Rivals' Off-Balance Sheet Disclosures and Investment Decisions: Evidence from the Oil and Gas Industry

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ABSTRACT

This paper studies the effect of mandated forward-looking off-balance sheet disclosures on rival firms' valuation and investment decisions. We focus our analysis on the mandatory disclosure of oil and gas (O&G) reserves, a setting in which off-balance sheet information is of particular importance to understand industry supply. Using a comprehensive sample of Canadian and US O&G producers we document two novel results. First, in contrast with prior research on the informational effect of peers' earnings announcements, we find strong evidence that more positive news about any peer's O&G reserves is associated with *lower* rival firms' announcement returns. Second, consistent with peers' disclosures affecting managerial decision making, we document that larger increases in peer reserves are accompanied by an *increase* in rival firms' investment. We corroborate our results by exploiting three sources of institutional variation. First, the North-American pipeline infrastructure conditions the supply of natural gas (and thus competition in this market), but does not affect the supply of oil. Second, the introduction of the fracking technology substantially altered the competition dynamics in the natural gas market. Third, mandatory O&G disclosure rules were modified in Canada and the US in a similar fashion, but at different points in time. Overall, our evidence suggests that disclosure regulation has substantial real effects through rivals' use of peer firms' off-balance sheet disclosures.

Keywords: Disclosure Rules, Disclosure of Oil and Gas Reserves, Informational Spillovers, Real Effects of Disclosure Regulation.

JEL Classifications: M41

1. Introduction

The analytical accounting literature distinguishes how firm disclosures have both "financial" and "real" externalities (Dye 1990, Kanodia and Sapra 2016). In the case of financial externalities, a firm's disclosure updates investors' information on the distribution of other firms' cash flows, thus changing firms' equilibrium price without altering their real cash flow distribution. In the case of real externalities, a firm's disclosure alters the distribution of other firms' cash flows by influencing managerial investment decisions in those firms. While prior empirical research studies investors' use of peer firms' information releases (i.e., financial externalities), little is known about whether and how firms' managers make use of those same releases in real business decisions (i.e., real externalities). This paper contributes by examining whether off-balance sheet disclosures contain information that industry peers use for real investment decisions.

Off-balance sheet disclosures may inform competitors for two reasons. First, in contrast to the on-balance sheet disclosures traditionally studied in the information transfer literature (in most cases earnings-related items), off-balance sheet disclosures often contain information that is forward-looking and thus more likely to inform about future competitive prospects affecting investment decisions. Second, off-balance sheet information is often non-financial and more specific in nature than on-balance sheet information. This is important because such information is potentially valuable for firms trying to understand the effect of peers' production prospects on the competitive landscape. That said, it is plausible that off-balance sheet information is of no use for industry peers because firms are reluctant to disclose information that could provide a competitive advantage to rivals or because these disclosures contain information that is already common knowledge among competitors.

To examine the real effects of peers' off-balance sheet information, we focus on the mandatory disclosure of oil and gas (O&G) reserves by North-American listed firms. This disclosure, known as *proved reserves* in both Canada and the U.S, is an estimate of the total amount of the firm's O&G reserves.[1] Appendix A includes examples of O&G reserves disclosures in Canada and the US.

The disclosure of O&G reserves in North-America is a particularly powerful setting to address our research question for several reasons. First, O&G reserves are the primary, non-financial operating asset of O&G firms, and thus an off-balance sheet disclosure of special importance. Indeed, anecdotal evidence suggests that market participants often consider O&G reserves disclosures more relevant for valuation purposes than on-balance sheet information.[2] Second, proved reserves are estimated as the present value of the future cash flows generated by the production of O&G reserves and hence they are a forward-looking measure of O&G firms' supply capacity. This is crucial given the long lead times on O&G extraction projects. Third, in a sector where companies are typically price takers, news about proved reserves likely convey information on industry supply. Note that, while knowledge regarding future O&G demand can be acquired using public sources of information such as weather forecasts, reports on future economic growth, and/or geopolitical analyses, knowledge regarding future O&G supply is more likely to be determined by firm-specific information such as variation in O&G reserves.[3]

[1] In both US and Canada, "proved" reserves are defined by disclosure rules as "those with at least a 90% probability of being actually recovered."

[2] For example, a JP Morgan Analyst Report (April 17, 2008) states: "EPS and CFPS growth do not tell the whole story as 1) they do not reflect long-term capital efficiency, 2) they are strongly dependent on commodity prices, which makes us reluctant to use it as a primary metric of success and 3) they do not take into account differences in timing of growth projects. In an industry with long lead times on projects, we think a focus on near-term EPS growth might be detrimental to investment decisions and thus to longer-term growth."

[3] While empirically challenging to categorize industries (Kedia 2006), competition in the O&G industry can be theoretically characterized by a Cournot model when firms compete by choosing output quantity or commit to capacity before choosing price (Kreps and Scheinkman 1983). Under the assumptions leading to Cournot

The institutional features and the evolution of the North American O&G industry provide unique opportunities for identification. Natural gas producers heavily depend on the pipeline transportation infrastructure to access end markets. We measure the degree of competition of each pair of North-American O&G firms based on the regions they can supply given the existing pipeline infrastructure. Moreover, the degree of competition among natural gas producers significantly increased after the introduction of the fracking technology for natural gas extraction around 2007, thus enabling us to test whether the effect of peers' O&G disclosures depends on the degree of competition. Finally, Canada and the U.S modified their O&G disclosure regulation at two different points in time during the sample period. In 2003, the Alberta Securities Commission (ASC) introduced National Instrument 51-101 "Standards for Oil and Gas Activities" (NI 51-101). In 2009, the U.S. Securities and Exchange Commission (SEC) introduced "Modernization of Oil and Gas Reporting" (MOGR). The similarity and staggered nature of these regulatory shocks offer a unique opportunity to empirically identify the real effects of disclosure regulation by testing whether off-balance sheet information has a stronger effect on peer firms after the tightening of reserves disclosure rules.

We conduct our empirical analyses using a comprehensive sample of public Canadian and US O&G producing firms between 2002 and 2011. First, we examine the stock market reaction to peer firms' releases of news about O&G reserves. We find that firms experience lower returns when peers announce larger increases in O&G reserves. This evidence is not consistent with reserves disclosures conveying information on O&G demand. Rather, we

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competition, prior analytical research (e.g., Hwang and Kirby 2000, Vives 2000) predicts that mandatory firm disclosures have an effect on competitors' behavior. In contrast, predictions using alternative assumptions of competition (i.e., Bertrand) are ambiguous.

interpret this evidence as suggesting that reserves disclosures are, on average, informative about the competitive position of peer firms and/or about industry supply.[4]

Second, we test whether peers' disclosures of proved reserves are associated with firms' investment decisions. Consistent with peers' disclosures inducing real externalities, we observe higher levels of CAPEX when competitors disclose larger increases in proved reserves. We interpret this evidence as suggesting that firms react to rival firms' increases in reserves in an effort to avoid losing profits and/or competitive edge.

Additional tests aimed at sharpening identification confirm our interpretation of the above results. Specifically, we find that the empirical pattern we document is stronger among pairs of firms with overlapping end-markets, among gas producers after the implementation of the fracking technology, and among pairs of firms in which the disclosing peer is subject to tighter O&G disclosure rules.

Finally, we compare investors' and competitors' reaction to peers' reserves disclosures to contemporaneous earnings news. Consistent with prior research and in contrast to our findings on O&G reserves disclosures, increases in peers' earnings appear to be associated with higher returns at rival firms. However, earnings news do not exhibit any clear association with peers' investment decisions, suggesting that, at least in the O&G industry, peers' on-balance sheet information is of limited use to competitors.

This paper makes several contributions to the accounting literature. First, our study adds to the literature on the real externalities of accounting information. The available evidence documents spillover effects of accounting misreporting on competitors' real

[4] For example, an increase in gas reserves by industry peers could signal a future increase in supply of gas, and a subsequent drop in the price of natural gas. While the price drop is probably more than offset by the higher sales volume at the disclosing firm, this need not be the case at the non-disclosing peer. The US Energy Department also makes this argument when analyzing the determinants of natural gas prices. They maintain that "the domestic natural gas prices are driven primarily by supply (…), so that increased natural gas supply tends to lower prices" (Source: US Energy Information Administration, accessed at http://www.eia.gov/energyexplained/index.cfm?page=natural_gas_factors_affecting_prices).

investment decisions (e.g., Sidak 2003, Sadka 2006, Durnev and Mangen 2009, Beatty, Liao and Yu 2013). In contrast to these papers, our study does not focus on the announcement of accounting irregularities. Instead, we contribute to this literature by providing evidence that regular, periodic disclosures in accounting reports have real effects on peer firms.[5]

In addition, we contribute to the literature on the financial externalities of accounting information. This literature distinguishes between two types of such externalities, namely "contagion" and "competitive" effects of intra-industry announcements (Land and Stulz, 1992). A corporate announcement is said to have a "contagious" effect when firms' good (bad) news elicit a positive (negative) stock market reaction of peer firms. Alternatively, when firms' good (bad) news elicit a negative (positive) stock market reaction of peer firms, this effect is referred to as "competitive".

While the contagion effect of accounting information has been widely documented in the context of earnings announcements (e.g. Firth 1976, Foster 1981, Clinch and Sinclair 1987, Han and Wild 1990, Freeman and Tse 1992, Wang 2014, Arif and De George, 2015), management earnings forecasts (Baginski 1987, Han, Wild and Ramash 1989, Pyo and Lustgarten 1990), profit warnings (Tse and Tucker 2010, Alves, Pope and Young 2009), and earnings restatements (Xu, Najand and Ziegenfuss 2006; Gleason, Jenkins and Johnson 2008; Silvers 2016), ours is the first paper documenting competitive effects from accounting information.[6]

Further, our paper adds to the O&G accounting literature examining the information content of O&G disclosures. Prior research documents a weak association between levels

[5] Peer disclosures may have real effects by affecting firms' responsiveness to investment opportunities. For example, Badertscher, Shroff and White (2013) study the effect of public firms' higher disclosure standards on private peers' responsiveness to investment opportunities. In this paper, however, we address a different type of research question, namely whether peer disclosures affect investment *levels* rather than *opportunities*.

[6] Two studies in the finance literature document competitive effects of intra-industry announcements, namely Lang and Stulz (1992) and Firth (1996). However, these papers focus on announcements of financing events and policies (bankruptcy and dividend distributions) rather than on accounting information.

