plans.

Nevertheless, we bear in mind that we miss an essential aspect of managerial compensation — the intrinsically speculative components of compensation packages — whose effects run counter to the one just discussed. We have the "number of the CEO options" as a variable but no further indications about their moneyness, their sensitivity to the share price (delta), and, even more crucial, the sensitivity to the underlying volatility (vega). Besides, the number of CEO options is highly correlated with CEO ownership in our sample, with a staggering correlation of 0.8129 (See Table 12 in the appendix). It is worth mentioning that while stock options could induce excessive risk-taking behavior, especially for options near the money, the evidence from empirical studies is mixed. For instance, Adam et al. (2017), after controlling for other firms' characteristics, find no significant effects of the delta and vega of both the

CEO and the CFO on the level of selective hedging in their study of North American gold mining firms. However, other studies cited therein indicate that stock option compensation is positively related to the likelihood of managers engaging in risky strategies that might ultimately hurt the shareholders.

The share of institutional investors in the firms' capital structure reveals interesting associations with speculative hedging. Institutional shareholding is viewed as a proxy for (lack of) information asymmetry because institutional investors have privileged access to management information and help diffuse it in financial markets. Sound theoretical arguments exist in favor of hedging in the presence of information asymmetries between managers and shareholders: For instance, DeMarzo and Duffie (1995) argue that firms should sometimes hedge based on private information that cannot be conveyed costlessly to shareholders. In this regard, firms with significant institutional ownership should hedge less because they face less information asymmetry. However, the empirical evidence remains contentious. While Geczy et al. (1997) find that firms with significant institutional ownership are more likely to hedge with currency derivatives, Dionne and Triki (2013), using a system of equations that considers both the risk management and debt decisions simultaneously, find a negative relationship between the extent of hedging and institutional ownership on their part.

Our earlier results show that the association between institutional ownership and either the decision to hedge or the hedging extent is statistically insignificant at the usual inference levels. Nonetheless, we observe a consistent negative association between institutional ownership and our measure of speculation across all horizons and commodities. Moreover, this negative relationship is statistically significant at the 5% level at most for all our regressions, except for oil's two-year specification. Hence, our findings reflect that while other corporate aspects might take precedence in the decision to hedge and how much to hedge, institutional ownership is a proven deterrent to speculation and serves as a mechanism between the board and the managers to prevent selective hedging.

5 Real implications of speculative hedging

5.1 Essential heterogeneity models: an outline

We follow Brave and Walstrum (2014) and briefly describe the econometric framework we use to investigate any real or financial implications of speculative hedging.

We are interested in the marginal impact of a treatment (intensive speculation in our case) on a firm target variable, such as Tobin's Q or the market systematic risk, while controlling for a number of covariates.

The following Mincer-like equation expresses our model specification:

$$y_{i,t} = \alpha + \beta d_{i,t} + \gamma z_{i,t-1} + u_{i,t} \tag{4}$$

where $y_{i,t}$ is the target variable of firm i at the end of quarter t, $d_{i,t}$ is the observed value of a dummy variable $D \in \{0, 1\}$ indicating whether firm i resorts to low (0) or high (1) intensity selective hedging during quarter t, $z_{i,t-1}$ is a vector of predetermined control variables, $u_{i,t}$ is an individual-specific error term, and finally, β represents the average return from using high-intensity selective hedging (i.e., the treatment effect).

Two types of selection bias could arise and affect the estimation of β.

- First, a bias due to "selection on unobservables." This is the case when the treatment variable is correlated with the error in the outcome equation. This correlation could be induced by incorrectly omitted observable variables that partly determine both D and y. This scenario reflects the classical problem of endogeneity that could be solved by the instrumental variable (IV) methods.

- A trickier and separate selection issue is the bias inherent to "selection on returns," at the root of the "essential heterogeneity" concept. This problem appears when common unobservable factors affect both the treatment decision D and the error term u. For instance, this is the case when the participation decision is endogenous. This type of selection bias makes the returns from high-intensity selective hedging vary across oil producers, making the effect β in Equation (4) intrinsically random (heterogeneous). Not only do the firms have heterogeneous treatment effects, but they partially understand this heterogeneity. Hence, the rate at which they comply with the treatment is a function of their (unobserved) treatment effect, leading plausibly to "self-selection."

Heckman et al. (2006) developed an econometric methodology based on IVs to solve the problem of essential heterogeneity (i.e., β is correlated with D). Their methodology is built on the generalized Roy model.

The observed dependent variable results from two underlying potential outcomes $Y_D = \{Y_0, Y_1\}$ related to a treatment decision $D = \{0, 1\}$ respectively.

- The potential outcomes depend linearly on observable variables $\mathbf{X}$ and unobservable components $\{U_0, U_1\}$,
- The decision process for treatment, captured by a latent variable I, is also a linear function of observables $\mathbf{Z}$ and an unobservable component V,

The model can be succinctly written as:

$$
\begin{aligned}
Y_D &= (1-D)Y_0 + DY_1 \\
Y_0 &= \alpha_0 + \mathbf{X}\boldsymbol{\beta_0} + U_0 \\
Y_1 &= \alpha_1 + \mathbf{X}\boldsymbol{\beta_1} + U_1 \\
I &= \mathbf{Z}\boldsymbol{\gamma} - V \\
D &= \begin{cases} 1 & \text{if } I > 0 \\ 0 & \text{if } I \leq 0 \end{cases}
\end{aligned}
\tag{5}
$$

Identification is achieved either through parametric restrictions on U_0, U_1, and V or by the method of instrumental variables. In the second case, the matrix $\mathbf{Z}$ includes all the observables of the outcome equation $\mathbf{X}$, along with additional variables $\mathbf{Z_{IV}}$ that satisfy the following constraints: $\text{Cov}(\mathbf{Z_{IV}}, U_0) = \mathbf{0}$, $\text{Cov}(\mathbf{Z_{IV}}, U_1) = \mathbf{0}$ and $\boldsymbol{\gamma} \neq \mathbf{0}$.

Equation (5) above implies that:

$$I > 0 \Leftrightarrow \mathbf{Z}\boldsymbol{\gamma} > V \Leftrightarrow F_V\left(\mathbf{Z}\boldsymbol{\gamma}\right) > F_V\left(V\right) \Leftrightarrow \mathrm{P}\left(\mathbf{Z}\right) > U_D$$

where F_V – often called the link function – is the cumulative distribution function of the unobserved component V.

$\mathrm{P}\left(\mathbf{Z}\right)$, referred to as the propensity score, reflects the probability of being selected for treatment, while U_D, a uniformly distributed random variable on the interval $(0, 1)$ denotes the propensity of not being selected or resistance to treatment. In this way, we can see that the decision of being treated or not is the result of a tug-of-war between the propensity score $\mathrm{P}\left(\mathbf{Z}\right)$ and the individual-specific resistance to treatment U_D.

The MTE (Marginal Treatment Effect) is the marginal benefit to treatment $(D = 1)$ conditional on the observable variables $\mathbf{X}$ and the propensity of not being treated (U_D):

$$\mathrm{MTE} \equiv \mathrm{E}\left(Y_1 - Y_0 \mid \mathbf{X} = \mathbf{x}, U_D = u_D\right) \tag{6}$$

The ATE (Average Treatment Effect) is the average benefit associated with treatment conditional on $\mathbf{X}$. It is obtained by integrating the MTE over the support of the probability distribution of U_D:

$$\mathrm{ATE} \equiv \mathrm{E}\left(Y_1 - Y_0 \mid \mathbf{X} = \mathbf{x}\right) \tag{7}$$

Given the propensity score $\mathrm{P}\left(\mathbf{Z}\right)$ and the observed treatment status $D = \{0, 1\}$, the following conditional expectations of Y can constitute the basis of the parametric estimation procedure:

$$\mathrm{E}\left\{Y \mid \mathbf{X} = \mathbf{x}, \mathrm{P}\left(\mathbf{Z}\right) = p, D = 0\right\} = \alpha_0 + \mathbf{x}\boldsymbol{\beta_0} + \mathrm{E}\left\{U_0 \mid \mathbf{X} = \mathbf{x}, \mathrm{P}\left(\mathbf{Z}\right) = p, D = 0\right\} \tag{8}$$

$$\mathrm{E}\left\{Y \mid \mathbf{X} = \mathbf{x}, \mathrm{P}\left(\mathbf{Z}\right) = p, D = 1\right\} = \alpha_1 + \mathbf{x}\boldsymbol{\beta_1} + \mathrm{E}\left\{U_1 \mid \mathbf{X} = \mathbf{x}, \mathrm{P}\left(\mathbf{Z}\right) = p, D = 1\right\} \tag{9}$$

For the parametric estimation of the MTE, we assume that the unobservable components follow a multivariate normal distribution $(U_0, U_1, V) \sim N\left(\mathbf{0}, \boldsymbol{\Sigma}\right)$. We consider the cumulative distribution function of a standard normal distribution Φ as the link function, such that the propensity score derives from a probit model. Thus, $\mathrm{P}(\mathbf{Z}) = \Phi(\mathbf{Z}\gamma)$. From the definition of the MTE in Equation (6), we obtain an explicit formula for our normal parametric estimation procedure:

$$\mathrm{MTE}(\mathbf{X} = \mathbf{x}, U_D = u_D) = (\alpha_1 - \alpha_0) + \mathbf{x}(\boldsymbol{\beta_1} - \boldsymbol{\beta_0}) + (\sigma_{1V} - \sigma_{0V})\,\Phi^{-1}(u_D) \tag{10}$$

where $\sigma_{iV}, i \in \{0,1\}$ is the covariance between U_i and V in the matrix $\mathbf{\Sigma}$[10].

Finally, the estimation of MTE parameters is conducted by linear regression on Equations (8) and (9) with:

$$\mathrm{E}\{Y \mid \mathbf{X} = \mathbf{x}, \mathrm{P}(\mathbf{Z}) = p, D = 1\} = -\sigma_{1V}\frac{\phi(\Phi^{-1}(p))}{p}$$

$$\mathrm{E}\{Y \mid \mathbf{X} = \mathbf{x}, \mathrm{P}(\mathbf{Z}) = p, D = 0\} = \sigma_{0V}\frac{\phi(\Phi^{-1}(p))}{(1-p)}$$

where ϕ denotes the density function of a standard normal distribution. The fractions on the right-hand side of the above expressions are the inverse Mills ratios.

Interested readers can consult Cameron and Trivedi (2005) for a comprehensive review of the assumptions underpinning treatment evaluation models and Heckman et al. (2006) for further technical details about the estimation of essential heterogeneity models.

5.2 Empirical Results

5.2.1 Univariate analysis

Before delving into the multivariate analysis of the real and financial implications of speculative hedging, we first would like to portray a broad picture of the major differences between the characteristics of firms that speculate the most and those that speculate the least.

To this end and following Dionne and Mnasri (2018), we classify our firm-year panel observations according to the quartiles of the selective hedging measure we developed for oil at

[10] σ_V^2, the variance of V, is normalized to 1.

the one-year horizon[11]. The firms engaging in high-intensity selective hedging are those in the upper quartile of the distribution, as opposed to those in the lower quartile speculating with low intensity. This classification allows us to get a clear-cut picture of any differences in the firm's financial and operational characteristics according to their speculative aggressiveness but at the expense of losing half of our sample observations (those in the interquartile range).

Table 7: Firms' financial and operational characteristics by oil speculative hedging intensity at one-year horizon

Variable	Lowest quartile (1)		Highest quartile (2)		Comparison (1) vs. (2)	
	Mean	Median	Mean	Median	t-stat	z-score
Firm size	8.198	8.217	6.792	6.709	8.4320***	7.653***
Tobin's Q	1.445	1.358	1.705	1.498	−3.6348***	−2.576***
Dividend payout	0.464	0.000	0.327	0.000	2.4517**	2.468**
Liquidity	0.324	0.180	0.655	0.155	−2.9189***	−0.102
Leverage	0.605	0.575	0.548	0.552	2.2060**	1.550
Tax savings	0.048	0.046	0.053	0.051	−1.5415	−1.970**
Investment opportunities	0.070	0.064	0.116	0.084	−4.4949***	−3.452***
Institutional ownership	0.692	0.769	0.420	0.406	8.1850***	7.412***
CEO shareholding	0.0053	0.0005	0.0069	0.0007	−0.4017	−0.090
Observations	144		143		287	

Superscripts ***, ** and * indicate statistical significance at the 1%, 5% and 10% levels, respectively. Student t-test to test the equality of means and Wilcoxon-Mann-Whitney z-score to test the equality of medians.

Table 7 presents the means and medians of the two sub-samples and how they compare. We use the Student t-test to test the equality of the means (with unequal variances) and the Wilcoxon-Mann-Whitney z-score test to test the equality of the medians across the two sub-samples.

