DISCUSSION PAPER SERIES

DP12152

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FINANCIAL ECONOMICS

ISSN 0265-8003

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Discussion Paper DP12152
Published 17 July 2017
Submitted 17 July 2017

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Abstract

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JEL Classification: M41

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

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Acknowledgements

Market-wide Effects of Off-Balance Sheet Disclosures: Evidence from the Oil and Gas Industry

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November 2016

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We thank Pietro Bonetti, Richard McVeel, Panos Patatoukas (discussant), Peter Pope, Nemit Shroff and participants at the 2016 London School of Economics-Manchester Business School Conference and the 2016 UIC Conference for helpful comments and suggestions. We also thank Wanyi Chen, Tian Fu, Shisheng Jiang, Lichao Liu, Colin McGee, Du Nguyen, Joaquín Peris, Elie Toubiana, and Javier Sánchez Vázquez de Parga for excellent research assistance. We are grateful to The CanOils Database Ltd. for giving us access to its database and thank Jonathan Moore and Tracey Nabe for their continued help throughout this study. We thank Nathan Hedley and his team for kindly giving us access to the Evaluate Energy database and for their technical support. We benefited from conversations with industry practitioners and regulators. Specifically, we are indebted to John Lee (SEC Academic Engineering Fellow); Brian Banderk, David Elliot, and Carrie Nermo (Alberta Securities Commission); Gary Finnis (partner at Sproule Associates Ltd.); Douglas Isaac and Jim Saloman (partners at PriceWatehouseCoopers). Gaizka Ormazabal thanks the Marie Curie and Ramon y Cajal Fellowships. Marc Badia and Gaizka Ormazabal acknowledge financial contributions from the Spanish Ministry of Science and Innovation, grants ECO2010-19314 and ECO2011-29533. Miguel Duro acknowledges support from Columbia University CIBER.

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ABSTRACT

This paper studies the spillover effects of firms' off-balance sheet disclosures. We focus our analysis on the mandatory disclosure of oil and gas (O&G) reserves, a setting in which off-balance sheet information is particularly important to understand industry competition. Using a comprehensive sample of Canadian and US O&G producers we document two novel results. First, in contrast to prior research on the informational effect of peers' earnings announcements, we find evidence that firms' exhibit *lower* stock returns when their peers announce more positive news about O&G reserves. Second, consistent with peers' disclosures affecting managerial decision making, we document that larger increases in peers' reserves are accompanied by an *increase* in firms' investment. We corroborate our results by exploiting three sources of institutional variation. First, the North-American pipeline infrastructure constrains the supply of natural gas, and thus competition in the gas market, but not 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, albeit at different points in time. Overall, our evidence suggests that off-balance sheet disclosures have substantial market-wide effects in the form of both financial and real externalities.

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1. Introduction

Designing socially efficient disclosure regulation requires an understanding of the potential informational externalities associated with the mandated disclosures. However, despite being central to the economic justification of regulation, there is a paucity of evidence on market-wide effects from regulation, especially on externalities (Beyer et al., 2010; Leuz and Wysocki, 2016). This paper contributes to the understanding of market-wide effects of financial reporting by examining the effect of peers' off-balance sheet disclosures on market valuations and real investment decisions.

To examine the effect of peers' off-balance sheet information, we focus on the mandatory disclosure of oil and gas (O&G) reserves by North-American-listed firms. In both Canada and the US, O&G firms are required to disclose their proved reserves, which are defined as the "total amount of the firm's O&G reserves with at least a 90% probability of being actually recovered" (CSA, 2003; SEC, 2009). Appendix A provides examples of O&G reserves disclosures in Canada and the US.

Several considerations suggest that this is a particularly powerful setting to address our research question. First, O&G reserves are the primary non-financial operating assets of O&G firms and thus off-balance sheet disclosures of special importance. Indeed, survey-based evidence suggests that market participants often consider O&G reserves disclosures more relevant for valuation purposes than on-balance sheet information.[1] Second, proved reserves are a forward-looking measure of O&G firms' supply capacity. Proved reserves are

[1] In 2007, as part of the Extractive Activities research project, the IASB ran a user survey to understand the information needs when analyzing minerals and O&G companies. The responses from the surveyed financial analysts indicated that the primary source of information they relied on when analyzing extractive activities is presented in the disclosures or other reporting rather than in the financial statements. http://www.ifrs.org/Meetings/MeetingDocs/IASB/2008/September/19th%20-%20Board/Extract-0809-AP15A-obs.pdf

not only disclosed in barrels, but also in dollars, as the present value of the expected cash flows generated by the production of O&G reserves. The forward-looking nature of this information is important given the long lead times on O&G extraction projects. Third, as explained below in more detail, the rich sources of institutional variation in this setting offer unique opportunities for empirical identification.

We conjecture that peers' disclosures of O&G reserves can generate market-wide externalities by providing relevant information to investors and managers about industry competition. In a sector where companies are typically price takers, news about proved reserves likely convey information about industry supply. 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 geopolitical analyses, knowledge regarding future O&G supply is likely determined by firm-specific information such as variation in O&G reserves.