(changes) of security prices and levels (changes) of O&G valuation disclosures required by ASC 932 (formerly SFAS 69) for US O&G firms.[7] Three plausible reasons might explain these results: unreliable estimations of reserve quantities (Clinch and Magliolo 1992), flaws in the mandated valuation model (e.g. use of spot prices and a fixed discount rate of 10%), and model misspecifications (Boone 2002). Patatoukas, Sloan and Zha (2015) mitigate these shortcomings by focusing on royalty trusts and find robust evidence supporting the incremental relevance of ASC 932 disclosures for valuation. Using a comprehensive sample of North American O&G public firms, we further contribute to this literature by documenting the contrast between the competitive effect of the information spillovers related to reserves disclosures, and the contagion effect of the information spillovers related to earnings.

Our findings are relevant for regulators. Regarding the O&G industry, our evidence suggests that investors benefit from the forward-looking nature of O&G reserves disclosures incrementally to the information in accounting earnings. Furthermore, we find that information transfers are stronger after the introduction of the new O&G reporting regulations in Canada and the US, consistent with the initial intention of standard-setters.

More generally, this study furthers our understanding of the real externalities of disclosure regulation. Our paper responds to Leuz and Wysocky (2016)'s call for research on regulation externalities (that is, beyond the classical cost-benefit analysis at the firm level) as well as for sharper identification strategies. In a context of global convergence, our findings suggest that standard-setters should be aware of the potential transnational spillover effects of domestic regulations. While O&G reserve disclosures may appear specific to the North American O&G industry, we believe that our study is informative for regulators and standard setters outside Canada and the US. For example, although IFRS does not contain

[7] See, e.g., Magliolo (1986), Harris and Ohlson (1987), Doran, Collins and Dhaliwal (1988), Alciatore (1993), Shaw and Wier (1993), and Spear (1994).

requirements to disclose reserve estimates and each country decides its own disclosure regime, an on-going IASB project develops common reporting requirements for investigative, exploratory and developmental activities across a wide range of activities.

Section 2 describes the sample. Section 3 investigates the stock market reaction and firms' investment decisions around peers' disclosures. Sections 4 and 5 exploit the shocks introduced by the fracking technology and the new O&G disclosure regulations, respectively. Section 6 compares the information transfers of news in O&G off-balance sheet disclosures and news in earnings. Section 7 presents additional evidence and robustness tests. Section 8 concludes.

2. Data and Sample Characteristics

Our initial sample comprises all O&G firms listed on stock exchanges in Canada and the US disclosing O&G reserves in the period from 2002 to 2011.[8] For the sample firms listed on Canadian stock exchanges, we collect data on O&G reserve disclosures and other firm fundamentals from the CanOils Database Ltd. (hereafter CanOils).[9] We complement this information with data from ASC Database and with hand-collected data from Annual Information Forms, Annual Reports, and Forms 51-101F1, F2, and F3 obtained from the System for Electronic Document Analysis and Retrieval (SEDAR). The dates of release of the Annual Information Forms and Annual Reports are retrieved from SEDAR using a Python algorithm. For the sample firms listed on US stock exchanges we collect data on O&G reserve disclosures from Capital IQ and Evaluate Energy (a provider of financial data

[8] These exchanges are the Toronto Stock Exchange (TSX) and the Toronto Venture Exchange (TSX-V) in Canada, and NASDAQ, AMEX, and NYSE in the US.

[9] CanOils is the leading commercial database for all the Canadian O&G exploration and production companies. It contains information from annual financial statements and yearly O&G reserve disclosures from all the O&G companies listed on the Toronto Stock Exchange (TSX) and the Toronto Venture Exchange (TSX-V).

for US O&G firms). We complete our final dataset by hand-collecting data from 10K reports found in the SEC database, EDGAR.

We obtain stock market data from Datastream, Bloomberg, TSX Venture Summary Trading Files, and the Center for Research in Security Prices (CRSP). Datastream and Bloomberg provide historical stock market data for common equities traded on the TSX. TSX Venture Trading Summary Files is a database supplied by the TMX group with market information on the TSX-V equities.[10]

Our empirical tests require imposing some filters on this initial sample. First, we exclude companies for which we do not find stock prices in the Datastream, Bloomberg, and TSX-V databases. Second, we exclude observations without reserves data (these observations correspond to firms in a very early stage of exploration). Third, we drop observations from firms that are not pure O&G producers because the valuations of these firms might relate to factors other than O&G reserves, thus potentially confounding our results.[11] These data requirements result in a final sample of 361 firms and 1,843 firm-disclosure observations during the sample period. To our knowledge, ours is the most comprehensive sample ever used in a study of the North American O&G industry.

To analyze firms' reactions to peers' disclosures, we construct a sample of firm-peer disclosures by pairing each firm-disclosure observation with all the peer-disclosure observations occurring in the next 365 days. This process results in 395,968 observations.

[10] We adjust prices for splits, consolidations, and dividends using additional sources. For splits, we use the TSX Venture Listed Company Contacts, a TMX Group database that provides monthly outstanding shares, and we combine it with the information on the date of splits from CanOils. For dividends, we programmed a Python algorithm to download all daily publications from the Toronto Stock Exchange FTP website (http://www.tmx.com/en/listings/products_services/ir_data_solution/venture_market_information.html) to extract the ex-dividend date, currency, and dividend amount for each company. We thank Jill Scullion, from TMX group, for suggesting this idea.

[11] These include integrated oil, funds, and exploration and production firms with more than 5% of revenues coming from sources other than exploration and production (i.e., real estate, drilling, marketing, and midstream and refining services).

Table 1 presents the descriptive statistics of main firm characteristics for the sample of firm-disclosure and firm-peer-disclosure observations. The higher number of Canadian firm-disclosure observations reflects that the Toronto Stock Exchange (TSX) and the TSX Venture Exchange list the largest number of O&G firms among all the stock markets worldwide. The sample firms typically produce more gas than oil. The average portion of gas production is 57% and it exhibits a substantial cross-sectional variation with a standard deviation of 35%.

To measure O&G reserves news for each firm-disclosure observation, we define *Δ_Reserves* as the percentage change in the annual O&G proved reserves. Proved reserves represent the amount of reserves classified as "proved" in regulatory filings and measured in either millions of barrels of oil equivalent (BOE) or Canadian dollars.[12] The reserves amounts are economically substantial. In Canada, the mean (median) value of proved reserves over the sample period is 35.17 (1.73) millions of BOE's, which are valued at C$ 399.16 (20.21) million. On average, this is equivalent to 82% of the book value of assets, and 107% of the total market capitalization of our sample firms. In the US, the mean (median) value of proved reserves is significantly larger at 282.22 (34.73) millions of BOE's, which are valued at US$ 2,444.74 (413.90) million. Relative to firm size, these amounts represent 188% of the book value of assets and 96% of the total market capitalization.[13]

[12] Regulatory filings of O&G reserves also mandate disclosures of proved reserves expressed in dollars. These dollar amounts are computed as the net present value of the disclosed physical reserves. In our main tests, we use physical reserves amounts (i.e., BOE) to ensure comparability of these amounts across time and to avoid measurement error (dollar estimates of reserves require assumptions about future production schedule, market prices, extraction costs, and discount rates, among other factors). That said, we repeat our main tests using reserve disclosures expressed in dollars and obtain similar inferences.

[13] That, on average, proved reserves can exceed both book value of assets and market value of equity is unsurprising. First, O&G assets on the balance sheet are recognized on a historical cost basis, subject to subsequent impairments. So, unlike off-balance-sheet O&G reserve disclosures, recognized O&G assets do not reflect the upside of new O&G discoveries or price increases under both Canadian and US GAAP. Second, these firms are leveraged, so market value of equity is less than the enterprise value.

The disclosed reserves amounts exhibit significant time-series variation. Indeed, *Δ_Reserves* is higher than 50% in more than 20% of the observations, mainly due to the effect of new O&G discoveries. Firms report increases in proved reserves more often than decreases (*Δ_Reserves* is positive in 65% of the observations). A natural explanation is that proved reserves are conservative estimates of O&G reserves (i.e. at least a 90% probability of being actually recovered) that over time tend to the mean as uncertainty unravels. Increases in proved reserves are associated with positive abnormal returns at the disclosing firm. In untabulated tests we find that firms disclosing above-median values of *Δ_Reserves* exhibit an abnormal stock return of 1.26 (t-stat. = 2.45) during the (-1, +1) day-window around the reserves disclosure. In contrast, firms disclosing below-median values of *Δ_Reserves* exhibit an abnormal stock return of -0.34 (t-stat. = -1.11) during the same window.

3. Market Reaction and Investment Decisions

3.1. Stock Market Reaction to Peers' Disclosures

To explore whether reserves disclosures contain information that can be used by competitors, we first analyze the stock price reaction to peers' release of reserves information. Using our sample of firm-peer-disclosure observations, we test the following model:

$$Abn\_Ret = \alpha_0 + \alpha_1 * \Delta\_Reserves\_Peer + \phi * Controls + Firm\text{-}Peer\ FE + \varepsilon \quad (1)$$

For each firm-peer-disclosure observation, *Abn_Ret* is the firm's market-adjusted return over the (−1, +1) day window around the peer's disclosure of reserves. Δ_*Reserves_Peer* is the peers' fractional change in disclosed proved reserves.[14] *Controls* is a vector of control

[14] We winsorize *Δ_Reserves_Peer* to eliminate the effect of outliers. We also conduct a battery of additional checks to ensure that our results are not driven by outliers. First, we eliminate observations with studentized

variables found by the literature to be correlated with the cross-section of returns. *Abn_Ret_Peer* is the peer's market-adjusted return over the (−1, +1) day window around the peer's disclosure of reserves. We include this variable to control for other relevant information about the peer on the peer's disclosure date. That is, this variable is a summary statistic for industry and firm-specific news (including other, potentially simultaneous, peer disclosures on that day).

Controls also includes variables found by prior literature to be associated with the cross-section of returns. *Size* is the logarithm of the firm´s equity market value, and *BM* is the Book-to-market ratio. Both variables are measured at the end of the fiscal year prior to the firm's disclosure date. *Past_Return* is the compounded return over the 365 days prior to the end of the fiscal year prior to the firm's disclosure date. The specification includes firm-peer fixed effects. That is, we test whether, for each pair of firms, the stock of each one of the pair firms reacts to changes in the peer's disclosed reserves. Note that including firm-peer fixed effects controls for firm and peer time-invariant characteristics as well as for their joint characteristics such as their degree of competition.

As previously explained, if the disclosure contains information mainly on industry demand, the release of good (bad) news by a rival firm will elicit a positive (negative) reaction on the firm's stock price. That is, α_1 will be positive. In contrast, if the disclosure contains information mainly on industry supply, the release of good (bad) news by a rival firm will elicit a negative (positive) stock price reaction, and thus α_1 will be negative.