We notice that most firms' characteristics significantly differ between the high-intensity

[11] The selected determinants exhibit the highest explanatory power for selective hedging variations at the one-year horizon. See Table 5.

and low-intensity speculators at the usual statistical test levels. The most active speculators are generally smaller, have more potential for growth (as captured by Tobin's Q), enjoy more investment opportunities, and pay dividends less frequently than the least active speculators. Moreover, we observe a net lower presence of institutional investors within firms selectively hedging at a high intensity.

Liquidity and leverage differences are less conclusive. Based on the comparison of the means, active speculators benefit from more liquidity and less leverage. However, the z-score test cannot reject the null hypothesis of equality between the medians.

5.2.2 The main drivers of intensive selective hedging decision

Before discussing our findings, we briefly comment on the instrumental variable we use in our parametric estimation. We need a variable related to the treatment decision (high-intensity speculative hedging), but that should not directly affect our dependent variables (firm's value, riskiness, or accounting performance).

Following the literature, we opt for the global real economic activity index developed in Kilian (2009). This indicator, available at a monthly frequency, captures the detrended real shipping freight costs around the world. Kilian (2009) shows that aggregate supply and demand shocks for industrial commodities markedly affect the real price of oil (hence, the potential need to engage in speculation or not) but act in a way distinct from the oil market-specific supply and demand shocks.

Table 8 shows the results of the selection equation for oil at the one-year horizon, revealing the direction, size, and statistical significance of the different characteristics in inducing a given firm into treatment (high-intensity speculation) as opposed to non-treatment (low-intensity speculation). The first stage results stem from the same probit model for all the dependent variables, though they exhibit (minor) differences in some cases due to missing values.

Three explanatory variables stand out: by decreasing order of statistical significance, they are firm size, investment opportunities, and the changes in the Kilian index. Firm size has a negative and highly statistically significant (1% level) effect on the probability of being in the

Table 8: First step of the essential heterogeneity model: Oil – one-year horizon

Variable	Tobin's Q	Systematic risk	Idiosyncratic risk	Oil beta	ROE
Δ Kilian index	−0.0054	−0.0062*	−0.0062*	−0.0062*	−0.0052
	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)
Firm size	−0.4174***	−0.4089***	−0.4089***	−0.4089***	−0.4327***
	(0.091)	(0.096)	(0.096)	(0.096)	(0.093)
Dividend	0.2750	0.3034	0.3034	0.3034	0.2913
payout	(0.230)	(0.237)	(0.237)	(0.237)	(0.232)
Liquidity	−0.0085	0.0317	0.0317	0.0317	0.0334
	(0.124)	(0.134)	(0.134)	(0.134)	(0.134)
Leverage	−0.4301	0.1854	0.1854	0.1854	0.1741
	(0.346)	(0.468)	(0.468)	(0.468)	(0.437)
Tax savings	2.4773	1.7950	1.7950	1.7950	0.1586
	(4.118)	(4.354)	(4.354))	(4.354)	(4.298)
Investment	3.2479**	3.3838**	3.3838**	3.3838**	3.7008**
opportunities	(1.409)	(1.426)	(1.426)	(1.426)	(1.503)
Oil	0.0054	0.0069	0.0069	0.0069	0.0042
spot price	(0.011)	(0.011)	(0.011)	(0.011)	(0.011)
Oil price	0.0337	0.0124	0.0124	0.0124	0.0257
volatility	(0.071)	(0.072)	(0.072)	(0.072)	(0.072)
Gas	0.0372	0.0830	0.0830	0.0830	0.0652
spot price	(0.107)	(0.111)	(0.111)	(0.111)	(0.110)
Gas price	−0.0892	−0.2065	−0.2065	−0.2065	−0.1600
volatility	(0.547)	(0.564)	(0.564)	(0.564)	(0.559)
CEO	−6.8248*	6.5955	6.5955	6.5955	−6.4733*
shareholding	(4.614)	(12.759)	(12.759)	(12.759)	(3.964)
Institutional	−0.5229	−0.6374	−0.6374	−0.6374	−0.6310
ownership	(0.382)	(0.391)	(0.391)	(0.391)	(0.388)
Intercept	2.8166***	2.2706***	2.2706***	2.2706***	2.6882***
	(0.732)	(0.781)	(0.781)	(0.781)	(0.749)
Observations	275	264	264	264	268
Pseudo R^2	0.2462	0.2595	0.2595	0.2595	0.2641

This table provides the results of the first step (selection equation) of the essential heterogeneity model. The dependent variable takes 1 if the firm is categorized as a high-intensity speculator and 0 if it is a low-intensity speculator. It is the same probit model for all the dependent variables, though the results exhibit some differences due to data discrepancies (missing variables). Independent variables are included in lagged values (first lag). Standard errors are reported in parentheses. The superscripts ***, ** and * indicate significance at the 1%, 5% and 10% levels, respectively.

Table 9: Second step of the essential heterogeneity model: Oil – one-year horizon

Variable	Tobin's Q		Systematic risk		Idiosyncratic risk		Oil beta		ROE	
	Treated	Untreated	Treated	Untreated	Treated	Untreated	Treated	Untreated	Treated	Untreated
Firm size	−0.3848*	−0.1656*	0.1881**	−0.0361	−0.0042**	−0.0017	−0.0271	0.0054	0.0103	0.0331
	(0.213)	(0.096)	(0.081)	(0.080)	(0.002)	(0.002)	(0.026)	(0.026)	(0.030)	(0.033)
Dividend	−0.0169	0.0896	−0.3159***	0.0275	−0.0036	−0.0008	−0.0485*	−0.0105	0.0405	0.0034
payout	(0.200)	(0.151)	(0.111)	(0.142)	(0.002)	(0.002)	(0.029)	(0.033)	(0.043)	(0.033)
Liquidity	−0.0566	0.0616	−0.0835**	−0.1412	−0.0006	0.0023	−0.0223	0.0613	0.0062	−0.0163
	(0.069)	(0.116)	(0.036)	(0.111)	(0.001)	(0.003)	(0.014)	(0.038)	(0.015)	(0.048)
Leverage	−0.4259	0.1367	−0.3463	−0.1181	0.0095	0.0194	−0.0390	0.0532	−0.0377	−0.0033
	(0.399)	(0.232)	(0.220)	(0.215)	(0.006)	(0.004)	(0.067)	(0.067)	(0.104)	(0.174)
Tax savings	−4.0705	−0.6463	0.1585	0.2742	0.1029**	−0.0026	−0.3637	0.6205	0.7309	−0.4809
	(3.346)	(2.011)	(2.439)	(1.280)	(0.047)	0.033	(0.547)	(0.603)	(0.759)	(0.480)
Investment	0.8890	4.3516***	−0.7707*	0.2256	0.0082	−0.0137	−0.0007	0.7272**	−0.0526	−0.0461
opportunities	(1.050)	(1.476)	(0.444)	(1.194)	(0.011)	(0.023)	(0.140)	(0.361)	(0.143)	(0.431)
Oil	0.0053	−0.0042	−0.0069**	0.0068***	−0.0001	0.0002***	0.0013	−0.0010	−0.0012	−0.0014
spot price	(0.006)	(0.003)	(0.004)	(0.002)	(0.000)	(0.000)	(0.001)	(0.001)	(0.002)	(0.001)
Oil price	−0.0273	−0.0005	0.0084	−0.0474**	0.0013*	−0.0004	−0.0155	−0.0100	−0.0087	−0.0031
volatility	(0.051)	(0.027)	(0.028)	(0.019)	(0.001)	(0.000)	(0.010)	(0.007)	(0.015)	(0.006)
Gas	−0.0568	0.0524	0.0308	0.0727***	0.0013*	0.0012*	0.0153	0.0332***	−0.0107	−0.0118
spot price	(0.071)	(0.033)	(0.039)	(0.028)	(0.001)	(0.001)	(0.016)	(0.009)	(0.013)	(0.010)
Gas price	0.7977**	−0.1372	−0.1654	−0.7173***	−0.0125**	−0.0157***	0.0700	−0.0597	0.1756**	0.0865*
volatility	(0.375)	(0.171)	(0.244)	(0.171)	(0.006)	(0.004)	(0.076)	(0.055)	(0.084)	(0.046)
CEO	0.1999	−4.4014	1.9715	−14.6664*	−0.2884	−0.2165	−2.1748	−3.9169*	3.0845	0.5920
shareholding	(7.424)	(6.333)	(5.576)	(7.805)	(0.190)	(0.145)	(1.326)	(2.059)	(2.440)	(1.217)
Institutional	0.1031	−0.0923	0.5400**	−0.0910	0.0089*	0.0006	0.0851	0.0391	0.0138	0.0563
ownership	(0.309)	(0.295)	(0.239)	(0.262)	(0.005)	(0.006)	(0.063)	(0.075)	(0.072)	(0.096)
K	−0.9741	−0.9714**	0.3695	−0.1529	0.0078	0.0115	−0.0453	−0.0017	−0.0459	0.1341
	(0.703)	(0.489)	(0.288)	(0.381)	(0.006)	(0.008)	(0.086)	(0.108)	(0.102)	(0.154)

Table 9: – CONTINUED ON NEXT PAGE

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Variable	Tobin's Q		Systematic risk		Idiosyncratic risk		Oil beta		ROE	
	Treated	Untreated	Treated	Untreated	Treated	Untreated	Treated	Untreated	Treated	Untreated
Intercept	3.4791***	3.0316***	0.3161	1.5978**	0.0480***	0.0167	0.2663*	−0.0233	−0.1474	−0.2737
	(1.146)	(1.164)	(0.456)	(0.801)	(0.013)	(0.019)	(0.148)	(0.290)	(0.175)	(0.331)
$\hat{\sigma}_{1V} - \hat{\sigma}_{0V}$	-0.0028		0.5224		-0.0037		-0.0436		-0.1801	
	(0.877)		(0.476)		(0.011)		(0.137)		(0.191)	
ATE	-1.4788**		0.1305		0.0137*		-0.0534		0.0781	
	(0.704)		(0.411)		(0.008)		(0.116)		(0.157)	
Observations	275		264		264		264		268	

This table provides the results of the second step (outcome equation) of the essential heterogeneity model. K represents the inverse Mills ratio included as an additional explanatory variable in the second step to account for selection bias. $\hat{\sigma}_{1V}$ ($\hat{\sigma}_{0V}$) is the estimated coefficient of K for the treated (untreated) groups. Independent variables are included in lagged values (first lag). Bootstrapped standard errors using 500 repetitions and clustered at the firm level are reported in parentheses. The superscripts ***, ** and * indicate significance at the 1%, 5% and 10% levels, respectively.

treatment group. Put differently, all things equal, smaller (larger) firms tend to speculate more (less). Besides, investment opportunities have a strong positive effect (statistically significant at the 5% level) on the probability of getting into the group of high speculators. Also, our instrument candidate (the change in the Kilian index) has a mild negative effect, statistically significant at the 10% level.

We interpret this as further evidence broadly in line with the Campbell and Kracaw (1999)'s hypothesis, suggesting that smaller firms faced with financial constraints but good investment opportunities might find it 'sensible' to speculate in order to circumvent the costly external financing due to information asymmetry. This interpretation becomes even more plausible when factoring in the negative sign of the change in the Kilian index. In times of increasing demand for industrial commodities, the oil price will likely rise in tandem with the optimistic global economic outlook, enhancing the profitability of the oil producers and alleviating any financial constraints they may face.

However, we should note that this interpretation only applies to the near future. As mentioned in Section 3, larger firms tend to speculate more past the one-year horizon, which is again confirmed by the first step's results of the essential heterogeneity approach. Table 17, in the appendix, shows that firm size, dividend payout, and liquidity are all positively and strongly associated with the probability of belonging to the treatment group, i.e., the group of high-intensity speculators, much in the spirit of Stulz (1996)'s prediction about firms with comparative advantage in risk-taking.

5.2.3 Speculative hedging and the firm value

As mentioned in the introduction, conventional wisdom in risk management considers that speculative transactions in derivatives have, on average, a zero net present value and, consequently, are of no intrinsic value for the firm. However, the practice of selective hedging is widespread, and a significant number of managers are open to admitting that they routinely incorporate their market views in their respective hedging activities. Our econometric approach allows us to investigate whether empirical evidence supports the prediction of the risk management theory regarding speculation.