Further, the competitive dynamics of the O&G industry crucially depends on the discovery and acquisition of reserves. The importance of learning about peers' reserves is illustrated by the familiar movie "There Will Be Blood". Based on a 1924 Congressional hearing, the script alludes to competitive considerations poignantly described by the following quote: "If you have a milkshake and I have a milkshake and I have a straw and my straw reaches across the room and starts to drink your milkshake. I drink your milkshake! I drink it up!" This quote suggests a first mover advantage among firms drilling in the same play because underground wells are connected.[2] If the firm already owns properties in the same play as the peer disclosing an increase in reserves, the firm could face either higher extraction costs (reaching the O&G deposit will require drilling deeper) or a reduction in the

[2] A play is a group of O&G fields in the same region that share common geological characteristics.

expected size of the O&G deposits available to the firm. But even if the firm does not own properties in that play (but might consider to do so), an increase in peers' O&G reserves could reduce the firm's growth opportunities due to the finite nature of O&G resources and/or higher acquisition costs (an increase in the price of the land).[3]

Theoretical research formalizes the above intuition. For example, Darrough (1993) models how two rival firms' disclosure and real operating decisions are codetermined, but vary with the type of product market competition. While empirically challenging to categorize industries (Kedia, 2006), competition in the O&G industry can be theoretically characterized by a Cournot model where firms commit to higher investments before choosing price (Kreps and Scheinkman, 1983). Under the assumptions leading to Cournot competition, prior analytical research (e.g., Hwang and Kirby, 2000; Vives, 2000) predicts that mandatory firm disclosures have an effect on competitors' behavior.

However, it is also plausible that peers' O&G reserves information is of little use for investors and/or managers to understand industry competition. Firms could manipulate reserves disclosures to manage investors' expectations or to limit those disclosures' informational value to rivals.[4] Estimations of reserve quantities could also be unreliable because of the high uncertainty involved in the O&G production activity or because of deficiencies in estimation models and disclosure rules. But even if reliable, peers' off-balance sheet disclosures might not be incrementally informative relative to their on-balance sheet figures. Furthermore, even if rival firms' O&G disclosures provide additional information for

[3] This holds regardless of whether the changes in peers' reserves are driven by discoveries or by acquisitions.
[4] Consistent with this argument, comment letters on recent regulatory changes in O&G reserves disclosures argue that tightening such disclosure requirements would introduce substantial proprietary costs. Specifically, Macleod Dixon LLP, on behalf of senior Canadian O&G firms representing more than 50% of the market cap of the O&G producers, stated that "the proposed instrument may result in issuers being required to publicly disclose proprietary and competitively sensitive information." Similarly, Nexen Inc. stated that "uniquely regulating the disclosure of resources in isolation creates a serious risk of impairing the competitiveness of Canadian O&G producers in the international arena."

investors, these disclosures could be uninformative for managers because corporate executives could have access to other, timelier sources of information. In other words, it is plausible that a substantial part of the released information about reserves is already common knowledge among industry managers at the time of the disclosure.

To analyze market-wide effects of O&G reserves disclosures we use a comprehensive sample of public Canadian and US O&G producing firms between 2002 and 2012. 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 their peers announce increases in O&G reserves. This evidence is consistent with peers' reserves disclosures conveying information about the competitive position of a firm.

Second, we test whether peers' reserves disclosures are associated with firms' investment decisions. Consistent with peers' disclosures affecting managerial decision-making, 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 competitive edge.

To further identify the effect of peers' O&G reserves disclosures, we exploit the unique institutional features and evolution of the North American O&G industry. Competition in the gas market exhibits substantial cross-sectional variation, since producers' ability to supply gas to a given geographical market heavily depends on their location relative to the pipeline infrastructure. We exploit this variation by testing whether our results are stronger among pairs of firms that are more likely direct competitors in the gas market. Moreover, competition among gas producers increased significantly after the introduction of the hydraulic fracturing ("fracking") technology, thus enabling us to test whether the effect of peers' O&G disclosures depends on the intensity of competition. Finally, Canada and the US

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 changes offer an opportunity to further identify the externalities of reserves disclosures by testing whether reactions to peers' O&G reserves disclosures become stronger after the tightening of disclosure rules.

The additional tests aimed at sharpening identification confirm our inferences. Specifically, we find that the documented empirical patterns are stronger among pairs of firms with overlapping geographical markets, with higher gas production, and after the implementation of the fracking technology. We also find that the informational effect of peers' O&G disclosures is stronger when the disclosing peer is subject to tighter O&G disclosure rules.

Finally, we compare the spillover effects of (off-balance sheet) O&G reserves information to those of contemporaneous on-balance sheet information. Including measures of peers' earnings news in our tests does not alter our inferences, suggesting that the spillover effects of O&G reserves disclosures are not subsumed by recognized accounting information. Also, these tests confirm prior research showing that firms exhibit *higher* returns when peer firms report higher earnings (see Foster 1981, among others). This contrasts with our findings on O&G reserves disclosures and suggests that, at least in the O&G industry, on-balance sheet and off-balance sheet amounts convey information of different nature.

Our study responds to a call for further research on the market-wide effects of firms' disclosure and reporting activities (Beyer et al., 2010; Leuz and Wysocki, 2016). These

effects have been characterized by prior literature as either "financial" or "real" externalities (Dye, 1990; Beyer et al., 2010). Financial externalities arise when a firm's disclosure is informative not only about its own financial position, but also about that of other firms, whereas real externalities exist when a firm's disclosure affects other firms' real decisions.

This paper adds to prior research on the *financial* externalities of accounting information. While several papers document that earnings announcements provide information to investors about other firms (e.g., Foster, 1981), the literature is silent about the financial externalities of off-balance sheet disclosures. Moreover, this literature distinguishes between "contagion" and "competitive" effects of earnings disclosures (e.g., Lang and Stulz, 1992; Wang, 2014). A corporate announcement is said to have a "contagion" effect when peer firms' good (bad) news elicit a positive (negative) stock market reaction. Alternatively, when peer firms' good (bad) news elicits a negative (positive) stock market reaction, this effect is referred to as "competitive".

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 et al., 1989; Pyo and Lustgarten, 1990), profit warnings (Tse and Tucker, 2010; Alves et al., 2009), and earnings restatements (Xu et al., 2006; Gleason et al., 2008; Silvers, 2016). However, there is no direct evidence on the potential competitive effects of accounting information.[5] Our study fills this gap by documenting competitive effects from off-balance sheet disclosures.