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residuals greater than three. Second, we repeat our tests using a robust regression that assigns lower weights to influential observations. Third, we apply a logarithmic transformation to *Δ_Reserves_Peer* (we take the logarithm of one plus *Δ_Reserves_Peer*). Fourth, we take quintile ranks of *Δ_Reserves_Peer*. Fifth, we define an indicator variable that equals one if *Δ_Reserves_Peer* is greater than 0.5 (i.e., the upper quartile threshold), and zero otherwise. We also construct this indicator variable based on fractional change in reserves and changes in reserves scaled by total assets. Sixth, when the corresponding data are available, we compute *Δ_Reserves_Peer* using proved reserves expressed in dollars. All these alternative specifications lead to the same inferences.

Table 2, Panel A, presents the results of estimating equation (1). Consistent with peers' reserves disclosures containing information on industry supply, the coefficient on Δ_*Reserves_Peer* is negative and significant regardless of the inclusion of control variables (*t*-stat. range from -5.40 to -5.85). α_1 ranges from -0.08 to -0.09. This suggests that a 50% increase in peer reserves is associated with a stock price decrease of approximately 4-5 basis points.[15]

3.2. Investment Decisions around Peers' Disclosures

We next explore whether peers' disclosures of reserves are associated with changes in firms' investment decisions. In parallel with the previous test, we replace the dependent variable *Abn_Ret* with *CAPEX*, defined as capital expenditures scaled by total assets. Following prior literature on the determinants of investment decisions, we include two additional variables, *Leverage*, and *ROA*. *Leverage* is defined as total debt scaled by total assets. *ROA* is net income scaled by total assets.

Table 2, Panel B, presents the results of estimating this variant of equation (1). In contrast to Panel A, the coefficient on Δ_*Reserves_Peer* is positive and significant (*t*-stat. range from 9.46 to 12.45). This result is consistent with firms responding to peers' increases in future supply by increasing its investment. The magnitude of α_1 ranges from 0.29 to 0.41. This suggests that a 50% increase in peer reserves is associated with a CAPEX increase of approximately 30-40% (*CAPEX* is expressed in percentage terms).

3.3. Exploiting Variation in the Degree of Competition

[15] As shown in Table 1, the mean value of *Abn_Ret* is positive. However, when estimating equation (1) excluding Δ_*Reserves_Peer* and fixed effects, the intercept is negative, suggesting that it is not clear that the positive average value of *Abn_Ret* reflects that peers' reserves announcements are generally good news.

Our setting provides an opportunity to measure the degree of competition in the natural gas market between each pair of firms based on their location. As gas transportation is mainly restricted to pipeline systems, the ability of a gas producer to supply a certain territory crucially hinges on the location of that producer relative to the pipeline network connecting the extraction site with that territory. Thus, the degree of overlap in the end-markets served by a given pair of firms (i.e., their degree of competition) is determined by those firms' location. Note that, in contrast, oil transportation offers substantially more flexibility (oil can be shipped via supertankers, trucks, and pipelines) and thus the degree of competition in the oil market among North-American suppliers is likely to exhibit less cross-sectional variation.

Figure 1 presents a map of the gas pipeline network in North America. The map shows that the network does not equally interconnect all the regions, suggesting that the degree of competition among gas producers crucially depends on their location. We note that, as the pipeline infrastructure extends across borders, the degree of competition of a given pair of firms is not necessarily defined by whether the firms are located in Canada or in the US. Figure 2 further illustrates this point by presenting on a map the actual pipeline capacity flows among regions in 2008. As shown in the figure, a firm located in the US Western region is unlikely to compete in the gas market with a firm located in the US Southeast region because the pipelines closest to the two firms do not supply any common market. In contrast, a firm located in Alberta (Canada) and a firm located in the US Midwest region are likely to compete in the gas market of Ontario.

To gauge the degree of competition between a given pair of firms we measure the similarity of the end markets each firm has the potential to serve. For each firm-year, we construct an output vector (V_o) containing an estimation the fraction of the gas supplied by

the firm to each of the North American regions defined by the U.S Energy Information Administration and Canada:

$$V_O = V_I \, x \, M_P = (I_1 \quad I_2 \quad I_3 \quad I_4 \quad I_5 \quad I_6 \quad I_7) \begin{pmatrix} P_{11} & \cdots & P_{17} \\ \vdots & \ddots & \vdots \\ P_{71} & \cdots & P_{77} \end{pmatrix}$$

$$= (O_1 \quad O_2 \quad O_3 \quad O_4 \quad O_5 \quad O_6 \quad O_7)$$

V_I measures the fraction of gas produced by the firm in each of the seven gas regions in North America.[16] M_P is an input-output matrix containing the fractions of gas capacity flows among regions. For example, P_{ij} is the fraction of gas capacity flow from region *i* to region *j*.[17] To compute P_{ij}, we collect annual data from the US Energy Information Administration (EIA) on the gas pipeline infrastructure capacity flows among regions (see Figure 2 for an illustration). Specifically, we collect information on how much gas can be potentially transported from one region to each one of the other six regions. Appendix C provides an example with the input-output matrix for 2008. $P_{13} = 0.16$ means that the production of gas in the region of Canada (region 1) that might potentially go to the Midwest (region 3) is 16%.

The degree of competition for each pair of firms is measured by computing the cosine similarity of the two output vectors V_O. The cosine similarity is a measure of similarity between two vectors of an inner product space that measures the cosine of the angle between them, i.e. $\cos\varphi = \frac{V1.V2}{\|V1\| * \|V2\|}$ (where v1 and v2 are the vectors V_O corresponding to the first and second firms in the pair). This measure ranges from 0 to 1. A score of 0 means that the vectors are orthogonal (i.e. at a 90º angle), and so the two firms do not share any end-market.

[16] Since no data are available on the fraction of gas produced by our sample firms in each region, we assume that all the production is done in the region where the firm headquarters are located. A casual inspection of our sample shows that this assumption is reasonable, especially for the medium and small firms that comprise most of our sample. To illustrate this point, Appendix B provides examples of firms that disclose information on the location of gas properties. As shown in the appendix, it is not uncommon that O&G firms only extract gas in the region in which they are headquartered.

[17] Note that this matrix is not symmetric and the amounts in a given column do not necessarily add up to 1. However, the amounts in a given row do add up to 1 unless the region exports to Mexico.

A score of 1 means that the vectors have the same orientation (i.e. at a 0º angle), so they are either identical or their values differ by a constant factor. In other words, the two companies share the same end-markets.

One possible concern about measuring end-market overlap by the cosine similarity of the vectors V_O is that this measure assigns the same value to a pair of undiversified firms (i.e., firms operating in a single end-market) than to a pair of diversified firms (i.e., firms operating several end-markets). To check that our inferences are not sensitive to a potential effect of diversification on the degree of competition, we compute a variant of the prior measure of the degree competition. Specifically, we compute the scalar product of the vectors V_O for each pair of firms. This statistic also has a lower bound of 0 and an upper bound of 1. While cosine similarity is a standardized measure (the scalar product of vectors is scaled by the magnitude of the vectors), this alternative measure is unstandardized and thus produces higher values when the two vectors have a larger magnitude (or modulus). To illustrate, assuming only two regions the scalar product of (1, 0) and (1, 0) (i.e., two undiversified firms operating only in one market) is larger than that of (0.5, 0.5) and (0.5, 0.5) (i.e., two diversified firms operating in the two markets). This is equivalent to assigning a higher value to the cases with less market diversification.

Table 1 presents the descriptive statistics of these two measures. The cosine similarity has an average of 0.56 and substantial variation (standard deviation of 0.43). The scalar product exhibits substantial variation, as both measures are highly correlated.

Table 3 presents the results of estimating equation (1) partitioning the sample of firm-peer-disclosure observations into pairs with a higher/lower degree of competition. As shown in Table 3, Panel A, the negative association between *Δ_Reserves_Peer* and *Abn_Return* is more pronounced in the subsample of firms with a higher degree of competition, and an F-

test shows that this more pronounced pattern is statistically significant. Additionally, in Table 3, Panel B, the coefficient on Δ_*Reserves_Peer* is more positive and more significant in the subsample of firms with a higher degree of competition, and an F-test shows that the difference across subsamples is statistically significant. For both panels, the pattern documented is not sensitive to partitioning the samples assuming either a deterministic or a probabilistic approach.

4. The Introduction of Fracking

The evidence in the prior section is consistent with the notion that peer's disclosed reserves contain information on industry supply rather than demand, and that firms react to increases in peer's reserves by increasing investment. To further corroborate that reserves disclosures are informative about the competitive environment, we next exploit the introduction of a technological change during our sample period that substantially changed the dynamics of competition in the natural gas market.

In recent years, the North American O&G industry has experienced the introduction of a new technique commonly known as "Hydraulic Fracturing" or simply "Fracking". The pairing of horizontal drilling with hydraulic fracturing brought on significant quantities of natural gas (shale gas) from previously low-producing gas deposits in North America. Between 2007 and 2013 the gas production in the US increased by 26% with shale gas accounting for 40% of all production compared with less than 5% at the beginning of 2000.

As a consequence of the discovery and development of new natural gas resources in the North American regions natural gas prices dropped significantly (in the US the price of natural gas decreased as much as 45% from 2007 to 2013). In contrast, although crude oil production in the US rose by 45% in the same period, oil prices followed a very different

path. This differential effect on oil prices is due to the global nature of the oil market (the US only produces around 10% of the world's total) and thus price levels are less sensitive to variations in the North American supply (Source: US Energy Department). In contrast, because of transportation constraints, the market for natural gas is fragmented and sensitive to local changes in supply. Thus, while the introduction of fracking significantly increased the competitive pressure in the natural gas market, the effect of this technology on the oil market was much less pronounced.

Figure 3 illustrates the decoupling of the natural gas and oil prices traditional behavior since the shale gas revolution in 2007. As shown in the figure, while the correlation between natural gas and oil prices was very high prior to 2007, the co-movement decreases significantly after that year. Although the market volatility that resulted from the financial crisis in 2007 initially masked this change in price structure, from 2008 this new pattern emerges more clearly.

We exploit the differential increase in competitive pressure induced by fracking to identify whether peers' reserves disclosures contain information about industry competition. To do so we test whether firms' reaction to peers' reserves disclosures is more pronounced after the introduction of the new technology and when peers are more active in the gas market. Specifically, we interact *Δ_Reserves_Peer* with *Post_Fracking*, an indicator variable that equals one if the peer's O&G information is disclosed in the year 2007 or later, and zero otherwise. Because the effect of fracking is concentrated in the natural gas market, we partition the sample based on *Gas_producer*, defined as one if the peer firm's production of natural gas is greater than 50% of its total production, and zero otherwise. To corroborate that the effect of fracking is indeed related to competition, we further partition our sample by the

degree of competition (as measured in the prior section) between each pair of firms and interact *Δ_Reserves_Peer*, *Gas_producer*, and *Post_Fracking*.