Table 10: First step of the essential heterogeneity model: Gas – one year horizon

Variable	Tobin's Q	Systematic risk	Idiosyncratic risk	Gas beta	ROE
Δ Kilian index	−0.0007	−0.0008	−0.0008	−0.0008	−0.0010
	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)
Firm size	−0.4918***	−0.4977***	−0.4977***	−0.4977***	−0.5308***
	(0.089)	(0.091)	(0.091)	(0.091)	(0.091)
Dividend	0.7301***	0.7364***	0.7364***	0.7364***	0.7900***
payout	(0.241)	(0.243)	(0.243)	(0.243)	(0.244)
Liquidity	0.0199	0.0243	0.0243	0.0243	0.0216
	(0.126)	(0.128)	(0.128)	(0.128)	(0.128)
Leverage	−1.6982***	−1.5090***	−1.5090***	−1.5090***	−1.6573***
	(0.437)	(0.480)	(0.480)	(0.480)	(0.527)
Tax savings	−5.4113	−6.2557*	−6.2557*	−6.2557*	−7.7791**
	(3.597)	(3.728)	(3.728)	(3.728)	(3.847)
Investment	1.9651	2.1308	2.1308	2.1308	1.8994
opportunities	(1.341)	(1.366)	(1.366)	(1.366)	(1.343)
Oil	0.0038	0.0019	0.0019	0.0019	0.0041
spot price	(0.010)	(0.011)	(0.011)	(0.011)	(0.010)
Oil price	0.0414	0.0533	0.0533	0.0533	0.0170
volatility	(0.069)	(0.069)	(0.069)	(0.069)	(0.070)
Gas	−0.0169	−0.0093	−0.0093	−0.0093	0.0102
spot price	(0.101)	(0.101)	(0.101)	(0.101)	(0.103))
Gas price	0.2171	0.2268	0.2268	0.2268	0.1752
volatility	(0.516)	(0.517)	(0.517)	(0.517)	(0.524)
CEO	−11.4114*	−12.0885	−12.0885	−12.0885	−11.4224*
shareholding	(6.423)	(8.877)	(8.877)	(8.877)	(6.370)
Institutional	−1.2624***	−1.2550***	−1.2550***	−1.2550***	−1.2316***
ownership	(0.296)	(0.297)	(0.297)	(0.297)	(0.299)
Intercept	4.6349***	4.5894***	4.5894***	4.5894***	4.9283***
	(0.740)	(0.761)	(0.761)	(0.761)	(0.780)
Observations	275	340	328	328	332
Pseudo R^2	0.3395	0.3280	0.3280	0.3280	0.3469

This table provides the results of the first step (selection equation) of the essential heterogeneity model. The dependent variable takes 1 if the firm is categorized as a high-intensity speculator and 0 if it is a low-intensity speculator. It is the same probit model for all the dependent variables, though the results exhibit some differences due to data discrepancies (missing variables). Independent variables are included in lagged values (first lag). Standard errors are reported in parentheses. The superscripts ***, ** and * indicate significance at the 1%, 5% and 10% levels, respectively.

Table 11: Second step of the essential heterogeneity model: Gas – one year horizon

Variable	Tobin's Q		Systematic risk		Idiosyncratic risk		Gas beta		ROE	
	Treated	Untreated	Treated	Untreated	Treated	Untreated	Treated	Untreated	Treated	Untreated
irm size	−0.2314	−0.1423	0.1525*	−0.1832	−0.0036*	−0.0016	0.0223*	0.0106	−0.0270	−0.0696
	(0.188)	(0.140)	(0.089)	(0.135)	(0.002)	(0.005)	(0.013)	(0.019)	(0.022)	(0.089)
Dividend	0.3916	0.2042	−0.2852	0.2513	−0.0081**	−0.0039	−0.0549**	−0.0074	0.0842**	0.1595
payout	(0.315)	(0.261)	(0.177)	(0.209)	(0.004)	(0.008)	(0.025)	(0.031)	(0.042)	(0.141)
Liquidity	0.0521	0.0618	0.0271	−0.0680	0.0008	0.0043	−0.0048	0.0093	−0.0045	−0.0593
	(0.086)	(0.176)	(0.059)	(0.125)	(0.001)	(0.003)	(0.006)	(0.022)	(0.015)	(0.110)
Leverage	−0.5505	−0.7731	−0.1638	−0.4354	0.0217	0.0253	−0.0359	0.0206	−0.1824	−0.2390
	(0.720)	(0.675)	(0.358)	(0.496)	(0.011)	(0.019)	(0.050)	(0.064)	(0.142)	(0.327)
Tax savings	−3.0129	−5.0808	0.4963	−1.0675	0.0883	0.0064	0.3374	0.1623	−1.0819	−0.7998
	(3.953)	(3.332)	(2.194)	(1.841)	(0.041)	(0.073)	(0.304)	(0.286)	(0.594)	(1.167)
Investment	0.4643	4.7804	−0.1917	−0.1348	0.0168	−0.0056	−0.0642	0.1218	0.1787	−0.5419
opportunities	(0.882)	(2.281)	(0.331)	(0.947)	(0.010)	(0.030)	(0.078)	(0.190)	(0.191)	(0.609)
Oil spot	0.0048	0.0079	−0.0004	0.0069	0.0000	0.0001	0.0018	0.0023	−0.0011	−0.0009
price	(0.005)	(0.007)	(0.003)	(0.002)	(0.000)	(0.000)	(0.001)	(0.000)	(0.001)	(0.002)
Oil price	−0.1002	−0.0292	−0.0181	−0.0085	0.0019	0.0000	−0.0079	−0.0111	−0.0008	0.0087
volatility	(0.046)	(0.044)	(0.028)	(0.025)	(0.001)	(0.001)	(0.005)	(0.005)	(0.008)	(0.013)
Gas spot	0.1199	−0.0024	0.0388	0.0522	0.0008	0.0015	−0.0060	0.0010	−0.0055	−0.0219
price	(0.065)	(0.034)	(0.039)	(0.028)	(0.001)	(0.001)	(0.007)	(0.005)	(0.010)	(0.013)
Gas price	0.1100	0.0586	−0.2844	−0.3559	−0.0112	−0.0188	0.0061	−0.0431	0.0995	0.2282
volatility	(0.296)	(0.193)	(0.216)	(0.169)	(0.005)	(0.005)	(0.035)	(0.033)	(0.066)	(0.096)
CEO	6.8501	−6.6107	0.3552	−6.8666	−0.1666	0.0907	0.1817	0.7142	1.7087	−1.8639
shareholding	(10.208)	(7.280)	(4.315)	(6.982)	(0.152)	(0.182)	(0.976)	(0.777)	(1.456)	(4.441)
Institutional	−0.3052	−1.1128	0.1654	−0.5136	0.0101	−0.0020	0.0474	0.0765	−0.1423	−0.2164
ownership	(0.556)	(0.708)	(0.254)	(0.470)	(0.008)	(0.016)	(0.048)	(0.055)	(0.088)	(0.267)
K	−0.7972	−1.2935	−0.1294	−0.7833	0.0092	0.0039	0.0015	0.0451	−0.2161	−0.3783
	(0.670)	(0.738)	(0.286)	(0.596)	(0.008)	(0.021)	(0.053)	(0.076)	(0.084)	(0.408)

Table 11: – CONTINUED ON NEXT PAGE

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Variable	Tobin's Q		Systematic risk		Idiosyncratic risk		Gas beta		ROE	
	Treated	Untreated	Treated	Untreated	Treated	Untreated	Treated	Untreated	Treated	Untreated
Intercept	2.3753	3.9621	−0.0492	3.2402	0.0362	0.0200	−0.1022	−0.1497	0.1922	1.0151
	(1.187)	(1.917)	(0.601)	(1.820)	(0.011)	(0.069)	(0.080)	(0.223)	(0.125)	(1.155)
$\hat{\sigma}_{1V} - \hat{\sigma}_{0V}$	0.4963		0.6539		0.0053		-0.0437		0.1622	
	(1.005)		(0.631)		(0.0220)		(0.087)		(0.417)	
ATE	-1.6726*		-0.8509		0.0096		0.0320		-0.4155	
	(0.900)		(0.593)		(0.020)		(0.087)		(0.337)	
Observations	340		328		328		328		322	

This table provides the results of the second step (outcome equation) of the essential heterogeneity model. K represents the inverse Mills ratio included as an additional explanatory variable in the second step to account for selection bias. $\hat{\sigma}_{1V}$ ($\hat{\sigma}_{0V}$) is the estimated coefficient of K for the treated (untreated) groups. Independent variables are included in lagged values (first lag). Bootstrapped standard errors using 500 repetitions and clustered at the firm level are reported in parentheses. The superscripts ***, ** and * indicate significance at the 1%, 5% and 10% levels, respectively.

We find some evidence that speculative hedging has indeed a detrimental causal effect on the firm value. Focusing on the one-year hedging horizon for oil, where our model specification in Section 3 exhibits the highest explanatory power (highest R^2), we observe a negative and statistically significant difference at the 5% level in the average treatment effect (ATE) between the high (treated) and the low (untreated) speculating firms(See Table 9). For a given dependent variable, the ATE captures the average benefit gained in being induced in the treated group, conditional on the independent variables.

Firm size is the only statistically significant explanatory variable (at the 10% level) affecting the firm's value, as proxied by Tobin's Q, for both groups. Firm size hurts Tobin's Q, and the magnitude of its effect is more pronounced for the high-speculators group. Moreover, even though investment opportunities are thought to be one of the reasons why a firm may engage in intensive speculation, the positive effect of investment opportunities on the firm's value is only significant for those speculating the least.

The discussion above is related to oil speculative hedging at a one-year horizon. Notably, as shown in Table 11, the negative effect of speculative hedging on firm value is also present and statistically significant at the 10% level for gas. Even though the effects of the specific independent variables vary from case to case, the detrimental causal effect of speculation on the firm value is a robust fact across both energy commodities.

As indicated previously, the ATE (average treatment effect), as its name suggests, reflects the sample average of the heterogeneous benefits of treatment, conditional on the explanatory variables. As such, it conceals an interesting, potentially informative aspect of our modeling choice.

Figure 5 below, which depicts the MTEs (marginal treatment effects) of Tobin's Q at the one-year hedging horizon for gas, provides a glimpse of the heterogeneous response of firm value to treatment (i.e., engaging in high-intensity speculation.)

The x-axis represents the "resistance to treatment." It quantifies how the unobserved component V in the latent variable I underlying the treatment's decision opposes the propensity score of being treated (See Equation 5). Hence, all else being equal, the lowest (respectively highest) resistance value of 0 (1) reflects the highest (lowest) likelihood of engaging in intensive speculative hedging[12].

We observe that the estimated marginal treatment effects are an increasing function of the resistance to treatment. In other words, conditional on observables, the value of the firms that are lenient to high-intensity speculation is more negatively impacted (below average) compared with the firms that forcefully resist high-intensity speculation, whose value is above average.

Turning to the impact of high-intensity selective hedging on oil at the same one-year horizon, we notice that the response is less heterogeneous. Figure 6 shows that the estimated MTEs are "flat" and virtually indistinguishable from the average (ATE). In this case, the unobservable component of the treatment decision's latent variable affects all firms somewhat equally. This point illustrates a scenario where the classical instrumental variables (IVs) method would be valid.

5.2.4 Speculation and the firm riskiness

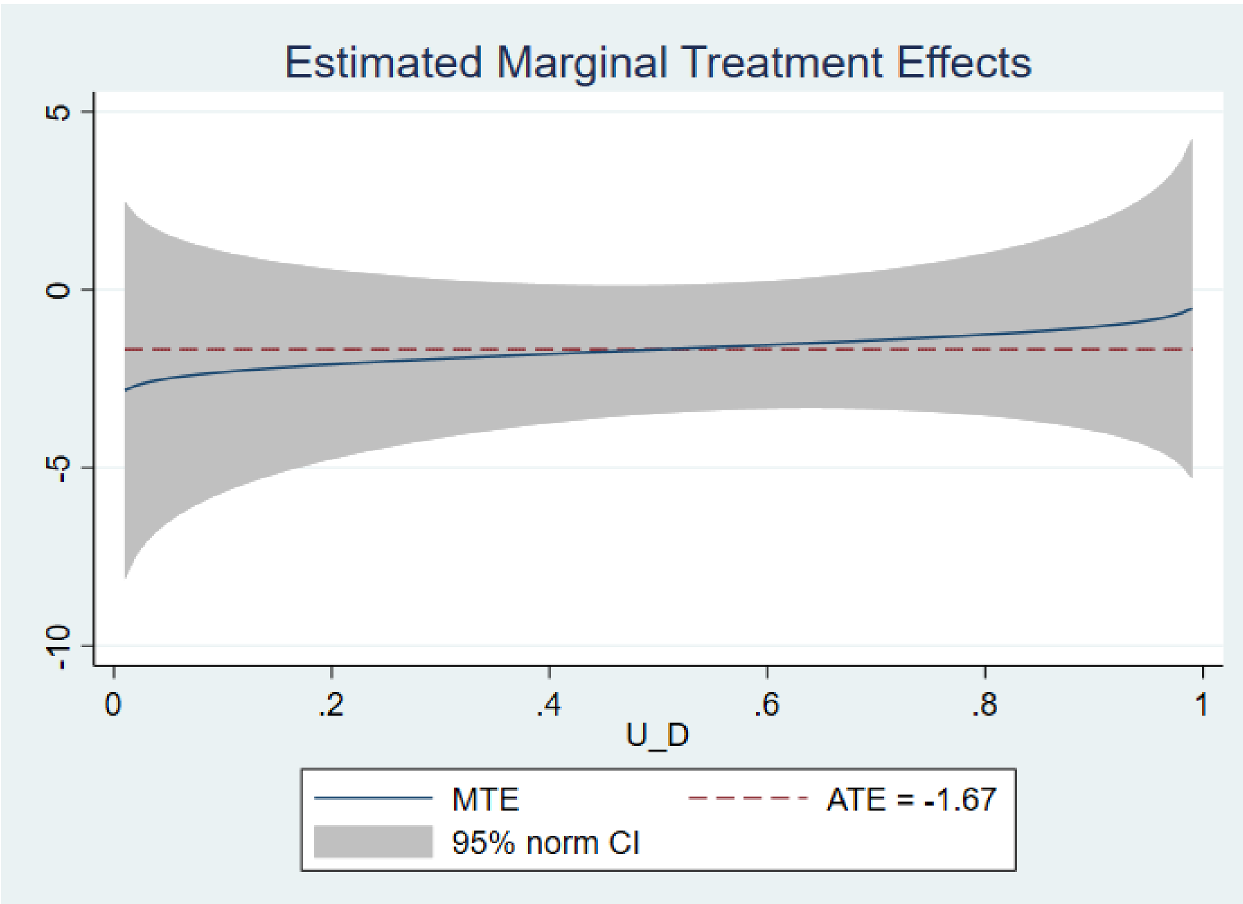
Financial theory suggests that all else equal, pure speculation should translate into increased firm risk. Following the essential heterogeneity approach, we investigate whether selective hedging causes a significant increase in risk variables such as systematic risk, idiosyncratic risk, or oil and gas betas. We find mixed results depending on the considered horizon.