[5] 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.

This paper also advances the nascent literature on *real* externalities of accounting information. The available evidence of such externalities is restricted to the spillover effects of accounting restatements and misreporting on competitors' investment decisions (Sidak, 2003; Sadka, 2006; Durnev and Mangen, 2009; Beatty et al., 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 peers' regular, periodic off-balance sheet disclosures in accounting reports also generate real externalities.

Our evidence also contributes to the growing empirical literature on the real effects of disclosure regulation (Kanodia and Sapra, 2016; Leuz and Wysocki, 2016). This literature builds on prior work on the effect of transparency on investment efficiency (e.g., Biddle and Hilary, 2006; Francis et al., 2009; Bushman et al., 2011; Chen et al., 2011; Shroff et al., 2014; Biddle et al. 2015). More recently, several papers exploit specific settings to analyze the disciplining effect of mandated disclosures on corporate decisions apart from investment (Gao et al., 2009; Granja, 2014; Dyreng et al., 2015; Christensen et al., 2016). Using a specific setting (i.e., the O&G North American industry), we extend this literature by showing that disclosure mandates affect not only the disclosing firm's investment decisions, but also other firms' investment decisions.[6]

Finally, our paper adds to the O&G accounting literature examining the valuation effect of off-balance sheet information and, in particular, of O&G reserves disclosures. Prior research documents a weak association between levels (changes) of security prices and levels (changes) of O&G valuation disclosures required by ASC 932 (formerly SFAS 69) for US

[6] The notion that firm disclosures can have real effects on other firms is also present in Badertscher et al. (2013), who document that public firms' higher disclosure standards increases private peers' responsiveness to investment opportunities. Further, Shroff et al. (2016) document that information about peers affects firms' cost of raising debt. Finally, Bernard (2016) shows that disclosures can lead to costs from peers' predatory response.

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 et al. (2015) mitigate these shortcomings by focusing on royalty trusts and find evidence supporting the incremental relevance of ASC 932 disclosures for valuation. Our paper improves the understanding of the valuation effects of O&G reserves by documenting important information spillovers of such disclosures.

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. In the context of global convergence, our findings suggest that standard-setters should be aware of the potential spillover effects of disclosure regulation. 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 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.

The rest of the paper proceeds as follows. Section 2 describes the sample. Section 3 investigates the stock market reaction and firms' investment decisions around peers' disclosures, taking into account how the North-American pipeline infrastructure restricts

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

competition in natural gas markets. Sections 4 and 5 exploit the shocks introduced by the fracking technology and the new O&G disclosure regulations, respectively. Section 6 presents robustness tests. Section 7 concludes.

2. Data and Sample Characteristics

Our initial sample comprises all O&G firms, disclosing O&G reserves in the period from 2002 to 2012, listed on stock exchanges in Canada and the US. These stock exchanges are the Toronto Stock Exchange (TSX) and the Toronto Venture Exchange (TSX-V) in Canada, and NASDAQ, AMEX, and NYSE in the US. 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).[8] We complement this information with data provided by the ASC 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). We retrieve the release dates of the forms and reports 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 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 Bloomberg, the Center for Research in Security Prices (CRSP), Datastream, and TSX Venture Summary Trading Files. Bloomberg and Datastream provide historical stock market data for common equities traded on the TSX.

[8] 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 TSX and TSX-V.

TSX Venture Trading Summary Files is a database supplied by the TMX group with market information on the TSX-V equities.[9]

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 valuations of these firms might relate to factors other than O&G reserves, thus potentially confounding our results.[10] These data requirements result in a final sample of 361 firms and 1,843 firm-disclosure observations during the sample period. This cross section is broader than in most prior studies of the North American O&G industry.

To analyze each firm's reaction to its peer firms' 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. Figure 1 illustrates the sample formation procedure. Consider firm 1 disclosing reserves at date t_1. For this firm 1, we include the reserves disclosures of each peer firm (firms 2 to N) occurring within the 365-day window after t_1 (dates t_2 to t_N). We repeat this pairing process for each firm in every disclosing year. This results in 395,968 firm-peer-disclosure observations, corresponding to 60,420 unique pairs of firms with overlapping disclosure periods.

[9] 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.

[10] 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).

In terms of sample composition, 63% of the sample observations correspond to firms headquartered in Canada. This reflects that the Canadian exchanges (TSX and TSX-V) 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%. This proportion exhibits substantial cross-sectional variation, with a standard deviation of 35%. Table 1 provides descriptive statistics for other sample characteristics.

To measure O&G reserves news for each firm-disclosure observation, we define *Δ_Reserves* as the fractional change in the annual O&G proved reserves. Proved reserves represent the amount of reserves classified as "proved" in regulatory filings, measured in millions of barrels of oil equivalent (BOE).[11] 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.[12]

[11] Regulatory filings of O&G reserves also mandate disclosures of proved reserves expressed in dollars, estimated as the net present value of the disclosed physical reserves. We acknowledge that proved reserves measured in dollars (as opposed to physical reserves amounts, i.e., BOE) might be more informative because they incorporate additional managerial assumptions about future production schedule, market prices, extraction costs, and discount rates, among other factors. However, in our main tests we use reserves amounts measured in BOE to facilitate comparability of these amounts across time and to avoid measurement error from managerial estimates. In any case, we repeat our main tests using reserve disclosures expressed in dollars (untabulated) and obtain qualitatively similar results.

[12] It is not surprising that average proved reserves can exceed both book value of assets and market value of equity. 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* exceeds 50% in more than 20% of the observations, mainly due to the effect of new O&G discoveries. *Δ_Reserves* is positive for 65% of the observations. Increases in proved reserves are associated with positive abnormal returns at the disclosing firm, see Badia et al. (2017).