Tables 4 and 5 present the results of analyzing the effect of the introduction of fracking in firms' responses to peers' disclosures. As shown in Panels A of these tables, the pattern documented in Table 2 is concentrated among firms with relatively higher gas production and after the introduction of the fracking technology. Panels B of both tables suggest that this pattern is indeed related to the degree of competition between each pair of firms. Overall, the evidence in Tables 4 and 5 is consistent with the notion that larger increases in peers' reserves are associated with lower returns and higher investment when the competition between the two firms exogenously increases.

5. Tightening Reserves Disclosure Rules

The evidence in prior sections suggest that O&G reserves disclosures convey information about industry competition. In this section we explore whether disclosure rules significantly influence firms' reaction to peers' reserves disclosures. That is, we test whether O&G reserves disclosure rules have real effects by influencing peer firms' investment decisions. To do so, we exploit changes in the mandatory disclosure rules of O&G reserves during our sample period.

In Canada, the Alberta Securities Commission (ASC) introduced the National Instrument 51-101 "Standards for Oil and Gas Activities" (NI 51-101) in 2003. The U.S. Securities and Exchange Commission (SEC) introduced a similar regulation, "Modernization of Oil and Gas Reporting" (MOGR), in 2009. The intended purpose of these regulatory changes was to reduce ambiguity and inconsistency in reserves disclosure rules. Both regulations tightened the rules governing oil and gas reserve disclosures by introducing

quantitative, bright-line probability thresholds in the definition of reserves amounts.[18] In addition to enhanced disclosure requirements, NI 51-101 and MOGR introduced other requirements related to monitoring such as the establishment of reserves committees, the auditing of reserve disclosures by an external evaluator and the disclosure of the evaluator's identity, the person in charge of auditing reserve amounts, and the disclosure of the processes used to produce the reserves estimation, and a specific declaration of endorsement of the reserve disclosures by managers and directors.

Anecdotal evidence suggests that these regulatory changes had a material effect on the informativeness of North-American O&G firms' reserves disclosures. For example, Ryder Scott Petroleum Consultants (the second largest US O&G evaluator) referred to these regulatory changes as "the most sweeping changes in petroleum reserves reporting rules in more than 30 years." The descriptive analysis of annual restatements of O&G reserves in Figure 4 suggests that the upcoming regulation elicited a significant reaction among O&G firms. Figures 4a and 4b plot means and medians of O&G reserves *Revisions* over the sample period for Canada and the US. In Canada, Figure 4a reveals an abnormal accumulation of negative revisions (left axis, in %) in the year before the implementation of NI 51-101 (i.e., 2003). Figure 4b shows a similar pattern in the US. Again, an abnormally high amount of negative revisions occur in 2008 (the year before the introduction of MOGR).[19] Consistent

[18] Before 2003, Canadian securities regulators defined proved reserves as "those reserves that can be estimated with a *high degree of certainty* to be recoverable." That is, an amount such that "it is *likely* that the actual remaining quantities recovered will exceed the estimated proved reserves." In contrast, NI 51-101 tightened the definition of proved reserves to "those reserves that have a probability of being produced of at least 90%." Similarly, before 2009, US regulation defined proved reserves as "the estimated quantities of crude oil, natural gas, and natural gas liquids, which geological and engineering data demonstrate with *reasonable certainty* to be recoverable from known reservoirs." As did NI 51-101, the SEC rule adopted a definition of proved reserves consistent with the Canadian Oil and Gas Evaluation Handbook (COGEH). MOGR defined the term "reasonable certainty" by stating that "there should be at least a 90% probability that the quantities actually recovered will equal or exceed the estimate."

[19] To interpret the accumulation of negative revisions shortly before the implementation of NI 51-101 and MOGR, we first note that negative revisions of proved reserves are relatively rare. Because proved reserves are

with these regulations having a first-order effect on those firms' reserves reporting practices, Badia et al. (2016) find that, in both countries, the reserve disclosures filed under the new regulations are associated with decreases in bid-ask spreads and are more closely related stock price changes.

To test the effect of NI 51-101 and MOGR on firms' response to peers' reserves disclosures, we interact *Δ_Reserves_Peer* with an indicator variable for whether the disclosing peer is subject to a tighter regulation. Specifically, *New_Rule* equals one if the peer firm is a Canadian firm and the date of reserves disclosure occurs after 2003 (that is, under NI 51-101), or if the peer firm is a US firm and the date of reserves disclosure occurs after 2009 (that is, under MOGR), and zero otherwise. Similar to prior tests, we partition the sample based on the degree of competition between each firm and the disclosing peer.

Table 6 presents the results. In Panel A, the interaction between *Δ_Reserves_Peer* and *New_Rule* is negative and significant only for the subsample of pairs with a higher level of competition. That is, firms' stock prices react more negatively to larger increases in peers' reserves disclosures after the tightening of disclosure rules in the foreign peer's country than to similar disclosures by domestic competitors or by foreign competitors before the regulatory change. Consistently, in Panel B, the interaction between *Δ_Reserves_Peer* and *New_Rule* is positive and significant only for the subsample of pairs with a higher level of competition. That is, after the tightening of disclosure rules in the foreign peer's country firms exhibit larger investment increases when peers disclosure larger reserves increases. In contrast, this effect is weaker when domestic peers make similar disclosures or when foreign peers make similar disclosures before the regulatory change.

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conservative estimates (i.e., proved reserves are defined as those with probability of being produced of 90%), the resolution of uncertainty about these reserves is usually favorable. Thus, revisions are typically positive.

Overall, the evidence in Table 6 suggests that reserves disclosure rules have real effects in the economy. To the extent that disclosure rules affect how firms' disclosures are used by peer firms, Table 6 documents a real externality of disclosure regulation. This evidence is important to understand the effect of tightening pre-existing mandatory disclosure of off-balance sheet information.

6. Additional Tests

6.1. Off versus On-Balance Sheet Disclosures

A remaining open question from prior tests is whether off-balance sheet reserves disclosures are more likely to convey information about competition than on-balance sheet amounts. As previously mentioned, the evidence in prior work seems to suggest that on-balance sheet information (most notably accounting earnings) convey information about industry-wide demand rather than on competition (i.e., industry supply). To reconcile our findings with prior literature on intra-industry information transfers, we repeat the tests in Table 3 including a measure of earnings news, *Δ_Earnings*, defined as the change in annual earnings expressed as a fraction of book value of equity at the beginning of the year.

Table 7 shows the results. In Panel A, the coefficient on *Δ_Earnings* is positive and significant, but only in the subsample of firm pairs with more overlap in end-markets. Consistent with prior literature, this evidence suggests that earnings are more likely to convey information about industry-wide demand. Being able to replicate the results from prior literature on this specific setting also mitigates the potential concern that our evidence reflects a specific feature of the O&G industry that might not generalize to other industries. While O&G reserves are especially important off-balance sheet disclosures and, therefore, their effect is potentially easier to detect than that of other off-balance sheet disclosures.

Nevertheless, we see no reason why forward-looking, non-financial disclosures in other industries could not be similarly used by competitors and market participants to understand the competitive landscape of the industry.

In contrast to Panel A, Panel B reports no significant association between *Δ_Reserves_Peer* and *CAPEX*. Moreover, the difference in the coefficients on *Δ_Reserves_Peer* between the subsamples with higher/lower end market overlap is insignificant. This evidence is not consistent with competitors using rival firms' earnings disclosures to make investment decisions (i.e., earnings disclosures having real effects), but it is consistent with accounting earnings conveying information about industry-wide demand.

Table 7 (Panels A and B) also shows that the coefficient on *Δ_Reserves_Peer* remains statistically significant when *Δ_Earnings* is included in the specification. This suggests that the informative effect of off-balance sheet information is incremental to that of on-balance sheet information and thus further mitigates the concern that our results could be confounded by other information simultaneously released by the firm. Overall, the evidence in Table 7 is consistent with the notion that the information contained in the earnings disclosures is confirmatory in nature (Ball and Shivakumar, 2008) and less relevant for competitors than off-balance sheet reserves disclosures.

6.2. Alternative Explanations

One possible concern about the results in prior sections is that our evidence could reflect group-wide shocks rather than disclosure spillovers. That is, the economic conditions determining the firm's disclosure decision also drive the observed effects for other firms. As explained by Leuz and Wysocki (2016), this concern is essentially a variant of the "reflection

problem" (Manski 1993). While this is a common concern in the empirical literature on externalities, the reflection problem cannot explain our results. Note that a common industry shock would generate a positive, rather than a negative correlation between *Abn_Return* and *Δ_Reserves_Peer*. Moreover, our tests include as a control the disclosing peer's abnormal return (*Abn_Return_Peer*), which captures the co-movement of stock prices. Finally, our results in Table 6 are hard to reconcile with the reflection problem. Note that any given O&G firm should not be more likely to experience a common shock with a foreign competitor rather than with a domestic competitor precisely after the change in disclosure rules in the competitor's country.

That said, we perform a battery of additional tests to further check that our inferences are not affected by potential industry shocks. First, in the model of Table 2, Panel A, we include as additional controls the fractional change in proved reserves disclosed by the firm prior to the peer's disclosure and the abnormal return within a (-1, +1) day-window around the firm's own reserves announcement. These variables further control for the potential correlation across O&G firms' reserves disclosures and the corresponding announcement returns. Second, in the model of Table 2, Panel B, we include the peer firm's CAPEX (measured contemporaneously to the dependent variable CAPEX) as an additional control variable. Third, we include year effects to capture year-specific market and/or industry conditions. Fourth, we also include two additional control variables aimed at capturing potentially confounding information on economic conditions in the O&G industry. *OilReturn* is the return of the oil index West Texas Intermediate (WTI) over the (−1, +1) day window around the announcement. *GasReturn* is the return of the gas index Henry Hub (HH) over the (−1, +1) day window around the announcement. Our inferences are robust to all these additional checks.

Another related and common concern in the investment literature is the difficulty to control for simultaneous changes in the firm's cost of capital and investment opportunity set (Leuz and Wysocki 2016). Again, the evidence in Table 6 helps alleviate this concern. Note that the pattern we document in Table 6 is related to a change in disclosure rules rather than to a change in the underlying economics of the sample firms. That is, it is not clear why a given O&G firm should be more likely to experience an increase in investment opportunities precisely when a foreign competitor discloses reserves after a change in disclosure rules in the competitor's country and not before the rules change and when a domestic peer discloses reserves.

That said, to confirm that our results are robust to the potential correlation of peer's disclosures with increases in firm's investment opportunities for the company in that year, we repeat our tests in Table 2, Panel A including firm-year fixed effects. This research design effectively tests whether the stock of a given firm in a given year (that is, holding the firm's investment opportunity constant) reacts more negatively to peer's reserves disclosures when the increase in reserves is larger. Our inferences do not change.