Speculation through oil-related derivative instruments significantly heightens the idiosyncratic risk at the one-year horizon. As Table 9 shows, the ATE is positive and statistically significant at the 10% level, which means that conditional on the firm's characteristics and market conditions, resorting to high-intensity speculation significantly increases, on average, the specific risk of a given firm, compared to a similar firm engaging in low-intensity speculation, instead. Notably, this is the only instance in which selective hedging is shown to have statistically significant financial effects.

There is some heterogeneity in the effect of high-intensity selective hedging on the risk variables, too. We illustrate it with the MTEs of the firm-specific risk at the one-year hedging horizon, where the ATE is statistically significant at the 10% level. In Figure 7, we notice

[12] The "resistance to treatment" has the same probability support as the propensity score $\mathrm{P}(\mathbf{Z})$

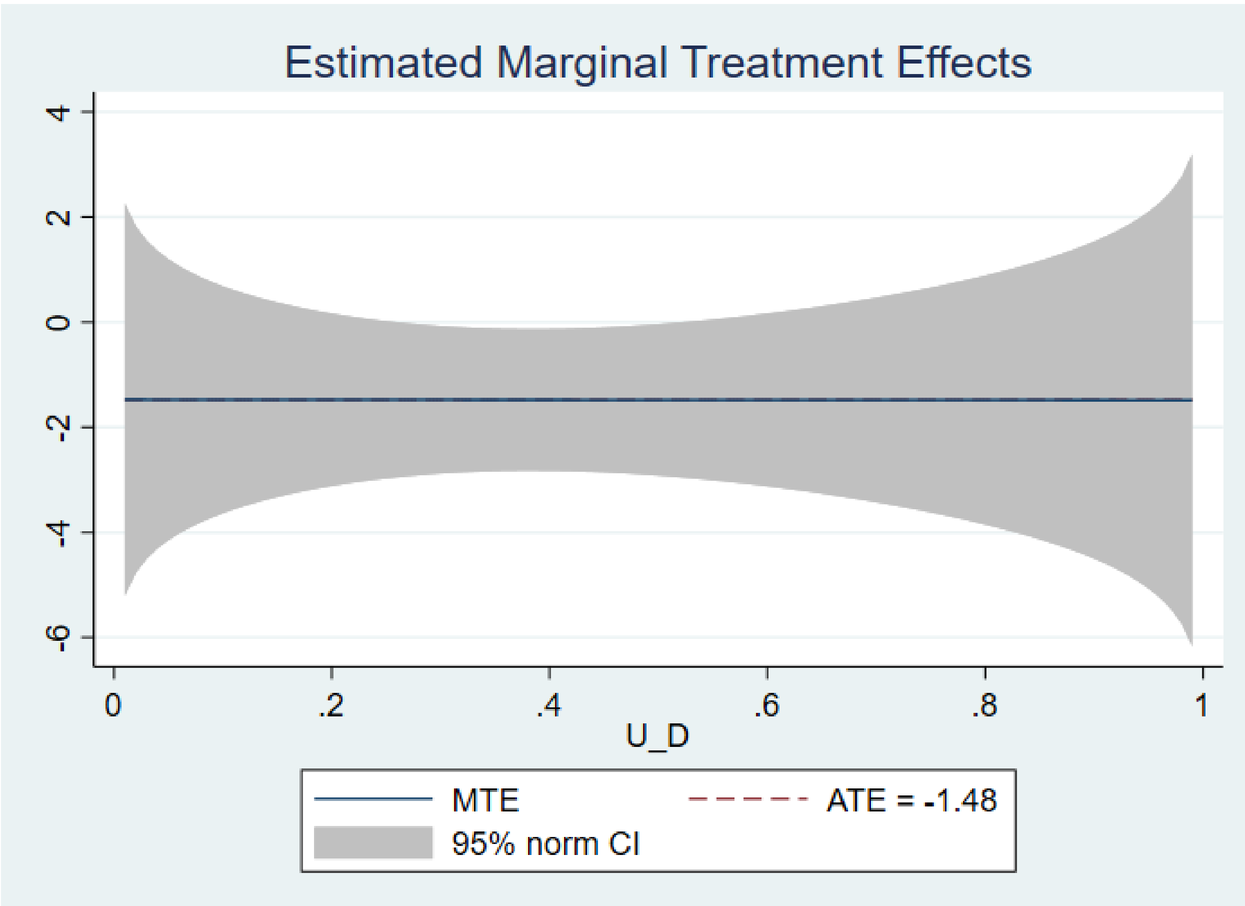
Figure 5: Estimated marginal treatment effects (MTEs) for gas hedging at the one-year horizon: Firm value



The x-axis represents the "resistance to treatment": the higher the value, the less inclined the firm is to engage in high-intensity speculation, conditional on observables.

that the estimated MTEs are a decreasing function of the resistance to treatment due to the unobservable component in the decision process. The increase in the idiosyncratic risk is more prominent than the average for firms with low resistance to treatment (high-intensity speculators.) As the resistance to treatment increases along the x-axis, the idiosyncratic risk decreases and falls below the ATE for firms strongly resisting treatment (low-intensity speculators, in our case, towards the far right of the x-axis.)

Figure 6: Estimated marginal treatment effects (MTEs) for oil hedging at the one-year horizon: Firm value

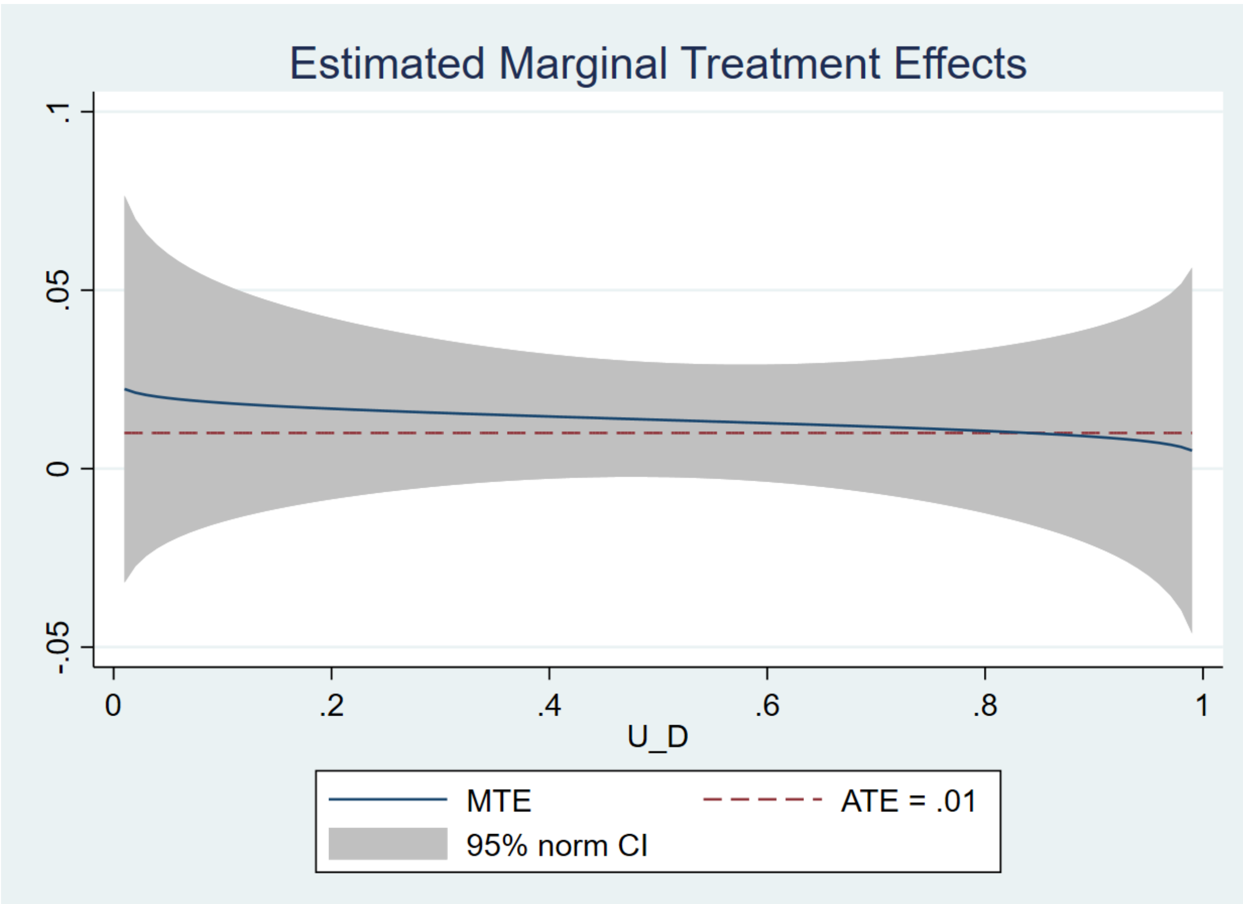


The x-axis represents the "resistance to treatment": the higher the value, the less inclined the firm is to engage in high-intensity speculation, conditional on observables.

Turning to the market risk, we find that the difference between the high-intensity vs. low-intensity speculative hedgers (conditional on observables) is insignificant at all horizons and commodities, except for gas in the current fiscal year, where it is statistically significant at the 1% level (See Table 16 in the appendix). This result is puzzling, and we still need to grasp the reasons that might explain it.

We do not discuss the other risk variables (oil beta, gas beta, ROE) as the ATEs are

Figure 7: Estimated marginal treatment effects (MTEs) for oil hedging at the one-year horizon: Idiosyncratic risk



The x-axis represents the "resistance to treatment": the higher the value, the less inclined the firm is to engage in high-intensity speculation, conditional on observables.

not statistically significant at the usual levels, irrespective of the hedging horizon or energy commodity. For the sake of completeness, we provide the remaining estimation results for the essential heterogeneity estimation in the appendix, along with the remaining MTE graphs for the case of oil hedging at the one-year horizon.

6 Conclusion

This study aims to shed light on the question of "selective hedging," which refers to situations in which managers actively incorporate their individual market perspectives into the risk management policies of their respective corporations. Utilizing a large data sample of US oil and gas producers for our investigations, we specifically focus on two aspects of this multifaceted issue: What are the main attributes of the firms that engage in this type of speculation, and what are the real implications of selective hedging on the firm's value, global riskiness, and accounting performance? Answering these two questions enables us to evaluate the empirical relevance of a number of proposed theoretical arguments advanced to justify this practice.

To this end, we first construct an annual measure of speculative hedging. We derive predicted hedge ratios based on the firm's financial and operational characteristics using Heckman's two-stage estimation method, which considers the natural sequential decision process (whether to hedge or not and to what extent). Our measure of speculation is defined as the annual root mean square error of the difference between the observed and the predicted hedge ratios. This approach allows us to disentangle "selective hedging" from "fundamental hedging," whose primary purpose is to correct market imperfections. Hence, our indicator takes into account two dimensions: the differences in hedge ratio levels and their temporal variability.

We provide evidence that selective hedging is strongly linked to several firm attributes. Importantly, we uncover a significant "horizon effect" in the relationship between firm size – a proxy for the degree of information asymmetry – and speculative behavior. Smaller firms tend to speculate in the short term (hedging horizon of less than one year), while larger firms are more prone to speculate in the medium run (two-year horizon). As measured by Tobin's Q, strong growth potential appears to be a strong driver of selective hedging. Additionally, speculation is observed in firms with sound financial health, as evidenced by the statistical significance of lower leverage, higher liquidity, and the payment of dividends. In the medium-term horizon (two years ahead). For the near term, our findings favor Campbell and Kracaw

(1999)'s conjecture that relatively small firms with favorable investment prospects speculate more, attempting to improve their internal resources because external financing is typically more expensive for them.