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. Finding that investors use the reserves disclosures of a firm's peers to re-assess that firm's market value would suggest that those peer disclosures are informative.

The reaction of a firm's stock price to peers' O&G reserves disclosures is likely to be different from the reaction to peers' earnings announcements documented in prior literature (e.g., Wang, 2014). In particular, it is possible that a firm experiences higher (lower) returns when peers disclose increases (decreases) in earnings (i.e., a contagion effect), but lower (higher) returns when peers disclose increases (decreases) in O&G reserves (i.e., a competitive effect). As explained by prior literature, the contagion effect of peers' earnings disclosures is due to the information about industry demand contained in earnings. In contrast, we posit that peers' O&G reserves disclosures can have a competitive effect for three reasons.

One reason is that an increase in O&G reserves by industry peers could signal a future increase in O&G supply, and a subsequent drop in oil/gas prices. While for the disclosing firm the higher reserves may offset the effect of lower prices, this need not be the case for the

non-disclosing peer.[13] A second reason is that increases in peers' O&G reserves could signal that peer firms will enjoy a first mover advantage to the detriment of the firm. Early entrants in O&G plays enjoy a first mover advantage because later entrants need to drill deeper (and thus incur higher costs) to reach the O&G deposits after these deposits have been partially depleted by the first mover or pay higher prices for nearby properties (Brown et al., 2015).[14] A third reason is that increases in peers' O&G reserves could signal that peer firms could limit a firm's growth opportunities. To see this, consider that increases in O&G reserves are often associated with acquisitions of new properties. Because the core areas of most plays are normally in the hands of a few operators, acquiring a company or some of its properties is the only way to gain entry.[15] Thus, given the limited nature of O&G resources, by acquiring new properties peers could block the firm's access to O&G plays.

However, peer reserves could also be informative for investors and elicit a contagion effect (i.e., higher/lower returns when peers disclose increases/decreases in O&G reserves). First, an increase in discoveries could be associated with higher expectations about O&G demand. Second, a discovery by a peer operating in the same geographic area could signal an increase in the probability of future findings by all the firms operating in that area. What is more, a peer may share a working or royalty interest with the firm in the same O&G properties. Whether this potential contagion effect of peers' O&G reserves disclosures is

[13] 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).

[14] For example, in March of 2009, Kodiak Oil & Gas Corp. stated in its 10-K that "as an early entrant in new or emerging plays, we expect to acquire undeveloped acreage at a lower cost than later entrants into a developing play".

[15] For example, in September of 2014, Encana announced the acquisition of Midland Basin pure-play company Athlon Energy for $7.1 billion "to establish a premier oil position in the Permian" (Encana press release, 29 September 2014). Similarly, Noble Energy announced the acquisition of Rosetta Resources to gain entry into Eagle Ford and Permian (Noble press release, 11 May 2015).

stronger than the previously hypothesized competition effect is an intriguing empirical question.

To examine firms' stock price reaction to peers' O&G reserves disclosures we estimate the following model using our sample of firm-peer-disclosure observations:

$$Abn\_Return_{ijt} = \alpha * \Delta\_Reserves\_Peer_{jt} + \phi * Controls_{ijt} + \mu_{ij} + \varepsilon_{ijt} \qquad (1)$$

For each firm-peer-disclosure observation, Abn_Return_{ijt} is firm *i*'s market-adjusted return over the (−1, +1) day window around the peer *j*'s disclosure of reserves on date *t*. $\Delta\_Reserves\_Peer_{jt}$ is the peer *j*'s fractional change in disclosed proved reserves.[16] $Controls_{ijt}$ is a vector of control variables found by the literature to be correlated with the cross section of returns. This vector includes $Abn\_Return\_Peer_{jt}$, the peer *j*'s market-adjusted return over the (−1, +1) day window around the peer's disclosure of reserves on date *t*. We include this variable to control for other potentially confounding information released on that date. That is, this variable is a summary statistic for industry and firm-specific news (including other, potentially simultaneous, peer disclosures on that day).

$Controls_{ijt}$ also includes variables found by prior literature to be associated with the cross-section of returns. $Size_{it}$ is the logarithm of the firm *i*'s equity market value, and BM_{it} is the book-to-market ratio. Both variables are measured at the end of the fiscal year prior to the firm *i*'s disclosure date. $Past\_Return_{it}$ is the compounded return over the 365 days prior to the

[16] 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 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 changes 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. Finally, we check whether our results appear driven by observations with a small denominator in *Δ_Reserves_Peer*. We repeat our tests excluding observations with below-median values of the denominator of *Δ_Reserves_Peer* (i.e., the lagged volume of disclosed reserves). All these alternative tests support our inferences.

end of the fiscal year prior to the firm *i*'s disclosure date. The specification includes firm-peer fixed effects (μ_{ij}). That is, we test whether, for each pair of firms (*i* and *j*), the stock of firm *i* reacts to changes in its peer *j*'s disclosed reserves. The firm-peer fixed effects control for firm and peer time-invariant characteristics as well as for both firms' joint characteristics such as their degree of competition.[17] Going forward, we suppress variable subscripts to simplify notation.

As previously explained, if peers' reserves disclosures contain information mainly about industry competition, we expect α will be negative. That is, the release of good (bad) news by a rival firm will elicit a negative (positive) stock price reaction. In contrast, if disclosures contain information mainly about industry demand or availability of O&G deposits for the firm, we expect α will be positive. That is, the release of good (bad) news by a rival firm will elicit a positive (negative) reaction on the firm's stock price.