7. Conclusion

This paper studies the effect of forward-looking off-balance sheet disclosures on rival firms' valuation and investment decisions. We focus our analysis on the mandatory disclosure of oil and gas reserves, a setting in which off-balance sheet information is of particular importance to understand industry supply.

Using a comprehensive sample of Canadian and US O&G producers we find that larger increases in peers' O&G reserves are associated with *lower* announcement returns at rival firms. This result is in contrast with prior research finding *higher* stock price returns

when peers report larger increases in earnings. Perhaps even more interestingly, we also find that, consistent with peers' disclosures affecting managerial decision making, larger increases in peer reserves are accompanied by an *increase* in investment at rival firms.

We corroborate our results by exploiting three sources of institutional variation. First, the North-American pipeline infrastructure conditions the supply of natural gas (and thus competition in this market), but does not affect the supply of oil. We thus measure variation in the degree of competition of pairs of sample firms and find that firms' reaction to peers' reserves disclosures is more pronounced in the subsample of firms with a higher degree of competition.

Second, the introduction of the fracking technology substantially increased competitive pressure in the natural gas market. Consistently, we find that firms' reaction to peers' reserves disclosures is more pronounced among gas producers in the period after the instruction of fracking.

Third, O&G disclosure rules were modified in Canada and the US in a similar fashion, but at different points in time, thus providing an opportunity to test whether a tightening of reserves disclosure rules affects firms' reaction to peers' disclosures. We find that firms' reaction to peers' reserves disclosures is more pronounced when the disclosing peer is a foreign firm after the change in disclosure rules in the foreign country.

Overall, our evidence is consistent with the notion that peers use rivals' off-balance sheet disclosures when making investment decisions. To the extent that this phenomenon is affected by reserves disclosure rules, our paper provides evidence of real effects (in particular, real externalities) of disclosure regulation.

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Appendix A. Examples of O&G Reserve Disclosures

A.1. Example of O&G reserve disclosures under NI 51-101 (Canada)

	Light Crude Oil (Mbbls)			NGLs (Mbbls)			Sales Gas (Mmcf)			6:1 Oil Equivalent (Mboe)		
Factors	Proved	Probable	Proved Plus Probable	Proved	Probable	Proved Plus Probable	Proved	Probable	Proved Plus Probable	Proved	Probable	Proved Plus Probable
December 31, 2005	330	110	440	498	121	619	28,146	8,405	36,551	5,519	1,632	7,151
Acquisitions	366	121	487	101	26	127	5,170	1,780	6,950	1,329	444	1,772
Revisions	(25)	(104)	(129)	(42)	(7)	(49)	(1,445)	808	(637)	(308)	24	(284)
Discoveries	102	52	154	92	26	118	8,398	3,043	11,441	1,594	585	2,179
Extensions	223	261	484	76	18	94	7,864	1,115	8,979	1,610	465	2,075
Dispositions	(16)	(3)	(19)	(222)	(64)	(286)	(1,617)	(456)	(2,073)	(508)	(144)	(651)
Production	(172)	-	(172)	(102)	-	(102)	(8,541)	-	(8,541)	(1,698)	-	(1,698)
December 31, 2006	**808**	**437**	**1,245**	**401**	**120**	**521**	**37,975**	**14,695**	**52,670**	**7,538**	**3,006**	**10,544**

Notes:

i) "Oil (MBbls)" means "oil expressed in thousands of barrels." "NGL (MBbls)" means "natural gas liquids expressed in thousands of barrels of oil equivalent." "Gas (MMcf)" means "natural gas expressed in millions of cubic feet (ft^3)." "Mboe" means "thousands of barrels of oil equivalent." Barrel of Oil Equivalent (BOE) is a metric used to combine oil and natural gas reserves and production into a single measure. One BOE of natural gas reserves is equivalent to 6,000 cubic feet (ft^3). For example, in the last row the number of BOE of proved reserves, i.e., 7,538, is computed as 808 + 401 + 37,975/6 = 7,538.

i) "Proved" reserves are defined as the amount of reserves P10 such that P[$X \geq$ P10] = 90%, where X is the amount of petroleum (naturally occurring on or within the Earth's crust) that has been discovered and is deemed to be economically recoverable. "Proved plus probable" reserves are defined as the amount P50 such that P[$X \geq$ P50] = 50%.

Source: Storm Exploration Inc. Disclosure of O&G reserves corresponding to fiscal year 2006. Available at www.sedar.com

A.2. Example of O&G reserve disclosures under MOGR (US)

Year ended December 31, 2010	Gas MMcf	Oil MBbl	NGL MBbl	Total Bcfe
Proved reserves at beginning of period	**897,546**	**77,963**	**30,257**	**1,546.9**
Revisions of previous estimates	**66,679**	**(2,243)**	**2,434**	**67.8**
Purchases	**21,700**	**16,443**	**5,730**	**154.8**
Extensions and discoveries	**39,570**	**16,234**	**4,058**	**161.3**
Production	**(70,924)**	**(5,131)**	**(1,880)**	**(113.0)**
Sales	**(184)**	**(4)**	**2**	**(0.2)**
Proved reserves at end of period	**954,387**	**103,262**	**40,601**	**1,817.6**
Proved developed reserves at end of period	**786,292**	**72,030**	**28,809**	**1,391.3**
Proved undeveloped reserves at end of period	**168,095**	**31,232**	**11,792**	**426.2**

Notes:

i) "Gas MMcf" means "millions of cubic feet (ft^3) of gas." "Oil MBbl" means "thousands of barrels of oil." "NGL MBbl" means "natural gas liquids expressed in thousands of barrels of oil equivalent." "Total Bcfe" means "billions of cubic feet equivalent." Total Bcfe is computed based on Gas MMcf, Oil MBbl, and NGL MBbl taking into account that a Barrel of Oil Equivalent (BOE) is equivalent to 6,000 ft^3. For example, in the row "Proved reserves at the end of the period" the figure 1,817.6 is computed as [954,387 + 103,262*6 + 40,601*6] / 1,000 = 1,817.6.

ii) "Proved" reserves are defined as the amount of reserves P10 such that P[$X \geq$ P10] = 90%, where X is the amount of petroleum (naturally occurring on or within the Earth's crust) that has been discovered and is deemed to be economically recoverable. "Proved plus probable" reserves (defined as the amount P50 such that P[$X \geq$ P50] = 50%) are not disclosed.

Source: Energen Corporation. Disclosure of O&G reserves corresponding to fiscal year 2010. Available at http://www.sec.gov/edgar.shtml.

Appendix B. Examples of Geographic Location of Wells

Example 1: Bellamont Exploration Ltd. (Source: SEDAR)

Annual Information Form Filing Date: 04/27/2007
Headquarters: Alberta (Canada Region)

"*The following is a description of the oil and natural gas properties, plants, facilities and installations in which the Corporation has an interest and that are material to the Corporation's operations and activities. The production numbers stated refer to the Corporation's working interest share before deduction of Crown and freehold royalties.*

Peace River Arch, Alberta: The properties allocated a reserve value are located in the Cindy, Eaglesham, Hines Creek, Belloy, Saddle Hills/Valhalla and Whitelaw areas of Alberta, approximately 100 kilometers northeast of the city of Grande Prairie."

Example 2: Stata Energy Corporation (Source: EDGAR)

10-K Filing Date: 02/27/2008
Headquarters: Louisiana (Southwest Region).

"During 2007, 92% of our production was derived from Gulf of Mexico reservoirs, while the remaining portion of our production was derived from the Rocky Mountain Region which was sold in June of 2007. At December 31, 2007, all of our reserves were derived from Gulf of Mexico reservoirs"

Example 3: EQT Corporation (Source: EDGAR)

10-K Filing Date: 02/25/2005
Headquarters: Pennsylvania (Northeast Region).

"The Company's reserves are located entirely in the Appalachian Basin. (…) Drilling was concentrated within Equitable's core areas of southwest Virginia, southeast Kentucky and southern West Virginia."

Example 4: Northern Oil & Gas Company (Source: EDGAR)

10-K Filing Date: 03/16/2009
Headquarters: Montana (Midwest Region).

"We are a growth-oriented independent energy company engaged in the acquisition, exploration, exploitation and development of oil and natural gas properties, and have focused our activities primarily on projects based in the Rocky Mountain Region of the United States, specifically the Williston Basin (Montana, and North Dakota)"

Appendix C. Examples of Measuring the Degree of Competition of Pairs of Firms

This appendix illustrates the computation of our measures of the degree of competition. We present the computation of these measures for two pairs of firms in our sample. Bellamont Exploration (Bellamont), Stata Energy Corp. (Stata), and Northern Oil & Gas Company (Nothern O&G) are located in the regions of Canada, Southwest and Midwest, respectively. In what follows we compute the degree of competition of the pairs Bellamont-Stata, and Bellamont-Nothern O&G in 2008.

The 2008 input-output matrix (M_P) is the following:

	Canada	Central	Midwest	Northeast	Southeast	Southwest	Western
Canada	0.37	0.15	0.16	0.15	0.00	0.00	0.17
Central	0.00	0.68	0.23	0.00	0.00	0.05	0.04
Midwest	0.09	0.11	0.68	0.11	0.01	0.00	0.00
Northeast	0.01	0.00	0.04	0.93	0.02	0.00	0.00
Southeast	0.00	0.00	0.12	0.07	0.80	0.01	0.00
Southwest	0.00	0.11	0.00	0.00	0.30	0.49	0.07
Western	0.00	0.01	0.00	0.00	0.00	0.00	0.93

Source: US Energy Information Administration´s state-to-state capacity (http://www.eia.gov/naturalgas/data.cfm#pipelines), and Canadian National Energy Board (https://www.neb-one.gc.ca/nrg/sttstc/crdlndptrlmprdct/stt/stmtdprdctn-eng.html).

The fractions in each row of M_P add up to 1 (i.e., 100%). For example, a firm producing in Canada is expected to export 15% of the production to Central, 16% to Midwest, 15% to Northeast, 0% to Southeast and Southwest, 17% to Western and the remaining 37% stays in the same Canadian region. The rows of Southwest and Western regions do not sum 100% because they export some production to Mexico.

The input vector (V_I) of Bellamont has a first component equal one for the region of Canada and zero for the rest of the regions. When multiplied by the input-output transition matrix above (M_P), we obtain the output vector shown below (i.e. the first row of M_P).

$$V_O = V_I \, x \, M_P = (1 \quad 0 \quad 0 \quad 0 \quad 0 \quad 0 \quad 0) \begin{pmatrix} 0.37 & \cdots & 0.17 \\ \vdots & \ddots & \vdots \\ 0.00 & \cdots & 0.93 \end{pmatrix} = (0.37 \quad 0.15 \quad 0.16 \quad 0.15 \quad 0 \quad 0 \quad 0.17)$$

The input vector (V_I) of Stata and Northern O&G are computed similarly.