However, past the one-year horizon, larger firms with good financial standing speculate more, in line with Stulz (1996) who predicts that it is precisely this type of firms that have a comparative advantage in risk-taking as they often have access to specialized information that is not necessarily reflected in market prices adequately, and "deep pockets" to overcome potential adversity along the way.

Regarding the firm's capital composition, institutional ownership effectively deters speculation. Increased CEO shareholding discourages active risk management as well. Nonetheless, we lack information on the speculative components of CEOs' compensation packages, which could encourage managers to speculate more.

To examine the causal effect of selective hedging on firm value, risk indicators, and accounting performance, we rely on the essential heterogeneity framework, which addresses various endogeneity-related issues, such as the biases induced by the selection on unobservable factors and selection on returns, respectively.

Comparing firms that engage in high-intensity selective hedging to those that speculate less aggressively, conditional on firm characteristics and market conditions, our findings indicate that speculation has a statistically significant detrimental impact on the firm value at the one-year horizon for both oil and gas. Moreover, selective hedging increases the idiosyncratic risk for oil at the same horizon, while the effects on systematic risk or oil beta are not significant. The estimated MTEs (marginal treatment effects) also reveal noticeable heterogeneity in the response to high-intensity speculation for most real and financial dependent variables. This aspect would be overlooked by the classical instrumental variables (IVs) methods.

The first stage estimation results of the essential heterogeneity approach confirm and complement our previous results. At the one-year horizon, firms that engage in aggressive oil speculation are typically smaller, have promising investment opportunities, and do so during periods of declining global demand for industrial commodities. At the two-year horizon, the empirical evidence tells a different story: larger firms with above-par levels of liquidity drive aggressive speculative hedging.

Despite the interesting findings of this study, we should acknowledge some limitations, primarily related to data availability. First, we would have liked to have a more complete characterization of the managers' compensation, especially the stock options for which we lack the moneyness or any other measure of their sensitivity to speculation. Second, we use financial attributes such as leverage, liquidity, and dividend payout to characterize the firm's financial health. However, in order to pinpoint the links between financial distress and selective hedging, it would be more appropriate to use direct measures of the probability of bankruptcy, such as Altman (1968)' Z-score or Ohlson (1980)'s O-score.

Our study paves the way for future research. The most obvious would be to incorporate the mentioned missing variables to more accurately portray the phenomenon of selective hedging and its ramifications with the firms' characteristics. Another interesting aspect would be considering alternative speculation measures to check the robustness of our findings and their sensitivity to a particular approach. Also, instead of a per-horizon approach, it is worthwhile to consider the portfolio approach for all derivatives covering a certain period (say, from the current fiscal year up to two years ahead) and analyze the most salient features of speculative hedging from that perspective. Finally, we have considered speculation in oil and gas separately. However, these two commodities are often produced concurrently, and it would be interesting to proceed to a joint analysis of selective hedging in both commodities and analyze its determinants and real implications, in the spirit of Dionne et al. (2023). We would then compare the results of the joint approach with the single-commodity analyses provided here.

Appendix A Additional tables

A.1 Correlation matrix of firms' characteristics

Table 12: Correlation matrix of the firms‘ financial and operational characteristics

Variable	Firm size	Tobin's	Dividend payout	Liquidity	Leverage	Tax savings	Investment opportunities	Oil spot price	Oil price volatility
Firm size	1								
Tobin's Q	−0.0532***	1							
Dividend payout	0.5761***	−0.026**	1						
Liquidity	−0.2217***	0.0329**	−0.0495***	1					
Leverage	0.2766***	−0.0441***	0.0313**	−0.2944	1				
Tax savings	−0.2299***	−0.0068	−0.1962***	0.0573***	−0.0251*	1			
Investment opportunities	−0.017	0.0006	0.0135	0.0542***	−0.0192	0.0018	1		
Oil spot price	0.2448***	0.0246*	0.0182	0.0283**	−0.0316**	−0.0838***	0.0043	1	
Oil price volatility	0.1506***	−0.0028	0.0222*	0.0114	−0.0087	−0.0319**	0.003	0.5769***	1
Gas spot price	0.1593***	0.0461***	−0.0079	0.0168	−0.0317**	−0.0717***	0.0173	0.6331***	0.3762***
Gas price volatility	0.1141***	0.0174	−0.0135	0.0146	−0.0275**	−0.0581***	0.0178	0.3904***	0.2743***
CEO shareholding	−0.0793***	−0.0041	−0.0773***	−0.0306**	0.0015	0.0291**	−0.0041	−0.0804***	−0.0628***
Institutional ownership	0.6656***	−0.0441***	0.3339***	−0.1685***	0.1339***	−0.1506***	−0.0022	0.2396***	0.1608***
Oil production risk	−0.1789***	0.0494***	−0.1966***	0.0325**	0.0036	0.0722***	0.0122	0.0313**	0.0253**
Gas production risk	−0.2143***	0.0628***	−0.2278***	0.0898***	−0.091***	0.0893***	0.0522***	0.0617***	0.0369***

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Table 12: Correlation matrix of the firms‘ financial and operational characteristics

Variable	Firm size	Tobin’s	Dividend payout	Liquidity	Leverage	Tax savings	Investment opportunities	Oil spot price	Oil price volatility
Number of CEO options	0.0537***	−0.0052	0.0099	−0.0389***	0.0276**	0.0176	−0.0007	0.0092	−0.0065
Number of analysts	0.7808	−0.0351***	0.5067***	−0.1726***	0.1316***	−0.1588***	−0.0163	0.1576***	0.1221***
Oil reserves	0.8182***	−0.0544***	0.5076***	−0.2306***	0.2305***	−0.1953***	−0.0854***	0.0487***	0.0358***
Gas reserves	0.8648***	−0.0627***	0.5264***	−0.3084***	0.3176***	−0.1985***	−0.0172	0.0446***	0.0359***

Variable	Gas spot price	Gas price volatility	CEO shareholding	Institutional ownership	Oil production risk	Gas production risk	Number of CEO options	Number of analysts	Oil reserves
Gas spot price	1								
Gas price volatility	0.6131***	1							
CEO shareholding	−0.012	−0.0073	1						
Institutional ownership	0.1361***	0.102***	−0.0419***	1					
Oil production risk	0.0502***	0.0191	0.0381***	−0.1818***	1				

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Table 12: Correlation matrix of the firms‘ financial and operational characteristics

Variable	Gas spot price	Gas price volatility	CEO shareholding	Institutional ownership	Oil production risk	Gas production risk	Number of CEO options	Number of analysts	Oil reserves
Gas production risk	0.0804***	0.0448***	0.0058	−0.2128***	0.4077***	1			
Number of CEO options	0.0435***	0.0285**	0.8129***	0.0236*	0.0296**	0.0387***	1		
Number of analysts	0.0806***	0.051***	−0.0886***	0.6603***	−0.1986***	−0.2612***	0.0267**	1	
Oil reserves	0.0079	0.0111	−0.0373***	0.5627***	−0.3054***	−0.2446***	0.0503***	0.6704***	1
Gas reserves	0.0107	0.0106	−0.0403***	0.5756***	−0.2301***	−0.2657***	0.0541***	0.7188***	0.7504***

Superscripts ***, **, and * indicate that the Pearson correlation coefficient is significantly different from zero at the 1%, 5%, and 10% levels, respectively.

A.2 Essential Heterogeneity Model – Horizons 0 & 2

Table 13: First step of the essential heterogeneity model: Oil – current year horizon

Variable	Tobin's Q	Systematic risk	Idiosyncratic risk	Oil beta	ROE
Δ Kilian index	−0.0001	−0.0006	−0.0006	−0.0006	−0.0001
	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)
Firm size	−0.0709	−0.0673	−0.0673	−0.0673	−0.0800
	(0.067)	(0.067)	(0.067)	(0.067)	(0.068)
Dividend	0.3553*	0.3818*	0.3818*	0.3818*	0.3823*
payout	(0.198)	(0.199)	(0.199)	(0.199)	(0.203)
Liquidity	0.2317**	0.2278**	0.2278**	0.2278**	0.2280**
	(0.104)	(0.104)	(0.104)	(0.104)	(0.106)
Leverage	0.5638	0.4547	0.4547	0.4547	0.7867*
	(0.351)	(0.376)	(0.376)	(0.376)	(0.405)
Tax savings	3.6856	4.0561	4.0561	4.0561	3.4010
	(3.159)	(3.226)	(3.226)	(3.226)	(3.228)
Investment	0.8829	0.9590	0.9590	0.9590	0.8793
opportunities	(0.822)	(0.830)	(0.830)	(0.830)	(0.856)
Oil spot	0.0103	0.0129	0.0129	0.0129	0.0108
price	(0.010)	(0.010)	(0.010)	(0.010)	(0.010)
Oil price	−0.0024	−0.0175	−0.0175	−0.0175	0.0145
volatility	(0.060)	(0.061)	(0.061)	(0.061)	(0.062)
Gas spot	−0.1654*	−0.1704*	−0.1704*	−0.1704*	−0.1371
price	(0.090)	(0.090)	(0.090)	(0.090)	(0.092)
Gas price	0.7765*	0.7747*	0.7747*	0.7747*	0.6259
volatility	(0.450)	(0.452)	(0.452)	(0.452)	(0.456)
CEO	−7.0020	−5.5336	−5.5336	−5.5336	−4.7632
shareholding	(7.412)	(7.466)	(7.466)	(7.466)	(7.875)
Institutional	−0.8823***	−0.8380***	−0.8380***	−0.8380***	−1.0131***
ownership	(0.283)	(0.285)	(0.285)	(0.285)	(0.291)
Intercept	−0.0510	−0.1238	−0.1238	−0.1238	−0.1396
	(0.570)	(0.580)	(0.580)	(0.580)	(0.586)
Observations	354	346	346	346	342
Pseudo R^2	0.1078	0.1018	0.1018	0.1018	0.1179

NOTES: See notes to Table 8.

Table 14: Second step of the essential heterogeneity model: Oil – current year horizon

Variable	Tobin's Q		Systematic risk		Idiosyncratic risk		Oil beta		ROE	
	Treated	Untreated	Treated	Untreated	Treated	Untreated	Treated	Untreated	Treated	Untreated
Firm size	−0.1841**	−0.0124	0.1187**	−0.0446	−0.0036***	−0.0038***	−0.0093	0.0653	−0.0152	−0.0117
	(0.077)	(0.070)	(0.048)	(0.078)	(0.001)	(0.002)	(0.014)	(0.041)	(0.023)	(0.022)
Dividend	0.1433	−0.0507	−0.2768	0.4289	−0.0080	−0.0049	−0.0505	−0.1714	0.1553*	0.0260
payout	(0.290)	(0.338)	(0.209)	(0.383)	(0.006)	(0.013)	(0.064)	(0.200)	(0.090)	(0.097)
Liquidity	0.0785	−0.1883	−0.0357	0.5077**	−0.0033	0.0009	−0.0243	−0.0384	0.0726*	−0.1628**
	(0.132)	(0.230)	(0.097)	(0.247)	(0.003)	(0.010)	(0.026)	(0.131)	(0.042)	(0.080)
Leverage	−0.0198	−0.1159	−0.1233	1.0247*	0.0004	0.0095	−0.0020	−0.1411	0.2455	−0.0623
	(0.467)	(0.562)	(0.248)	(0.543)	(0.008)	(0.020)	(0.076)	(0.327)	(0.186)	(0.239)
Tax savings	−0.5803	−5.0872	2.0001	3.7786	0.0165	−0.0631	−0.3923	−0.8619	1.2468	−0.7366
	(3.330)	(4.127)	(2.649)	(4.379)	(0.067)	(0.153)	(0.883)	(2.361)	(0.812)	(1.073)
Investment	0.1565	0.1353	−0.0575	1.6610	0.0161	−0.0330	−0.2005	−0.4335	0.3680	−1.0632
Opportunities	(0.676)	(1.211)	(0.536)	(1.497)	(0.016)	(0.048)	(0.208)	(0.793)	(0.285)	(0.717)
Oil spot	0.0095	−0.0015	−0.0019	0.0246*	−0.0001	−0.0001	0.0025	−0.0051	0.0020	−0.0018
price	(0.007)	(0.010)	(0.007)	(0.013)	(0.000)	(0.000)	(0.002)	(0.006)	(0.002)	(0.003)
Oil price	−0.0549	−0.0582***	0.0186	−0.1243***	0.0014**	0.0024**	−0.0189**	0.0033	0.0052	−0.0093
volatility	(0.034)	(0.020)	(0.022)	(0.030)	(0.001)	(0.001)	(0.008)	(0.019)	(0.015)	(0.008)
Gas spot	−0.0711	0.1421	0.0370	−0.2373	0.0035	0.0042	−0.0058	0.1285	−0.0800**	0.0189
price	(0.116)	(0.146)	(0.106)	(0.194)	(0.003)	(0.007)	(0.036)	(0.093)	(0.036)	(0.038)
Gas price	0.9801*	−0.5865	−0.3525	0.7534	−0.0291**	−0.0307	0.1711	−0.5013	0.4698**	0.0352
volatility	(0.595)	(0.654)	(0.514)	(0.869)	(0.015)	(0.031)	(0.160)	(0.418)	(0.188)	(0.167)
CEO	−2.9565	3.7932	2.8881	−29.7669**	−0.1962	−0.1905	−2.4993*	11.6702	0.2952	−1.3058
shareholding	(7.988)	(8.104)	(4.975)	(11.853)	(0.183)	(0.246)	(1.435)	(9.845)	(2.222)	(2.514)
Institutional	−0.0817	0.5696	0.1049	−1.1713	0.0140	−0.0017	0.0676	0.3227	−0.3695	0.1580
ownership	(0.622)	(0.800)	(0.513)	(0.944)	(0.013)	(0.035)	(0.152)	(0.477)	(0.232)	(0.268)
K	−0.8625	0.8146	−0.3572	−2.6601	0.0194	0.0281	0.0413	0.7123	−0.6477*	0.2747
	(1.143)	(1.399)	(0.889)	(1.828)	(0.024)	(0.069)	(0.283)	(0.915)	(0.382)	(0.431)