Table 2, Panel A, presents the results of estimating equation (1). Consistent with peers' reserves disclosures containing information on industry competition, the coefficient on $\Delta\_Reserves\_Peer$ is negative and significant regardless of the inclusion of control variables (*t*-stat. range from −5.40 to −5.85). α ranges from −0.08 to −0.09 across specifications. That is, an increase of 100% in the reserves of one peer (i.e., $\Delta\_Reserves\_Peer = 1$) is, on average, associated with a stock price decrease of approximately 8 basis points (recall that *Abn_Return* is expressed in %). At first glance, this magnitude might seem small. We note, however, that this estimate only captures the effect of one peer disclosure. Estimating the overall stock

[17] We define firm-peer fixed effects preserving the order of the pair of firms. For example, the firm 1-peer 2 fixed effect is different from the firm 2-peer 1 fixed effect. The firm 1-peer 2 fixed effect is an indicator variable that equals one for observations where Abn_Return_{12t} relates to firm 1 and $\Delta\_Reserves\_Peer_{2t}$ relates to (peer) firm 2. The firm 2-peer 1 fixed effect is an indicator variable that equals one for observations where Abn_Return_{21t} relates to firm 2 and $\Delta\_Reserves\_Peer_{1t}$ relates to (peer) firm 1. This definition of pair fixed effects takes into account that, given the relative characteristics of both firms, the average effect of firm 2's disclosures on firm 1 can be different from the average effect of firm 1's disclosures on firm 2.

price reaction to peers' disclosures would require considering the firm's reaction to the disclosures of all peers. Also, while a 100% increase in reserves might seem large, such magnitude is not exceptional among O&G firms (over 10% of our sample firms report reserves increases of 100% or more). These considerations suggest that peers' reserves disclosures have a material impact on valuation and thus significant market-wide effects.

3.2. Investment Decisions around Peers' Disclosures

Evidence in Table 2 suggests that O&G reserves disclosures impose *financial* externalities (that is, investors use peers' O&G reserves disclosures to assess a firm's market value). However, our prior tests are still inconclusive in terms of whether these disclosures also impose *real* externalities (that is, whether peers' O&G reserves disclosures also affect managerial decision-making at the firm). To provide more direct evidence on the latter, we next test whether peers' O&G reserves disclosures are associated with changes in firms' investment decisions.

We conjecture that firms are likely to react to higher peer reserves by increasing investment. Our reasoning is structured in parallel to our three prior arguments justifying a potential competitive effect of peers' disclosures. First, if the increase in peers' O&G reserves signals a future drop in the price of O&G (due to an increase in supply of O&G), the firm could boost investment in development to mitigate the effect of the reduced prices by increasing future production quantities. Second, if the increase in peers' O&G reserves signals that a peer firm has a first mover advantage in terms of exploiting a play, the firm could incur higher capital expenditures to accommodate more difficult extraction requirements or purchase more expensive properties in the same area. Third, if the increase in peers' O&G reserves signals that the peer's acquisition limits the firm's growth opportunities,

the firm could partially avoid this limitation by increasing investment (i.e., acquiring other properties).

While possible in certain cases, we do not expect that, on average, firms respond to higher peer reserves by decreasing investment. A firm could disinvest in a certain territory because competition in that territory becomes tougher, but the firm will probably invest in other territories to avoid a future decrease in profits. In any case, finding either an increase or a decrease in firms' investment in response to higher peer O&G reserves disclosures would suggest that these disclosures are used by firms to make investment decisions and thus, would be consistent with the notion that these disclosures generate real externalities.

To examine whether peers' O&G reserves disclosures affect firms' investment decisions, we replace the dependent variable in previous tests, *Abn_Return* with *CAPEX*, defined as capital expenditures scaled by total assets, measured in the year of the disclosure of reserves.[18] 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 9.35 to 13.45). This result is consistent with the notion that firms respond to higher future competition by increasing investments. The magnitude of α ranges from 0.37 to 0.54 across specifications. That is, an increase of 100% in the reserves of one peer (i.e., Δ_*Reserves_Peer* = 1) is, on average, associated with a CAPEX increase of approximately

[18] For example, if a firm discloses reserves corresponding to fiscal year 2006 in March 2007, we measure *CAPEX* in fiscal year 2007. That is, in parallel to our tests using *Abn_Return*, *CAPEX* is measured contemporaneously to the disclosure date corresponding to Δ_*Reserves_Peer* (recall that, as illustrated in Figure 1, Δ_*Reserves_Peer* relates to peers' reserves disclosed within one year after the firm's disclosure of reserves).

0.4% (recall that *CAPEX* is expressed as %). As in our prior discussion on the results of Table 2, Panel A, we note that estimating the total investment reaction to peers' disclosures would require considering the firm's reaction to the disclosures of all peers (the previous figure corresponds to the reserves information released by a single peer firm). Moreover, Δ_*Reserves_Peer* is large (greater than 1) in a significant number of cases. In sum, our results suggest economically significant market-wide effects of peers' reserves disclosures in the investment decision-making process.

3.3. Exploiting Variation in the Degree of Competition

To corroborate our inferences from the previous analysis, we first exploit cross-sectional variation in the degree of competition among our sample firms. Finding that the empirical patterns we document are concentrated among pairs of firms that are more likely to be competitors would further support the hypothesis that peers' reserves disclosures are informative about industry competition.

Conducting such test requires measuring the degree of competition among sample firms. Since our study is based on a single industry, the usual approach to measuring competition based on industry affiliation is not applicable to our setting. However, the natural gas market provides an opportunity to measure the degree of competition between O&G 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. As a consequence, the degree of overlap in the geographical markets served by a given pair of firms − and thus their degree of competition − is determined by those firms' location. In contrast, the degree of competition in the oil market among North-American suppliers likely

exhibits less cross-sectional variation because oil can be distributed not only through pipelines, but also using tankers and trucks.

Figure 2 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. Similarly, Figure 3 shows substantial variation in the pipeline capacity flows across the seven North American O&G regions, namely Canada and the six US regions defined by the U.S. Energy Information Administration. To illustrate, both figures suggest that 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. As the pipeline infrastructure extends across borders, the degree of competition of a given pair of firms is not necessarily determined by whether both firms are located within the same country.