For each pair of vectors, the cosine similarity and the scalar product for each pair of vectors (i.e. our standardized and unstandardized measures of the degree of competition, respectively) are as follows:

	Canada	Central	Midwest	Northeast	Southeast	Southwest	Western		
Bellamont Exploration Ltd.	0.37	0.15	0.16	0.15	0.00	0.00	0.17	Cosine Similarity	0.10
Stata Energy Corp	0.00	0.11	0.00	0.00	0.30	0.49	0.07	Scalar Product	0.03

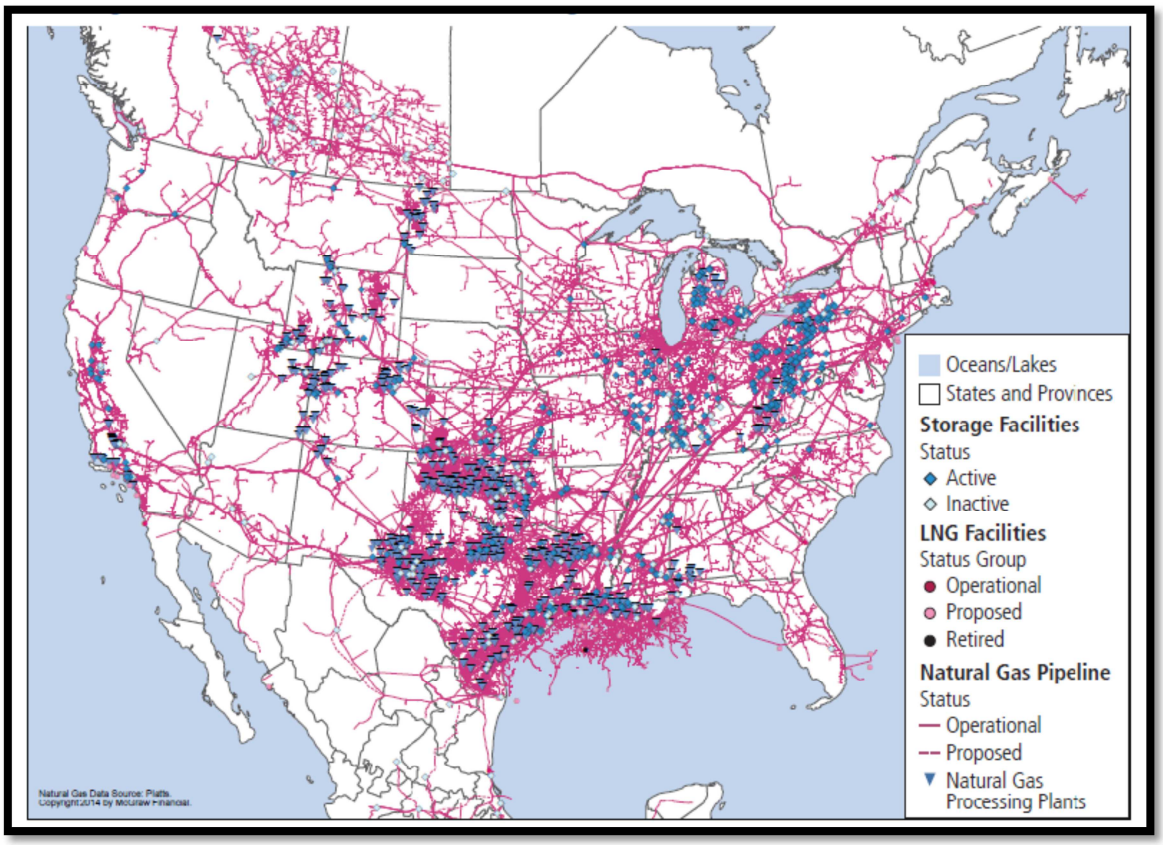
	Canada	Central	Midwest	Northeast	Southeast	Southwest	Western		
Bellamont Exploration Ltd.	0.37	0.15	0.16	0.15	0.00	0.00	0.17	Cosine Similarity	0.51
Northern Oil & Gas Company	0.09	0.11	0.68	0.11	0.01	0.00	0.00	Scalar Product	0.18

The cosine similarity and scalar products between Bellamont and Northern O&G (0.51, 0.18), are substantially higher than the same measures between Bellamont and Stata (0.10, 0.03). This suggests that Bellamont and Nothern O&G exhibit a higher degree of competition than Bellamont and Stata. These numbers reflect that, while Canada and the Southwest region are directly connected by the gas pipeline network, there is no direct pipeline connection between Canada and the Southwest region.

Appendix D. Variable Definitions

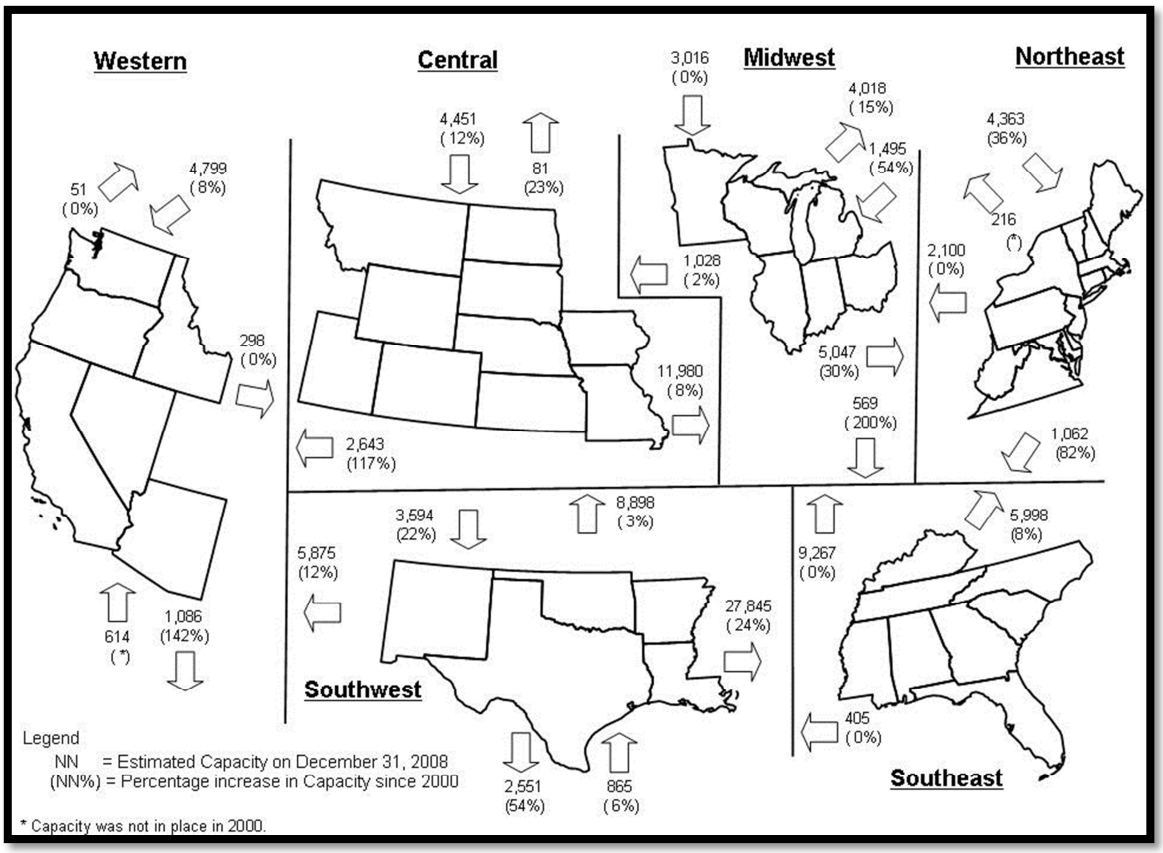
Abn_Ret	Market-adjusted compounded stock return over the (−1, +1) day window around each peer firm's annual release of information about O&G reserves (in %).
CAPEX	Capital Expenditures scaled by total assets (measured one year after the firm's disclosure date).
Δ_Reserves_Peer	Fractional change (with respect to prior year's disclosure) in the amount of proved reserves (in BOEs) disclosed by the peer firm.
Abn_Return_Peer	Peer firm's market-adjusted compounded stock return over the (−1, +1) day window around the peer firm's annual release of information about O&G reserves (in %).
Size	Logarithm of equity market value at fiscal year-end.
BM	Ratio of book value of equity to market value of equity at fiscal year-end.
Leverage	Total liabilities divided by total assets at fiscal year-end.
ROA	Return on assets computed as earnings before extraordinary items, scaled by total assets at fiscal year-end.
Past_Return	Stocks return compounded over the prior fiscal year (in %).
Post_Fracking	Indicator variable that equals one if the peer's O&G information is disclosed in the year 2007 or later, and zero otherwise.
Gas_Producer	Indicator variable that equals one if the peer firm's production of natural gas is greater than 50% of its total production, and zero otherwise.
New_Rule	Indicator variable that equals one if the peer firm is a Canadian firm and the date of reserves disclosure occurs after 2003 (that is, under the regulation "NI 51-101"), or if the peer firm is a US firm and the date of reserves disclosure occurs after 2009 (that is, under the regulation "Modernization of Oil and Gas Reserves"), and zero otherwise.
Δ_Earnings	Change in annual earnings before extraordinary items expressed as a fraction of book value of equity at the beginning of the year.

Figure 1. Natural Gas Infrastructure in the North American Market



This figure depicts the natural gas infrastructure system. As it can between in the graph, Canada's natural gas pipeline system is highly interconnected with the U.S. pipeline system. Source: US Energy Department (http://energy.gov/sites/prod/files/2015/06/f22/Appendix%20B-%20Natural%20Gas_1.pdf).