Table 14: – CONTINUED ON NEXT PAGE

Table 14: – CONTINUED FROM PREVIOUS PAGE

Variable	Tobin's Q		Systematic risk		Idiosyncratic risk		Oil beta		ROE	
	Treated	Untreated	Treated	Untreated	Treated	Untreated	Treated	Untreated	Treated	Untreated
Intercept	1.5917	0.9425	−0.0526	2.7243*	0.0670***	0.0355	0.1968	−0.8474	−0.6189*	−0.0087
	(1.001)	(1.096)	(0.766)	(1.429)	(0.022)	(0.049)	(0.237)	(0.728)	(0.339)	(0.312)
$\hat{\sigma}_{1V} - \hat{\sigma}_{0V}$	-1.6770		2.3029		-0.0087		-0.6710		-0.9225	
	(1.749)		(2.168)		(0.073)		(0.916)		(0.568)	
ATE	0.2201		-2.5429		0.0357		0.5909		-0.1483	
	(1.575)		(1.556)		(0.060)		(0.837)		(0.494)	
Observations	354		346		346		346		342	

NOTES: See notes to Table 9.

Table 15: First step of the essential heterogeneity model: Gas – current year horizon

Variable	Tobin's Q	Systematic risk	Idiosyncratic risk	Gas beta	ROE
Δ Kilian index	−0.0015	−0.0019	−0.0019	−0.0019	−0.0017
	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)
Firm size	0.0266	0.0465	0.0465	0.0465	0.0289
	(0.058)	(0.060)	(0.060)	(0.060)	(0.058)
Dividend	0.1703	0.1419	0.1419	0.1419	0.1778
payout	(0.181)	(0.184)	(0.184)	(0.184)	(0.182)
Liquidity	−0.0040	0.0019	0.0019	0.0019	−0.0117
	(0.070)	(0.070)	(0.070)	(0.070)	(0.070)
Leverage	−1.0869**	−1.0463**	−1.0463**	−1.0463**	−1.1209***
	(0.386)	(0.409)	(0.409)	(0.409)	(0.424)
Tax savings	−0.3779	−0.2513	−0.2513	−0.2513	−0.0341
	(2.350)	(2.416)	(2.416)	(2.416)	(2.431)
Investment	0.4894	0.5640	0.5640	0.5640	0.4597
Opportunities	(0.478)	(0.501)	(0.501)	(0.501)	(0.470)
Oil spot	0.0018	0.0014	0.0014	0.0014	0.0018
price	(0.008)	(0.008)	(0.008)	(0.008)	(0.008)
Oil price	0.0187	0.0218	0.0218	0.0218	0.0145
volatility	(0.053)	(0.054)	(0.054)	(0.054)	(0.053)
Gas spot	0.0539	0.0501	0.0501	0.0501	0.0632
price	(0.082)	(0.082)	(0.082)	(0.082)	(0.083)
Gas price	−0.0976	−0.0963	−0.0963	−0.0963	−0.0937
volatility	(0.407)	(0.411)	(0.411)	(0.411)	(0.412)
CEO	13.2084*	9.3845	9.3845	9.3845	11.4016
shareholding	(7.936)	(8.377)	(8.377)	(8.377)	(8.116)
Institutional	−0.6840***	−0.6634***	−0.6634***	−0.6634***	−0.7501
ownership	(0.232)	(0.233)	(0.233)	(0.233)	(0.234)
Intercept	0.2898	0.1537	0.1537	0.1537	0.2840
	(0.437)	(0.446)	(0.446)	(0.446)	(0.445)
Observations	407	396	396	396	399
Pseudo R^2	0.0502	0.0533	0.0533	0.0533	0.0515

NOTES: See notes to Table 8.

Table 16: Second step of the essential heterogeneity model: Gas – current year horizon

Variable	Tobin's Q		Systematic risk		Idiosyncratic risk		Gas beta		ROE	
	Treated	Untreated	Treated	Untreated	Treated	Untreated	Treated	Untreated	Treated	Untreated
Firm size	0.0152	0.0140	0.2245***	0.1109**	−0.0047***	−0.0053***	0.0032	0.0087	0.0244	−0.0059
	(0.080)	(0.116)	(0.038)	(0.049)	(0.001)	(0.002)	(0.008)	(0.009)	(0.015)	(0.010)
Dividend	0.6639**	−0.2676	−0.0672	−0.0244	−0.0050	−0.0012	−0.0405*	0.0060	0.0499	0.0479
payout	(0.288)	(0.334)	(0.117)	(0.137)	(0.004)	(0.004)	(0.024)	(0.029)	(0.051)	(0.046)
Liquidity	0.0654	−0.0038	−0.0206	0.0464	0.0000	0.0025	−0.0044	−0.0055	0.0190	−0.0199*
	(0.123)	(0.141)	(0.044)	(0.101)	(0.001)	(0.002)	(0.007)	(0.008)	(0.014)	(0.012)
Leverage	−3.5363**	1.2229	−1.7364***	−0.7028	0.0241	0.0058	0.0099	−0.0651	−0.2224	0.0403
	(1.692)	(1.110)	(0.592)	(0.737)	(0.021)	(0.019)	(0.118)	(0.163)	(0.241)	(0.205)
Tax savings	−1.8856	−1.1927	0.5822	0.2912	0.0993*	0.0173	0.1850	−0.0639	−0.7444	−0.1018
	(3.109)	(1.959)	(1.438)	(1.571)	(0.053)	(0.048)	(0.402)	(0.322)	(0.858)	(0.479)
Investment	1.6021	0.5704	0.3198	1.0745*	−0.0008	−0.0063	−0.0124	0.0333	0.0465	−0.0281
Opportunities	(1.020)	(0.946)	(0.295)	(0.617)	(0.009)	(0.016)	(0.087)	(0.151)	(0.155)	(0.201)
Oil spot	−0.0067	−0.0013	−0.0034	0.0008	0.0000	0.0001	0.0016**	0.0022***	−0.0013	−0.0001
price	(0.004)	(0.005)	(0.002)	(0.003)	(0.000)	(0.000)	(0.001)	(0.001)	(0.001)	(0.001)
Oil price	0.0403	−0.0654	0.0194	−0.0239	0.0012	0.0020**	−0.0076	−0.0062	−0.0119	−0.0097
volatility	(0.051)	(0.048)	(0.030)	(0.046)	(0.001)	(0.001)	(0.007)	(0.009)	(0.010)	(0.007)
Gas spot	0.2316***	0.0028	0.1005***	0.1654***	0.0012	0.0005	−0.0028	0.0038	−0.0069	−0.0101
price	(0.071)	(0.078)	(0.029)	(0.036)	(0.001)	(0.001)	(0.006)	(0.009)	(0.012)	(0.014)
Gas price	−0.2075	0.2730	−0.5299***	−1.0115***	−0.0158***	−0.0171***	0.0129	−0.0252	0.1407**	0.1382*
volatility	(0.298)	(0.288)	(0.157)	(0.204)	(0.005)	(0.006)	(0.037)	(0.042)	(0.069)	(0.083)
CEO	43.8910**	−19.5531	13.3142**	5.6492	−0.1077	−0.0056	−1.8793	1.4501	4.4537	0.4104
shareholding	(19.626)	(18.786)	(6.089)	(9.319)	(0.263)	(0.205)	(1.996)	(2.413)	(3.042)	(3.012)
Institutional	−1.9814**	0.5808	−0.7435**	−0.2439	0.0089	−0.0175	0.0642	0.0088	−0.1249	0.0936
ownership	(0.923)	(0.724)	(0.321)	(0.496)	(0.012)	(0.014)	(0.065)	(0.118)	(0.188)	(0.153)
K	−4.8555**	1.7611	−2.3632***	−0.9979	0.0132	−0.0247	0.0517	−0.0398	−0.2303	0.1225
	(1.939)	(1.743)	(0.784)	(1.105)	(0.026)	(0.027)	(0.153)	(0.264)	(0.345)	(0.300)

Table 16: – CONTINUED ON NEXT PAGE

Table 16: – CONTINUED FROM PREVIOUS PAGE

Variable	Tobin's Q		Systematic risk		Idiosyncratic risk		Gas beta		ROE	
	Treated	Untreated	Treated	Untreated	Treated	Untreated	Treated	Untreated	Treated	Untreated
Intercept	-0.9890	-0.6710	-1.4563^{***}	1.2894	0.0505^{***}	0.0873^{***}	0.0139	-0.0152	-0.1826	-0.1483
	(1.091)	(1.748)	(0.538)	(1.053)	(0.017)	(0.027)	(0.103)	(0.270)	(0.192)	(0.298)
$\hat{\sigma}_{1V} - \hat{\sigma}_{0V}$	-6.6167**		-1.3653		0.0380		0.0915		-0.3528	
	(2.640)		(1.477)		(0.039)		(0.311)		(0.418)	
ATE	-2.3970		-2.8815***		-0.0104		-0.0061		-0.0894	
	(2.043)		(0.980)		(0.029)		(0.244)		(0.404)	
Observations	407		396		396		396		399	

NOTES: See notes to Table 9.

Table 17: First step of the essential heterogeneity model: Oil – two year horizon

Variable	Tobin's Q	Systematic risk	Idiosyncratic risk	Oil beta	ROE
Δ Kilian index	0.0030	0.0028	0.0028	0.0028	0.0036
	(0.005)	(0.005)	(0.005)	(0.005)	(0.005)
Firm size	0.2986***	0.2921***	0.2921***	0.2921***	0.2961***
	(0.109)	(0.111)	(0.111)	(0.111)	(0.110)
Dividend	0.6841**	0.7452**	0.7452**	0.7452**	0.7179**
payout	(0.313)	(0.318)	(0.318)	(0.318)	(0.314)
Liquidity	0.4689***	0.5010***	0.5010***	0.5010***	0.4788***
	(0.177)	(0.187)	(0.187)	(0.187)	(0.179)
Leverage	0.0600	−0.0874	−0.0874	−0.0874	0.2484
	(0.689)	(0.716)	(0.716)	(0.716)	(0.730)
Tax savings	7.9320	10.3738*	10.3738*	10.3738*	8.6512
	(5.503)	(5.846)	(5.846)	(5.846)	(5.700)
Investment	1.1949	1.1820	1.1820	1.1820	1.2059
Opportunities	(1.167)	(1.183)	(1.183)	(1.183)	(1.169)
Oil spot	−0.0031	−0.0026	−0.0026	−0.0026	−0.0030
price	(0.016)	(0.016)	(0.016)	(0.016)	(0.016)
Oil price	0.0580	0.0343	0.0343	0.0343	0.0522
volatility	(0.097)	(0.098)	(0.098)	(0.098)	(0.097)
Gas spot	−0.1817	−0.1636	−0.1636	−0.1636	−0.2199
price	(0.151)	(0.152)	(0.152)	(0.152)	(0.154)
Gas price	0.8905	0.9238	0.9238	0.9238	1.0545
volatility	(0.828)	(0.831)	(0.831)	(0.831)	(0.838)
CEO	26.5160	25.5176	25.5176	25.5176	27.3087
shareholding	(16.915)	(16.884)	(16.884)	(16.884)	(16.996)
Institutional	0.6089	0.5834	0.5834	0.5834	0.6150
ownership	(0.408)	(0.409)	(0.409)	(0.409)	(0.409)
Intercept	−3.5830***	−3.6359***	−3.6359***	−3.6359***	−3.6622***
	(0.998)	(1.011)	(1.011)	(1.011)	(1.017)
Observations	148	145	145	145	146
Pseudo R^2	0.1965	0.1947	0.1947	0.1947	0.2030

NOTES: See notes to Table 8.