Our measure of the degree of competition estimates the overlap in North-American geographical markets for each pair of firms. This requires measuring the presence of firm i in each of the geographical markets. For this purpose we define S_i, a vector containing the fraction of the gas supplied by firm i in each of the seven North American O&G regions. For example, the element s_{in} of the vector S_i represents the fraction of the gas produced by firm i that is sold in region n. We approximate the value of the seven elements of S_i using the following decomposition:

$$S_i = P_i \cdot D = (p_{i1} \dots p_{i7}) \begin{pmatrix} d_{11} & \cdots & d_{17} \\ \vdots & \ddots & \vdots \\ d_{71} & \cdots & d_{77} \end{pmatrix}$$

P_i is a vector containing the fraction of gas produced by firm i in each of the seven gas regions in North America. Accordingly, element p_{in} of vector P_i represents the fraction of the gas produced by firm i that is extracted in region n. D is a matrix containing the fraction of gas distributed across the North-American regions. Similarly, element d_{nm} of matrix D represents the fraction of the gas produced in region n that is distributed to region m.

We estimate P_i assuming that the firm's production is concentrated in the region where the firm is headquartered. As Appendix B illustrates, this assumption likely holds in a large part of our sample (many of our sample firms are small and medium size O&G firms operating in one region). Matrix D is estimated using data on the distribution capacity of gas among regions given the gas pipeline infrastructure available in that year (see Figure 3 for an illustration).[19]

Based on the estimated values of S_i, the degree of competition for a given pair of firms j and k is measured by computing the cosine similarity of vectors S_j and S_k:

$$\cos\varphi_{jk} = \frac{S_j \cdot S_k}{\|S_j\| * \|S_k\|}$$

This measure ranges from 0 to 1. A score of 0 means that the two firms do not share any geographical market (the two vectors are orthogonal). A score of 1 means that the two companies share the same geographical markets (the two vectors are parallel).[20]

One possible concern about measuring the geographical market overlap of firms j and k using the cosine similarity of the vectors S_j and S_k is that this approach could assign the same value to a pair of undiversified firms (i.e., firms with potential access to a single overlapping geographical market) as to a pair of diversified firms (i.e., firms with potential access to multiple overlapping geographical markets). To investigate whether our inferences

[19] These data are collected from the US Energy Information Administration (EIA).
[20] See Hoberg and Phillips (2010) for a similar application of this methodology in the finance literature.

are sensitive to the potential effect of diversification on the degree of competition, we use an alternative definition of the prior measure of the degree competition. Specifically, we compute the scalar product of the vectors S_j and S_k. Appendix C provides a numerical example of the computation of the degree of competition for two pairs of sample firms using cosine similarity and scalar product.

While cosine similarity is a standardized measure (the scalar product of vectors is scaled by the magnitude of the vectors), the scalar product 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). Thus, this alternative measure takes into account that competition could be more intense when the overlapping firms are concentrated in that market. Both measures of competition (i.e., standardized and unstandardized) exhibit substantial variation with respect to their mean and median values (see Table 1), suggesting that their use can result in powerful tests.

Table 3 presents the results of estimating equation (1) partitioning the sample of firm-peer-disclosure observations into pairs with above/below median values of degree of competition. Table 3, Panel A, reveals that the negative association between *Δ_Reserves_Peer* and *Abn_Return* is more pronounced in the subsample of firms with a higher degree of competition. Consistent with this pattern, Table 3, Panel B, reveals that the positive association between *Δ_Reserves_Peer* and *CAPEX* is more pronounced in the subsample of firms with a higher degree of competition. These differences between subsamples are statistically significant and hold regardless of whether the degree of

competition is standardized (i.e., whether it is measured using cosine similarity or scalar product).

4. The Introduction of Fracking

The evidence in the prior section is consistent with the notion that peers' disclosed reserves contain information on industry competition, 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 altered the dynamics of competition in the natural gas market.

The North American O&G industry 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.[21] In contrast, because of transportation constraints,

[21] Source: US Energy Information Administration, available at http://www.eia.gov/dnav/ng/hist/n9190us3m.htm

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 4 illustrates the decoupling of the natural gas and oil prices traditional behavior since the shale gas expansion 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 the change in price structure, from 2008 onwards 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 define the indicator variable *Post_Fracking* as equal to one if the peer's O&G information is disclosed in the year 2007 or later, and zero otherwise.[22] We then interact *Post_Fracking* with *Δ_Reserves_Peer*. Since the effect of fracking is concentrated in the natural gas market, we test whether the documented empirical patterns are stronger among firms with peers predominantly engaged in natural gas production (measured by the indicator variable *Gas_Producer* defined as one if the peer'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

[22] 2007 is the year when significant shale drilling activity first began across the US portion of the Bakken formation (a rock unit spanning approximately 200,000 square miles in North Dakota and Montana). In that year, the share of shale gas in total US natural gas production increased from 5% to 10%. See Maugeri (2013) for more details.

competition among firms (as measured in the prior section) and interact *Δ_Reserves_Peer*, *Post_Fracking*, and *Gas_Producer*.

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. Unreported tests reveal that, in both panels, the differences in key coefficients across subsamples are statistically significant. 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 suggests 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. Finding that the effect of O&G reserves disclosures depends on how these disclosures are made would be powerful confirmatory evidence that the empirical pattern documented in Tables 2 and 3 is indeed driven by O&G reserves disclosures. Moreover, such evidence would inform the ongoing debate on disclosure regulation and more specifically on O&G reserves disclosure rules.