Figure 2. US Interregional Natural Gas Transmission Pipeline Capacity (in 2008)



This figure depicts the natural gas US regional capacity flow as of 2008 (million cubic feet per day, and in parentheses the increase of pipeline capacity from 2000). Source: US Energy Department (https://www.eia.gov/pub/oil_gas/natural_gas/analysis_publications/ngpipeline/RegiontoRegionMap.html)

Figure 3. Fracking Technology and O&G Prices

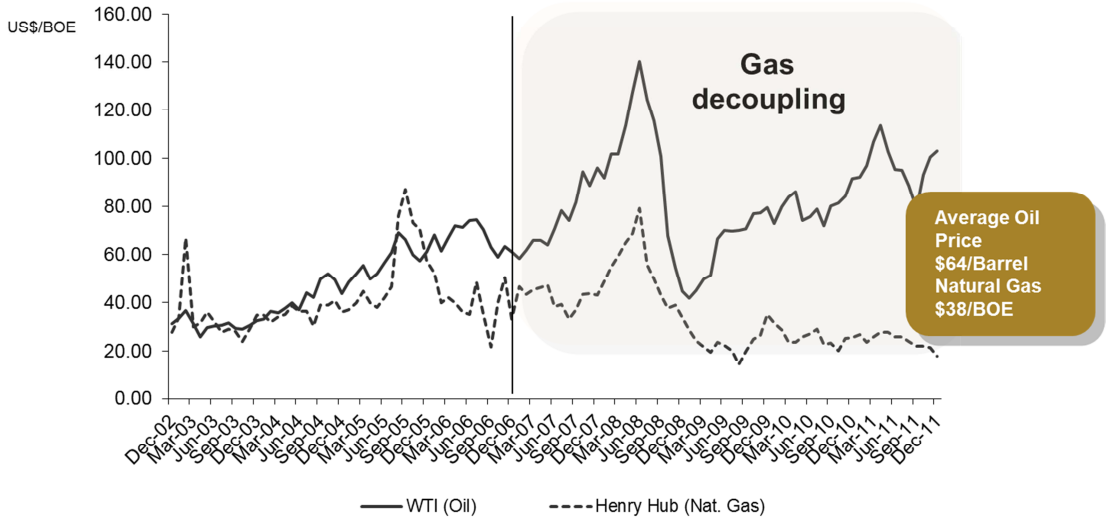


Figure 4 illustrates the decoupling of the natural gas and oil prices traditional behavior since the shale gas revolution in 2007. Before 2007, the correlation between natural gas and oil prices was very high. However, around 2007, significant technological shocks—such as the pairing of horizontal drilling with hydraulic fracturing—brought on significant quantities of natural gas from previously low-producing gas deposits in North America. This boom in unconventional energy and its uneven impact on both markets is the main reason for this price decoupling.

Figure 4. Changes in Reserves Disclosure Rules and Reserves Revisions

Figure 4.a. Canada

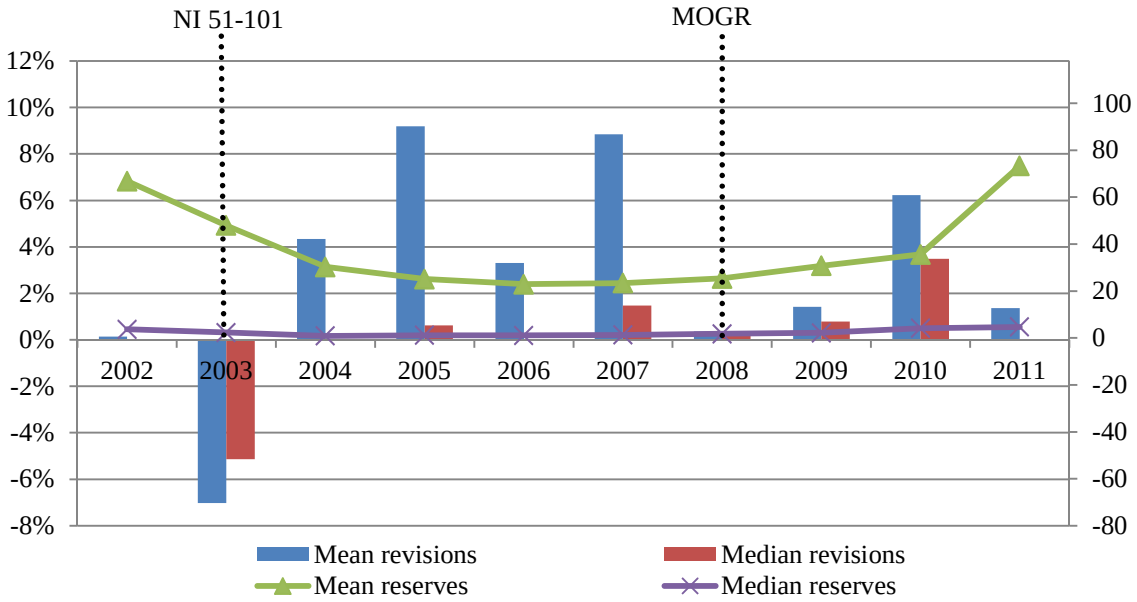


Figure 4a presents annual mean and median amounts of reserves revisions and proved reserves reported by Canadian O&G firms during the sample period. *Revisions* (left axis) is the amount of reserves revisions scaled by the amount of proved reserves corresponding to the revision, expressed in %. *Reserves* (right axis) is the reserve amounts classified as "proved" measured in millions of barrels of oil equivalent (BOE).

Figure 4.b. United States

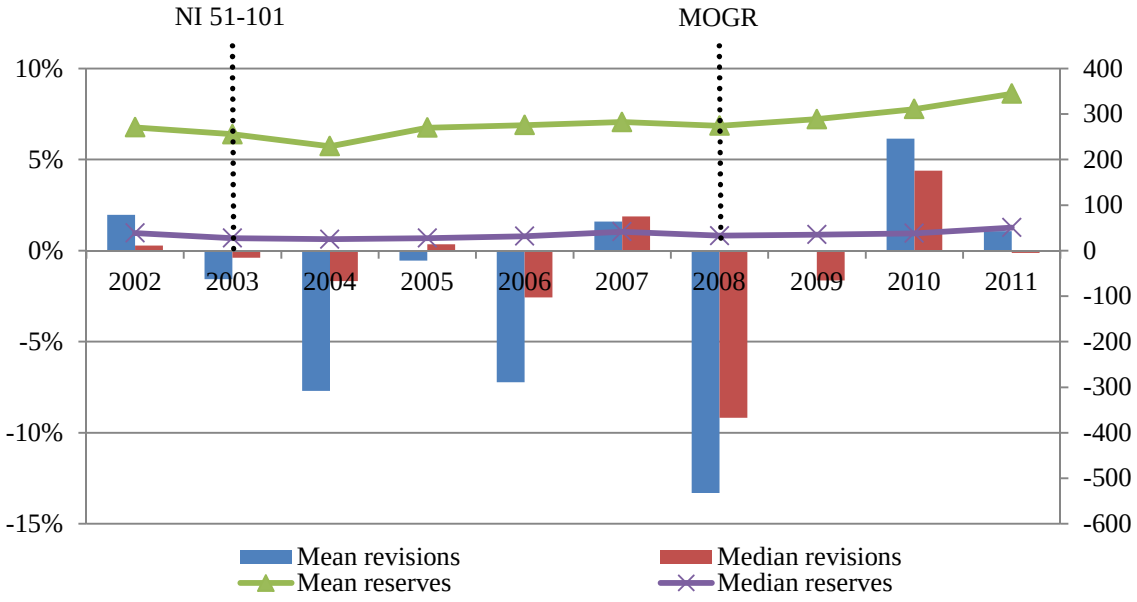


Figure 4b presents annual mean and median amounts of reserves revisions and proved reserves reported by US O&G firms during the sample period. *Revisions* (left axis) is the amount of reserves revisions scaled by the amount of proved reserves corresponding to the revision, expressed in %. *Reserves* (right axis) is the reserve amounts classified as "proved" measured in millions of barrels of oil equivalent (BOE).

Table 1. Descriptive Statistics

This table presents descriptive statistics for the samples of Canadian and US O&G firms. *Δ_Reserves* is the fractional change (with respect to prior year's disclosure) in the amount of proved reserves (in BOEs) disclosed by the firm. *Abn_Return* is the market-adjusted return of the firm compounded over the window (−1, +1) around the corresponding disclosure date, measured in %. *CAPEX* is capital expenditures scaled by total assets. The degree of competition is measured based on the geographic location and explained in detail in section 3.3 and Appendix C. See Appendix D for other variable definitions.

Variables	Mean	Median	St.dev.
At firm level (1,843 obs.):			
Fraction of gas production (in terms of BOE)	0.57	0.63	0.35
Δ_Reserves	0.64	0.09	2.66
Abn_Return (to own disclosures)	0.46	0.00	12.96
CAPEX	0.19	0.16	0.19
Size	5.00	5.12	2.44
BM	0.91	0.54	1.15
Past_Return	0.30	0.08	1.14
Leverage	0.24	0.22	0.21
ROA	0.04	0.00	0.98
At pair level (395,968 obs.):			
Abn_Return (to peer disclosures)	0.59	0.00	12.17
Measures of degree of competition:			
i) Standardized	0.56	0.43	0.42
ii) Unstandardized	0.16	0.17	0.12

Table 2. Firms' Reaction to Peers' O&G Disclosures

Panel A analyzes the stock price reaction to peer firms' releases of information about O&G reserves. Panel B analyzes investment decisions around peer firms' releases of information about O&G reserves. In Panel A, the dependent variable, *Abn_Return*, is the market-adjusted stock return in the (−1, +1) window around each peer's disclosure date. In Panel B, the dependent variable, *CAPEX*, is capital expenditures scaled by total assets measured one year after the firm's disclosure date. *Δ_Reserves_Peer* is the fractional change (with respect to prior year's disclosure) in the amount of proved reserves (in BOEs) disclosed by the peer firm. See Appendix D for other variable definitions. Standard errors are double-clustered by firm and disclosure date. *, ** and *** denote statistical significance at the 10%, 5% and 1% (two-tail) levels, respectively.

Panel A. Stock price reaction

	Dependent variable: *Abn_Return*		
Independent variables:	(1)	(2)	(3)
Δ_Reserves_Peer	−0.09***	−0.09***	−0.08***
	(−5.85)	(−5.69)	(−5.40)
Abn_Return_Peer		0.03***	0.03***
		(8.20)	(7.78)
Size			−0.38***
			(−3.23)
BM			0.30**
			(2.35)
Past_Return			−0.09
			(−1.32)
Firm-Peer Fixed Effects	YES	YES	YES
R^2	0.27	0.27	0.27
N	395,968	395,968	395,968

Table 2. Firms' Reaction to Peers' O&G Disclosures (continued)

Panel B. Investment Decisions

	Dependent variable: *CAPEX*		
Independent variables:	(1)	(2)	(3)
Δ_Reserves_Peer	0.41***	0.41***	0.29***
	(12.45)	(12.46)	(9.46)
Abn_Return_Peer		−0.001	0.00
		(−0.37)	(1.51)
Size			−2.38***
			(−2.66)
BM			−4.21***
			(−6.74)
Past_Return			0.66
			(1.38)
Leverage			−0.28***
			(−6.65)
ROA			2.81**
			(2.14)
Firm-Peer Fixed Effects	YES	YES	YES
R^2	0.47	0.47	0.53
N	395,968	395,968	395,968

Table 3. Partitioning by the Degree of Competition

This table reports results of estimating the stock price reaction and investment decisions around peer firms' releases of information about O&G reserves partitioning the sample based on the degree of competition between the firm and the disclosing peer. *High (Low)* are above (below) median values of the measure of the degree of competition. The two measures of degree of competition between pairs of firms are defined in section 3.3 and illustrated in Appendix C. The rest of the variables are defined in Appendix D. Panel A analyzes the stock price reaction to peer firms' releases of information about O&G reserves. Panel B analyzes investment decisions around peer firms' releases of information about O&G reserves. Standard errors are double-clustered by firm and disclosure date. *, ** and *** denote statistical significance at the 10%, 5% and 1% (two-tail) levels, respectively.