Table 18: Second step of the essential heterogeneity model: Oil – two year horizon

Variable	Tobin's Q		Systematic risk		Idiosyncratic risk		Oil beta		ROE	
	Treated	Untreated	Treated	Untreated	Treated	Untreated	Treated	Untreated	Treated	Untreated
Firm size	−0.1069	−0.1399	−0.0101	0.1062	0.0005	−0.0035	−0.1056	0.0812	−0.0396	−0.0244
	(0.149)	(0.219)	(0.147)	(0.156)	(0.003)	(0.008)	(0.069)	(0.063)	(0.060)	(0.041)
Dividend	−0.1457	0.0028	−0.2159	0.0198	0.0049	0.0005	−0.4733**	0.1420	0.0241	−0.2197
payout	(0.328)	(0.516)	(0.491)	(0.500)	(0.008)	(0.022)	(0.223)	(0.172)	(0.172)	(0.172)
Liquidity	−0.0369	−0.2909	−0.1298	0.0498	0.0045	0.0111	−0.2412**	0.1512	−0.0408	−0.0961
	(0.224)	(0.367)	(0.280)	(0.323)	(0.004)	(0.017)	(0.114)	(0.132)	(0.092)	(0.070)
Leverage	−0.1825	−0.6219	−0.2126	−0.1200	0.0114	0.0185	0.0140	−0.2489	−0.0830	−0.2432*
	(0.478)	(0.675)	(0.488)	(0.356)	(0.007)	(0.017)	(0.217)	(0.173)	(0.258)	(0.124)
Tax savings	−5.2539	4.6198	−4.5019	0.0297	0.0930	0.2144	−4.2714*	3.5871	−1.6861	−2.3032
	(5.353)	(5.608)	(6.824)	(5.808)	(0.110)	(0.291)	(2.494)	(2.191)	(2.517)	(1.548)
Investment	−1.0964	0.9327	−1.2735	0.0014	0.0151	−0.0055	−0.6287	0.0804	−0.1572	−0.3204
Opportunities	(0.868)	(1.533)	(0.930)	(1.036)	(0.019)	(0.040)	(0.414)	(0.276)	(0.399)	(0.321)
Oil spot	0.0012	0.0001	0.0065	0.0030	0.0002*	0.0004***	0.0002	0.0024	0.0003	−0.0027
price	(0.004)	(0.007)	(0.004)	(0.005)	(0.000)	(0.000)	(0.002)	(0.002)	(0.003)	(0.002)
Oil price	−0.0351	−0.0469	−0.1021***	−0.0426	0.0000	−0.0015	0.0117	−0.0049	−0.0116	−0.0040
volatility	(0.023)	(0.031)	(0.032)	(0.026)	(0.001)	(0.001)	(0.017)	(0.012)	(0.018)	(0.011)
Gas spot	0.0400	0.0512	0.0745	0.0301	0.0003	0.0016	0.0791**	−0.0267	−0.0053	0.0386
price	(0.052)	(0.111)	(0.070)	(0.067)	(0.001)	(0.004)	(0.037)	(0.027)	(0.035)	(0.024)
Gas price	−0.1200	−0.1849	−0.8255	−0.0291	−0.0071	−0.0263	−0.5292*	0.2158	−0.1386	−0.2001
volatility	(0.305)	(0.578)	(0.503)	(0.438)	(0.008)	(0.022)	(0.287)	(0.171)	(0.251)	(0.134)
CEO	−13.7201	−1.3795	−58.5446	9.5634	−0.1791	0.2625	34.6730	4.4048	−3.1972	−8.7127
shareholding	(13.570)	(19.643)	(38.862)	(18.377)	(0.369)	(0.685)	(23.074)	(6.697)	(12.591)	(7.267)
Institutional	−0.2128	−0.0220	0.2742	0.2837	0.0046	0.0038	−0.2656	0.2094	0.0501	−0.2309*
ownership	(0.260)	(0.451)	(0.519)	(0.341)	(0.007)	(0.018)	(0.229)	(0.134)	(0.186)	(0.123)
K	0.3563	0.6787	0.1812	−0.2683	−0.0245	−0.0167	0.8652*	−0.4179	0.2943	0.4447
	(0.821)	(1.230)	(1.003)	(0.956)	(0.017)	(0.048)	(0.460)	(0.365)	(0.390)	(0.304)

Table 18: – CONTINUED ON NEXT PAGE

Table 18: – CONTINUED FROM PREVIOUS PAGE

Variable	Tobin's Q		Systematic risk		Idiosyncratic risk		Oil beta		ROE	
	Treated	Untreated	Treated	Untreated	Treated	Untreated	Treated	Untreated	Treated	Untreated
Intercept	3.2070	2.2617	2.0265	0.1828	−0.0227	0.0306	2.3054*	−0.4550	0.7722	0.4820
	(2.484)	(1.733)	(2.821)	(1.261)	(0.049)	(0.063)	(1.212)	(0.534)	(1.141)	(0.336)
$\hat{\sigma}_{1V} - \hat{\sigma}_{0V}$	-0.3224		0.4495		-0.0078		1.2832**		-0.1504	
	(1.509)		(1.443)		(0.051)		(0.569)		(0.502)	
ATE	0.8064		-0.2774		-0.0339		0.3886		0.5327	
	(1.212)		(1.111)		(0.044)		(0.506)		(0.389)	
Observations	148		145		145		145		146	

NOTES: See notes to Table 9.

Table 19: First step of the essential heterogeneity model: Gas – two year horizon

Variable	Tobin's Q	Systematic risk	Idiosyncratic risk	Gas beta	ROE
Δ Kilian index	0.0002	0.0029	0.0029	0.0029	0.0002
	(0.004)	(0.004)	(0.004)	(0.004)	(0.004)
Firm size	0.0298	−0.0245	−0.0245	−0.0245	0.0298
	(0.093)	(0.102)	(0.102)	(0.102)	(0.093)
Dividend	0.3595	0.4742*	0.4742*	0.4742*	0.3595
payout	(0.267)	(0.276)	(0.276)	(0.276)	(0.267)
Liquidity	−0.0770	−0.1709	−0.1709	−0.1709	−0.0770
	(0.229)	(0.241)	(0.241)	(0.241)	(0.229)
Leverage	−0.1223	−0.1429	−0.1429	−0.1429	−0.1223
	(0.598)	(0.696)	(0.696)	(0.696)	(0.598)
Tax savings	1.4087	9.6563**	9.6563**	9.6563**	1.4087
	(3.222)	(4.911)	(4.911)	(4.911)	(3.222)
Investment	−1.0460	−2.5378**	−2.5378**	−2.5378**	−1.0460
Opportunities	(0.866)	(1.073)	(1.073)	(1.073)	(0.866)
Oil spot	0.0241*	0.0201	0.0201	0.0201	0.0241*
price	(0.012)	(0.014)	(0.014)	(0.014)	(0.012)
Oil price	−0.1508**	−0.1527*	−0.1527*	−0.1527*	−0.1508**
volatility	(0.076)	(0.082)	(0.082)	(0.082)	(0.076)
Gas spot	0.1496	0.2008	0.2008	0.2008	0.1496
price	(0.119)	(0.126)	(0.126)	(0.126)	(0.119)
Gas price	−0.8607	−1.1918*	−1.1918*	−1.1918*	−0.8607
volatility	(0.648)	(0.695)	(0.695)	(0.695)	(0.648)
CEO	−5.7578	−15.7568	−15.7568	−15.7568	−5.7578
shareholding	(14.536)	(15.455)	(15.455)	(15.455)	(14.536)
Institutional	−1.7287***	−1.7787***	−1.7787***	−1.7787***	−1.7287***
ownership	(0.345)	(0.359)	(0.359)	(0.359)	(0.345)
Intercept	−0.3686	−0.0762	−0.0762	−0.0762	−0.3686
	(0.767)	(0.903)	(0.903)	(0.903)	(0.767)
Observations	199	192	192	192	199
Pseudo R^2	0.1728	0.2204	0.2204	0.2204	0.1728

NOTES: See notes to Table 8.

Table 20: Second step of the essential heterogeneity model: Gas – two year horizon

Variable	Tobin's Q		Systematic risk		Idiosyncratic risk		Gas beta		ROE	
	Treated	Untreated	Treated	Untreated	Treated	Untreated	Treated	Untreated	Treated	Untreated
Firm size	−0.0661	−0.0447	0.1182**	0.0243	−0.0049***	−0.0034	0.0035	0.0013	0.0399	0.0129
	(0.057)	(0.111)	(0.057)	(0.057)	(0.002)	(0.002)	(0.012)	(0.016)	(0.030)	(0.015)
Dividend	0.0162	0.0189	−0.2084	−0.2293	0.0008	−0.0003	−0.0094	0.0149	−0.0929	0.0769
payout	(0.228)	(0.233)	(0.257)	(0.249)	(0.006)	(0.005)	(0.051)	(0.042)	(0.125)	(0.071)
Liquidity	−0.1436	0.2972	−0.1972	−0.0067	−0.0022	0.0099	−0.0553	−0.0766***	0.0814	−0.0294
	(0.155)	(0.516)	(0.165)	(0.282)	(0.004)	(0.006)	(0.037)	(0.029)	(0.055)	(0.040)
Leverage	0.1193	−0.2237	−0.1555	−0.0432	0.0104	0.0092	−0.0668	−0.0442	−0.2224*	−0.0039
	(0.368)	(0.555)	(0.393)	(0.424)	(0.008)	(0.013)	(0.071)	(0.077)	(0.131)	(0.131)
Tax savings	−2.7543	−3.9985	7.3781	−4.9153	0.1791**	0.0049	1.2536*	0.1996	−0.4639	−0.3442
	(2.355)	(2.474)	(4.642)	(5.481)	(0.089)	(0.099)	(0.709)	(0.843)	(0.980)	(0.510)
Investment	−0.3699	1.1925	−1.3139	1.2064	−0.0146	−0.0070	−0.2543	−0.0494	0.1237	0.1779
Opportunities	(0.740)	(1.569)	(0.974)	(1.272)	(0.024)	(0.035)	(0.185)	(0.326)	(0.321)	(0.233)
Oil spot	−0.0128	−0.0015	0.0079	−0.0072	0.0004	0.0002	0.0037*	0.0047	−0.0075	−0.0005
price	(0.011)	(0.017)	(0.010)	(0.013)	(0.000)	(0.000)	(0.002)	(0.003)	(0.007)	(0.004)
Oil price	0.0129	−0.0720	−0.0871	0.0065	−0.0010	0.0009	−0.0224	−0.0249	0.0193	−0.0003
volatility	(0.070)	(0.111)	(0.072)	(0.084)	(0.002)	(0.002)	(0.014)	(0.017)	(0.043)	(0.027)
Gas spot	0.0259	−0.0327	0.1100	−0.0502	0.0055**	−0.0016	0.0325	0.0041	−0.0320	0.0060
price	(0.091)	(0.082)	(0.103)	(0.107)	(0.002)	(0.002)	(0.021)	(0.017)	(0.056)	(0.022)
Gas price	0.2313	0.6721	−0.9495*	0.2418	−0.0490***	−0.0004	−0.2598*	−0.0641	0.3274	0.0715
volatility	(0.515)	(0.540)	(0.559)	(0.592)	(0.017)	(0.012)	(0.136)	(0.101)	(0.323)	(0.134)
CEO	−7.2132	1.1196	2.6822	−36.6429	−0.2317	−0.1849	−4.1004	−1.3263	4.6815	−2.2846
shareholding	(13.993)	(7.565)	(14.364)	(24.742)	(0.447)	(0.314)	(2.935)	(3.134)	(3.705)	(2.696)
Institutional	0.7030	1.0506	−0.2287	1.3928*	−0.0128	−0.0033	−0.0859	−0.1027	0.3767	−0.2671
ownership	(0.772)	(1.029)	(0.611)	(0.831)	(0.015)	(0.020)	(0.128)	(0.167)	(0.483)	(0.320)
K	0.6082	0.7461	−0.3511	0.7585	−0.0221	−0.0002	−0.1577	−0.1060	0.3822	−0.2884
	(0.815)	(0.969)	(0.631)	(0.700)	(0.017)	(0.018)	(0.139)	(0.143)	(0.453)	(0.323)