To empirically identify the effect of O&G disclosure rules, we exploit changes in the mandatory disclosure rules of O&G reserves during our sample period. In Canada, the ASC introduced NI 51-101 in 2003. The US SEC introduced a similar regulation, 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 O&G reserve

disclosures by introducing quantitative, bright-line probability thresholds in the definition of reserves amounts.[23] 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 5 suggests that the upcoming regulation elicited a significant reaction among O&G firms. Figures 5a and 5b plot means and medians of O&G reserves revisions over the sample period for Canada and the US. In Canada, Figure 5a reveals an abnormal accumulation of negative revisions (left axis, in %) in the year before the implementation of NI 51-101 (i.e., 2003). Figure 5b 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).[24] Consistent

[23] 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." Both the new and the old definitions included the implicit condition of economic viability.

[24] To interpret the accumulation of negative revisions shortly before the implementation of NI 51-101 and MOGR, we 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. (2017) 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 to 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 clearly 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 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. Unreported tests reveal that, in both panels, the differences in the interaction coefficients across subsamples are statistically significant. That is, after the tightening of disclosure rules in the peer's country, firms exhibit larger investment increases when peers disclose larger

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.

reserves increases. In contrast, this effect is weaker when domestic or foreign peers make similar disclosures before the regulatory change.

One potential concern regarding our interpretation of Table 6 is that firms' stock prices could react more to peers' reserves disclosures in later years of the sample period for reasons unrelated to the introduction of NI 51-101 and MOGR. For example, it is possible that the pattern in Table 6 is driven by peers' disclosures becoming more relevant after the increase in competition introduced by the fracking technology (i.e., the pattern in Tables 4 and 5), rather than by the regulatory changes. While such potential confounding effect does not affect our inferences regarding the existence of externalities associated with O&G reserves disclosures, the concern could cast doubt on our confirmatory analysis of Table 6. To explore the validity of this concern, we employ two falsification tests.[25]

First, we repeat our tests randomizing the dates of the introduction of NI 51-101 and MOGR. If the pattern in Table 6 is driven by a confounding time-trend rather than by these regulatory changes, we should observe similar results when regulatory changes are assigned to random dates. Accordingly, we re-estimate the coefficients in Table 6 for the subsample of firms with high degree of competition assigning a random year to the introduction of each regulation. For example, if the random draw assigns 2007 and 2005 to the introduction of NI 51-101 and MOGR, respectively, *New_Rule* is re-defined as one if the peer firm is a Canadian firm and the disclosure occurs after 2007 or if the peer firm is a US firm and the disclosure occurs after 2005, and zero otherwise.

[25] Prior literature points out two additional potential concerns about using regulatory changes for identification (e.g., Leuz and Wysocki, 2016). The first concern is that the regulation could respond to shifts in economic conditions that also affect regulated firms. The second concern is that regulation could affect the cost of capital of the regulated firms. These concerns do not apply to our setting because, unlike in other studies at the firm level, in our study of externalities the treated firm is the disclosing peer, not the reacting firm. The issue of common shocks among peer firms (i.e., "the reflection problem") is addressed in the next section of this paper.

Second, we repeat the tests randomizing the home country of the disclosing peer and keeping the actual regulatory dates. If the pattern in Table 6 is driven by a confounding event rather than by the introduction of NI 51-101 and MOGR, we should observe similar results when firms are randomly assigned to regulatory jurisdictions. Accordingly, in the second falsification test we randomly assign Canada or the US as the country of peers' headquarters.[26] If the random draw assigns "Canada" to a given disclosing peer firm, *New_Rule* is re-defined as one if the disclosure occurs after 2003 (i.e., the year of the introduction of NI 51-101), and zero otherwise. Alternatively, if the random draw assigns "US" to a given disclosing peer firm, *New_Rule* is re-defined as one if the disclosure occurs after 2009 (i.e., the year of the introduction of MOGR), and zero otherwise.

Table 7 presents the results of the two placebo tests for the results in Table 6 in the subsample of high degree of competition (i.e., column (1) in Panels A and B). Table 7, Panel A, column (2) shows the mean of the empirical distribution of coefficients on the interaction between *Δ_Reserves_Peer* and *New_Rule* obtained from randomizing the regulatory announcement dates. When the dependent variable is *Abn_Return*, the mean of this distribution ($E[\beta]$) is undistinguishable from zero (column (2)) and significantly different from β (column (3)). Columns (5) and (6) reveal a similar pattern for *CAPEX*.

Table 7, Panel B, columns (2) and (5) show the mean of the empirical distribution of coefficients on the interaction between *Δ_Reserves_Peer* and *New_Rule* obtained from randomizing the home country of the disclosing peers and keeping the actual regulatory dates. In Table 7, Panel A, this mean is significantly different from the coefficients in Table 6

[26] To ensure that this procedure does not alter the sample composition, the randomization preserves the percentage of peer firms in each country as in the actual data.

(β), both when the dependent variable is *Abn_Return* (column (3)), and when the dependent variable is *CAPEX* (column (6)).[27]

Overall, the evidence in Table 6 and 7 sharpen the empirical identification of market-wide effects of O&G reserves disclosures by showing that these effects are shaped by the rules governing the disclosures. Moreover, to the extent that disclosure rules affect how peers' disclosures are used by firms, Table 6 and 7 confirm the existence of a real externality of disclosure regulation. Finally, this evidence is important to understand the effect of tightening a pre-existing mandatory disclosure of off-balance sheet information.

6. Additional Tests

6.1. Off versus On-Balance Sheet Disclosures

A potential issue with our prior tests is that the information conveyed by off-balance sheet reserves disclosures could be subsumed by the information content of on-balance sheet amounts. Although in general this is a significant concern, in our specific setting reserves disclosures are often stand-alone, and thus unlikely to be completely confounded by simultaneously released accounting information. Moreover, as previously explained, our tests include *Abn_Return_Peer* (i.e., the abnormal return experienced by the disclosing peer) as a control for all other information about peers released on the disclosure day, including earnings announcements.