Panel A. Stock price reaction

	Dependent variable: *Abn_Return*			
	Standardized measure of the degree of competition		Unstandardized measure of the degree of competition	
Independent variables:	High	Low	High	Low
Δ_Reserves_Peer	−0.10***	−0.06***	−0.10***	−0.06***
	(−4.80)	(−3.65)	(−4.54)	(−4.00)
Controls	YES	YES	YES	YES
Firm-Peer Fixed Effects	YES	YES	YES	YES
R^2	0.30	0.24	0.30	0.24
N	200,082	195,886	192,187	203,781

Panel B. Investment Decisions

	Dependent variable: *CAPEX*			
	Standardized measure of the degree of competition		Unstandardized measure of the degree of competition	
Independent variables:	High	Low	High	Low
Δ_Reserves_Peer	0.36***	0.20***	0.36***	0.22***
	(9.21)	(5.75)	(9.19)	(6.26)
Controls	YES	YES	YES	YES
Firm-Peer Fixed Effects	YES	YES	YES	YES
R^2	0.53	0.53	0.52	0.52
N	200,082	195,886	192,187	203,781

Note: All the differences between subsamples are statistically significant

Table 4. Introduction of Fracking - Stock Price Reaction to Peers' Disclosures

This table analyzes stock price reactions to peer firms' releases of information about O&G reserves around the introduction of the fracking technology for extraction of natural gas. In Panel A, the sample is partitioned based on whether the disclosing peer is mainly a gas/oil producer (i.e., more than 50% of the firm's production is gas/oil). In Panel B, the sample is partitioned based on the degree of competition between the firm and the disclosing peer. *High (Low)* are above (below) median values of the measure of the degree of competition. The degree of competition is measured based on the geographic location (standardized measure) and explained in detail in section 3.3 and Appendix C. *Post_Fracking* equals one if the peer's disclosure is in year 2007 or later. In Panel B, *Gas_Producer* equals one if more than 50% of the peer firm's production is gas. The rest of the variables are defined in Appendix D. Standard errors are double-clustered by firm and disclosure date. *, ** and *** denote statistical significance at the 10%, 5% and 1% (two-tail) levels, respectively.

Panel A. Partitioning by Gas Production

	Dependent variable: *Abn_Return*	
Independent variables:	Peer is mainly a gas producer	Peer is mainly an oil producer
*Δ_Reserves_Peer*Post_Fracking*	−0.14***	0.03
	(−4.90)	(0.73)
Δ_Reserves_Peer	−0.02	−0.04
	(−1.03)	(−1.39)
Post_Fracking	0.25**	0.41***
	(2.18)	(3.13)
Controls	YES	YES
Firm-Peer Fixed Effects	YES	YES
R^2	0.27	0.30
N	232,246	163,722

Table 4. Introduction of Fracking - Stock Price Reaction to Peers' Disclosures (continued)

Panel B. Partitioning by Degree of Competition

	Dependent variable: *Abn_Return*	
Independent variables:	High degree of competition	Low degree of competition
*Δ_Reserves_Peer*Gas_Producer*Post_Fracking*	−0.17***	−0.09**
	(−3.46)	(−2.04)
*Δ_Reserves_Peer*Gas_Producer*	0.04	−0.02
	(0.99)	(−0.53)
*Δ_Reserves_Peer*Post_Fracking*	0.02	0.01
	(0.53)	(0.34)
*Gas_Producer*Post_Fracking*	−0.24	0.18*
	(−1.50)	(1.64)
Δ_Reserves_Peer	−0.07*	−0.02
	(−1.74)	(−0.87)
Gas_Producer	0.26**	0.28***
	(2.01)	(3.24)
Post_Fracking	0.64***	0.07
	(2.88)	(0.54)
Controls	YES	YES
Firm-Peer Fixed Effects	YES	YES
R^2	0.30	0.24
N	200,082	195,886

Table 5. Introduction of Fracking - Investment Decisions

This table analyzes firms' investment decisions around peer firms' releases of information about O&G reserves around the introduction of the fracking technology for extraction of natural gas. In Panel A, the sample is partitioned based on whether the disclosing peer is mainly a gas/oil producer (i.e., more than 50% of the firm's production is gas/oil). In Panel B, the sample is partitioned based on the degree of competition between the firm and the disclosing peer. *High (Low)* are above (below) median values of the measure of the degree of competition. The degree of competition is measured based on the geographic location (standardized measure) and explained in detail in section 3.3 and Appendix C. *Post_Fracking* equals one if the peer's disclosure is in year 2007 or later. In Panel B, *Gas_Producer* equals one if more than 50% of the peer firm's production is gas. The rest of the variables are defined in Appendix D. Standard errors are double-clustered by firm and disclosure date. *, ** and *** denote statistical significance at the 10%, 5% and 1% (two-tail) levels, respectively.

Panel A. Partitioning by Gas Production

	Dependent variable: *CAPEX*	
Independent variables:	Peer is mainly a gas producer	Peer is mainly an oil producer
*Δ_Reserves_Peer*Post_Fracking*	0.40***	0.03
	(7.05)	(0.66)
Δ_Reserves_Peer	0.02	0.14***
	(0.44)	(3.57)
Post_Fracking	−5.65***	−5.15***
	(−5.19)	(−4.75)
Controls	YES	YES
Firm-Peer Fixed Effects	YES	YES
R^2	0.55	0.56
N	232,246	163,722

Table 5. Introduction of Fracking - Investment Decisions (continued)

Panel B. Partitioning by Degree of Competition

Independent variables:	Dependent variable: *CAPEX*	
	High degree of competition	Low degree of competition
*Δ_Reserves_Peer*Gas_Producer*Post_Fracking*	0.39***	0.14**
	(5.33)	(2.20)
*Δ_Reserves_Peer*Gas_Producer*	0.04	−0.13***
	(0.84)	(−3.08)
*Δ_Reserves_Peer*Post_Fracking*	−0.04	0.27***
	(−0.74)	(3.34)
*Gas_Producer*Post_Fracking*	0.36**	−0.59***
	(2.21)	(−3.90)
Δ_Reserves_Peer	0.11**	0.00
	(2.43)	(0.01)
Gas_Producer	0.44**	0.48***
	(2.14)	(3.32)
Post_Fracking	−7.21***	−4.04***
	(−5.62)	(−3.90)
Controls	YES	YES
Firm-Peer Fixed Effects	YES	YES
R^2	0.55	0.54
N	200,082	195,886

Table 6. Tightening Rules on Reserves Disclosure

This table analyzes the effect of tightening reserves disclosure rules on firms' reaction to peer firms' releases of information about O&G reserves. For Canadian peer firms, *New_Rule* equals one if the date of reserves disclosure occurs after 2003 (that is, under the regulation "NI 51-101"), and zero otherwise. For US peer firms, *New_Rule* equals one if the date of reserves disclosure occurs after 2009 (that is, under the regulation "Modernization of Oil and Gas Reserves"), and zero otherwise. *High (Low)* are above (below) median values of the measure of the degree of competition. The degree of competition is measured based on the geographic location (standardized measure) and explained in detail in section 3.3 and Appendix C. Panel A analyzes stock market reactions to peers' reserves disclosures. Panel B analyzes firms' investment decisions around peers' reserves disclosures. Standard errors are double-clustered by firm and disclosure date. *, ** and *** denote statistical significance at the 10%, 5% and 1% (two-tail) levels, respectively.

Panel A. Stock Price Reaction

	Dependent variable: *Abn_Return*	
Independent variables:	High degree of competition	Low degree of competition
*Δ_Reserves_Peer*New_Rule*	−0.07***	0.06*
	(−2.12)	(1.95)
Δ_Reserves_Peer	−0.04	−0.10***
	(−1.55)	(−3.11)
New_Rule	1.16	0.52*
	(5.91)	(1.68)
Controls	YES	YES
Firm-Peer Fixed Effects	YES	YES
R^2	0.30	0.24
N	200,082	195,886

Panel B. Investment Decisions

	Dependent variable: *CAPEX*	
Independent variables:	High degree of competition	Low degree of competition
*Δ_Reserves_Peer*New_Rule*	0.16*	0.10
	(1.93)	(1.50)
Δ_Reserves_Peer	0.21***	0.15***
	(3.01)	(2.62)
New_Rule	−4.54	−9.21*
	(−4.25)	(−7.49)
Controls	YES	YES
Firm-Peer Fixed Effects	YES	YES
R^2	0.54	0.56
N	200,082	195,886

Table 7. Off versus On-Balance Sheet Peer Information

This table reports results of estimating the stock price reaction to peer firms' releases of Off versus On-Balance Sheet information about O&G reserves. *Δ_Reserves_Peer* is the fractional change (with respect to prior year's disclosure) in the amount of proved reserves (in BOEs) disclosed by the peer firm. *Δ_Earnings_Peer* is the change in earnings disclosed by the peer firm scaled by book value of equity. *High (Low)* are above (below) median values of the measure of the degree of competition. The degree of competition is measured based on the geographic location (standardized measure) and explained in detail in section 3.3 and Appendix C. See Appendix D for other variable definitions. Standard errors are double-clustered by firm and disclosure date. *, ** and *** denote statistical significance at the 10%, 5% and 1% (two-tail) levels, respectively.

Panel A. Stock Price Reaction

	Dependent variable: *Abn_Return*	
Independent variables:	High degree of competition	Low degree of competition
Δ_Reserves_Peer	−0.10***	−0.05***
	(−4.86)	(−3.56)
Δ_Earnings_Peer	0.16***	0.04
	(3.12)	(0.78)
Controls	YES	YES
Firm-Peer Fixed Effects	YES	YES
R^2	0.30	0.24
N	200,082	195,886

Panel B. Investment Decisions

	Dependent variable: *CAPEX*	
Independent variables:	High degree of competition	Low degree of competition
Δ_Reserves_Peer	0.36***	0.21***
	(9.26)	(5.73)
Δ_Earnings_Peer	0.11	0.19
	(1.22)	(1.57)
Controls	YES	YES
Firm-Peer Fixed Effects	YES	YES
R^2	0.53	0.53
N	200,082	195,886