Table 20: – CONTINUED ON NEXT PAGE

Table 20: – CONTINUED FROM PREVIOUS PAGE

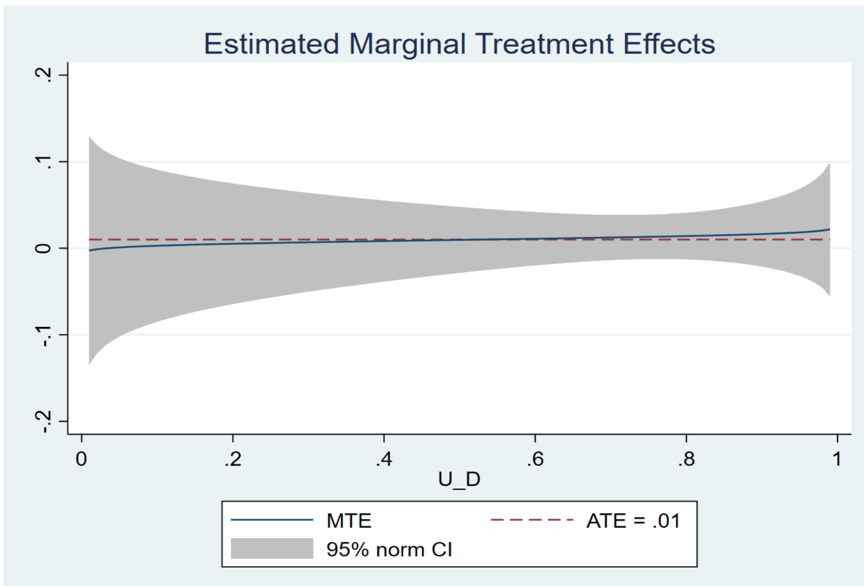
Variable	Tobin's Q		Systematic risk		Idiosyncratic risk		Gas beta		ROE	
	Treated	Untreated	Treated	Untreated	Treated	Untreated	Treated	Untreated	Treated	Untreated
Intercept	2.6457***	0.9059	−0.0309	0.2812	0.0313*	0.0419*	−0.0771	0.1190	0.2417	0.1594
	(0.909)	(0.760)	(0.804)	(0.596)	(0.016)	(0.022)	(0.141)	(0.172)	(0.492)	(0.270)
$\hat{\sigma}_{1V} - \hat{\sigma}_{0V}$	-0.1379		-1.1096		-0.0219		-0.0517		0.6706	
	(1.214)		(0.939)		(0.025)		(0.191)		(0.552)	
ATE	1.0535		0.4561		-0.0171		-0.2079		0.0995	
	(1.089)		(0.818)		(0.021)		(0.179)		(0.460)	
Observations	199		192		192		192		199	

NOTES: See notes to Table 9.

Appendix B Additional figures

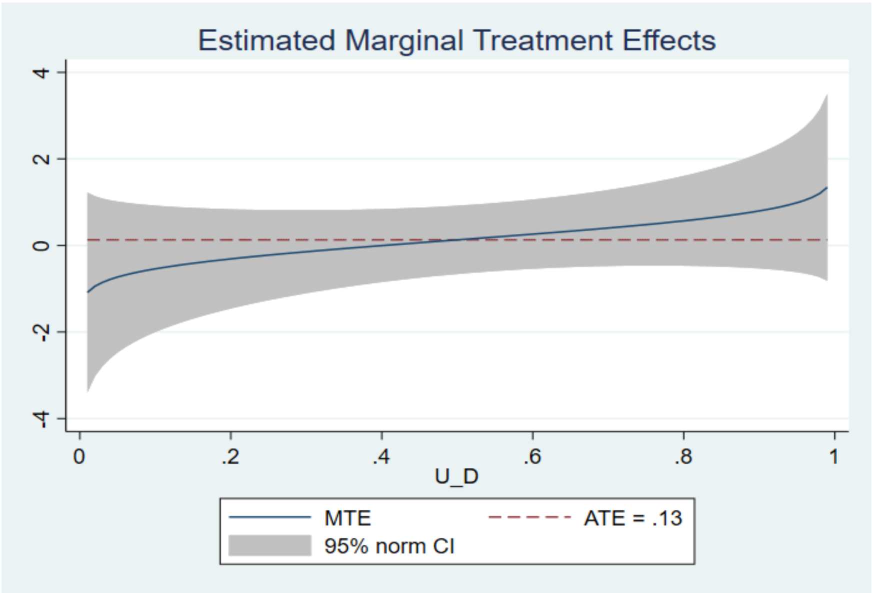
B.1 Estimated MTEs: Complementary figures

Figure 8: Estimated MTEs for gas hedging at the one-year horizon: Idiosyncratic risk



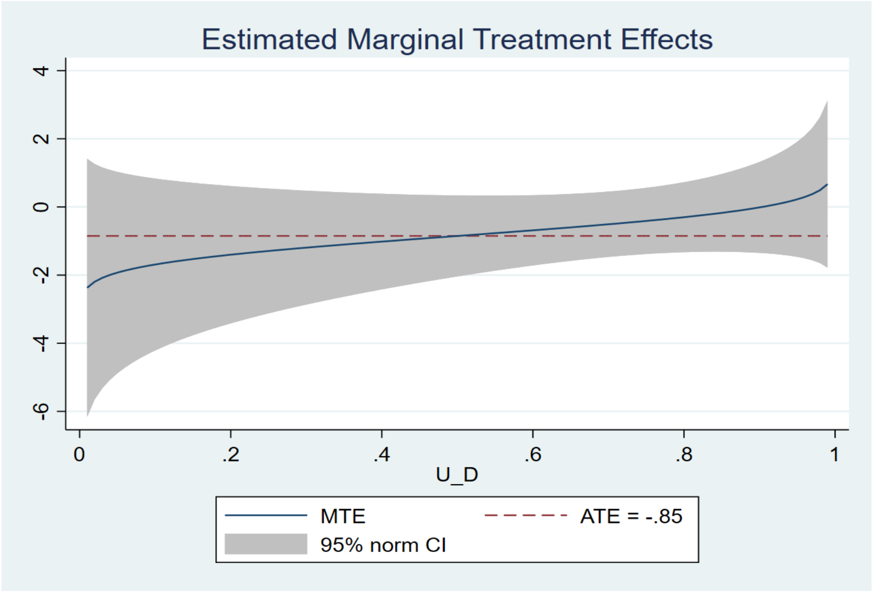
NOTES: See notes to Figure 6.

Figure 9: Estimated MTEs for oil hedging at the one-year horizon: Market risk



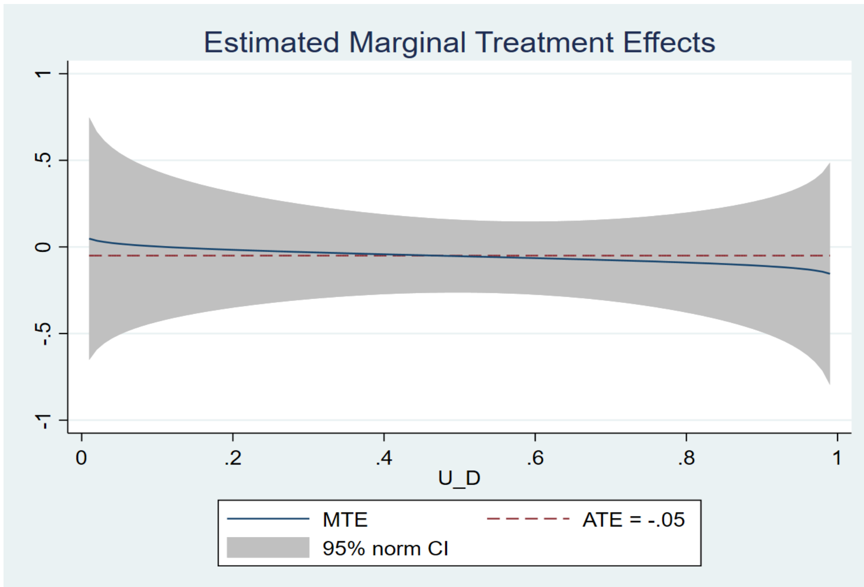
NOTES: See notes to Figure 6.

Figure 10: Estimated MTEs for gas hedging at the one-year horizon: Market risk



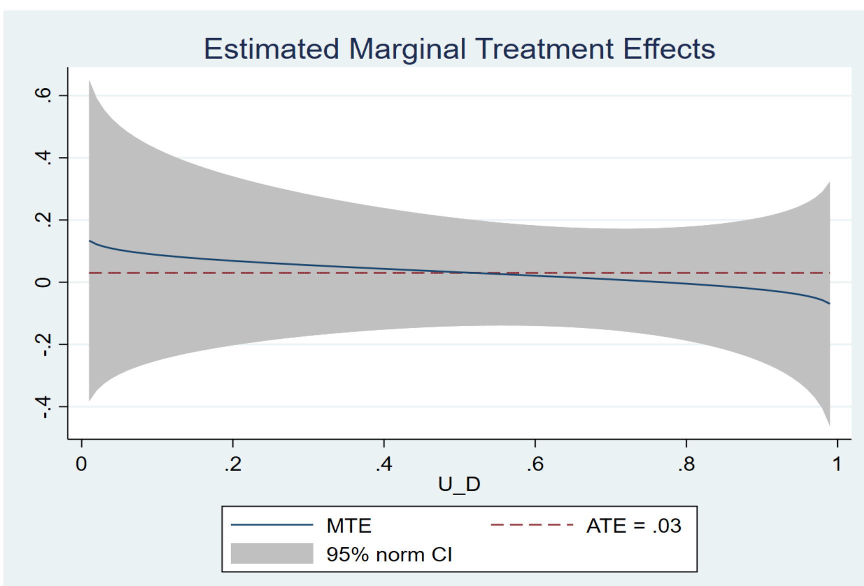
NOTES: See notes to Figure 6.

Figure 11: Estimated MTEs for oil hedging at the one-year horizon: Oil beta



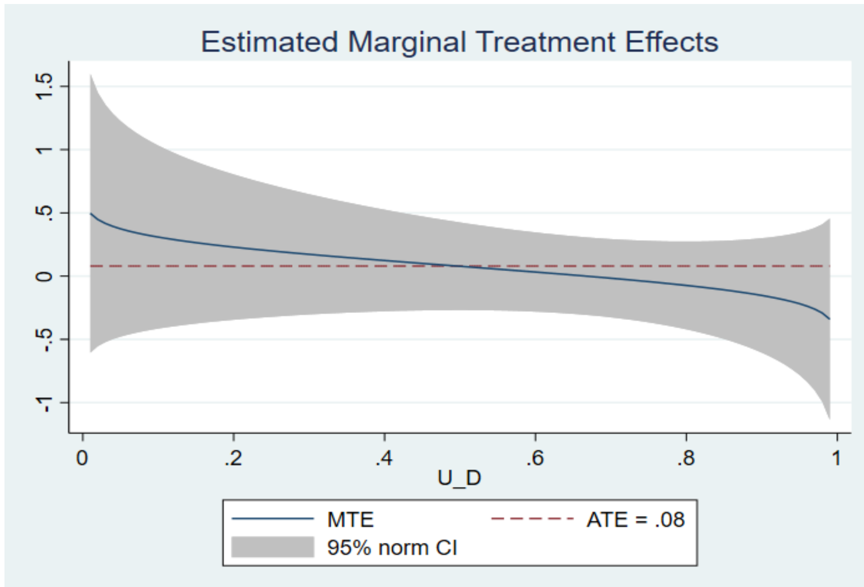
NOTES: See notes to Figure 6.

Figure 12: Estimated MTEs for gas hedging at the one-year horizon: Gas beta



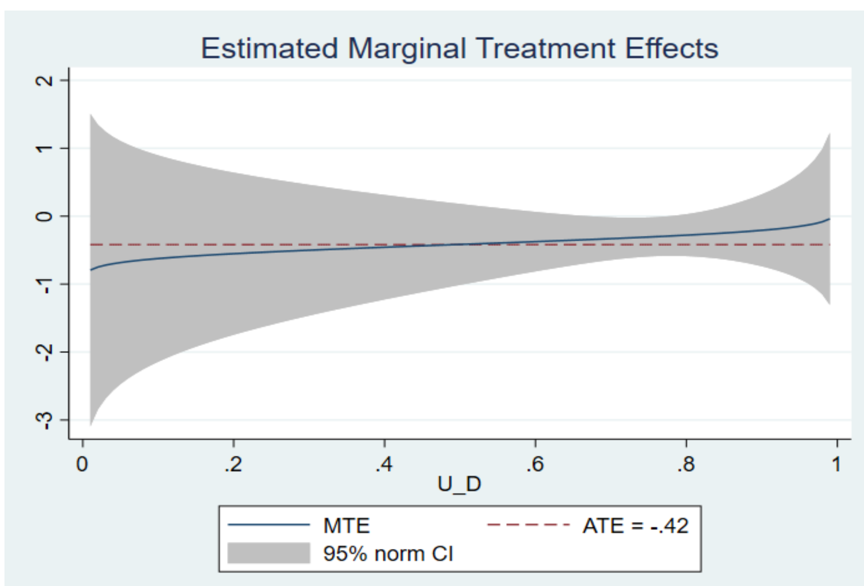
NOTES: See notes to Figure 6.

Figure 13: Estimated MTEs for oil hedging at the one-year horizon: Return on equity



NOTES: See notes to Figure 6.

Figure 14: Estimated MTEs for gas hedging at the one-year horizon: Return on equity



NOTES: See notes to Figure 6.

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