Nevertheless, we check that our inferences are unaffected by the potentially confounding informational effect of on-balance sheet news by repeating the tests in Table 3

[27] To further check that our inferences from Table 6 are not confounded by time trends or shifts in economic conditions, we repeat the analysis in Table 2 including year fixed effects (in addition to the pair fixed effects used in prior tests). The coefficient on the interaction between *Δ_Reserves_Peer* and *New_Rule* remains statistically significant for the subsample of firms with higher degree of competition in both Panel A and B.

including a measure of earnings news. Specifically, we include *Δ_Earnings*, defined as the change in annual earnings expressed as a fraction of book value of equity at the beginning of the year. As shown in Table 8, the inclusion of *Δ_Earnings_Peer* as additional control variable does not alter our inferences about *Δ_Reserves_Peer*.[28]

This test also has the purpose of reconciling our findings with prior literature on intra-industry information transfers. Replicating the results from prior literature in this specific setting mitigates the potential concern that our evidence reflects a specific feature of the O&G industry that might not generalize to other industries.[29] As previously mentioned, the evidence in prior work suggests that on-balance sheet information (most notably accounting earnings) has a contagion effect (that is, firms experience *higher* returns when peers disclose higher earnings).

Consistent with prior literature, the coefficient on *Δ_Earnings* in Table 8, Panel A, is positive and significant in the subsample of firm pairs with more overlap in geographical markets. Table 8, Panel B, also reports a positive and significant association between *Δ_Earnings_Peer* and *CAPEX*. In the light of the conclusions of prior papers on the contagion effect of earnings news, we interpret these results as suggesting that, in contrast to higher reserves, higher earnings at peer firms are positive news about the industry (i.e., a signal of higher demand and/or more investment opportunities).

6.2. The Reflection Problem

[28] As an alternative to *Δ_Earnings* we repeat our tests in Table 8 using fractional changes in total book value of assets and fractional changes in net book value of assets. Similar to Table 8, the coefficient on *Δ_Reserves_Peer* remains highly significant when these alternative measures of on-balance sheet information are included in the models.

[29] 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.

Another 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 peers' reserves disclosures could also drive firms' investment decisions. As explained by Leuz and Wysocki (2016), this concern is essentially a variant of the "reflection problem" (Manski, 1993).

In this setting, the reflection problem is related to another common concern in the investment literature, namely the difficulty in controlling for simultaneous changes in a firm's cost of capital and its investment opportunity set (Leuz and Wysocki, 2016). In this case, peers' disclosed reserves could be correlated with changes in peers' investment opportunities, which in turn could be correlated with changes in firms' investment opportunities (i.e., the reflection problem), thus confounding our inferences.

The reflection problem is unlikely to drive our results. A common industry shock would likely 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 peers' stock prices. Further, our results in Table 6 and 7 are hard to reconcile with the reflection problem. We note that the pattern we document in Tables 6 and 7 is related to a change in disclosure rules rather than to a change in the underlying economics of the sample firms.

However, we perform a battery of additional tests to further check that our inferences are not affected by potential common shocks. First, we include the peer firm's CAPEX (measured contemporaneously to the dependent variable CAPEX) as an additional control variable. Second, we include year effects to capture year-specific market and industry conditions. Third, we repeat our tests of firms' stock price reaction to peers' reserves

disclosures (i.e., Table 2, Panel A) including *firm-year* fixed effects.[30] This research design effectively tests whether the stock price of a given firm in a given year (that is, holding the firm's investment opportunities constant) reacts more negatively to peers' reserves disclosures when the increase in reserves is larger. Fourth, we 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. Finally, 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. Our inferences are unaffected.

7. Conclusion

This paper studies the effect of peers' off-balance sheet disclosures on firms' valuation and investment decisions. We focus our analysis on the mandatory disclosure of O&G reserves, a setting in which off-balance sheet information is of particular importance to understand industry competition. Peers' O&G reserves disclosures could affect securities prices through (at least) two channels: the direct effect on security prices through updated expected future cash flows, and indirectly through the consequences of anticipated changes in firms' real investment decisions.

[30] It is not possible to include *firm-year* fixed effects in the tests of Table 2, Panel B (where *CAPEX* is the dependent variable) because the CAPEX variable does not exhibit within firm-year variation.

Using a comprehensive sample of Canadian and US O&G producers we find that larger increases in rivals' O&G reserves are associated with firms' *lower* announcement returns. This result contrasts to prior research finding *higher* stock price returns when peers report larger increases in earnings. We also find that, consistent with peers' disclosures affecting managerial decision making, larger increases in peers' reserves are accompanied by an *increase* in investment. Our results are overall consistent with the competition effect (versus the contagion effect) for firms' responses to peers' reserves disclosures.

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 in firm pairs based on the overlap of the geographical markets they have access to with the existing pipeline network. We 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 introduction 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 peers' disclosures are made after the change in disclosure rules in their country.

Overall, our evidence is consistent with the notion that both investors and managers use rival firms' off-balance sheet disclosures when making investment decisions. Thus, our paper provides evidence of market-wide effects of disclosure regulation in the form of both *financial* and *real* externalities.

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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.

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.

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 expressed in Bcfe 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.

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 Geographically Concentrated Production

Example 1: 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 2: 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 3: 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 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 (Northern 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-Northern O&G in 2008.

Matrix *D* in 2008 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 *D* add up to 1 (i.e., 100%). For example, a firm producing in Canada is expected to sell 37% locally, and to export 15% of the production to Central, 16% to Midwest, 15% to Northeast, 0% to Southeast and Southwest, and 17% to Western. The rows of Southwest and Western regions do not add up to 1 because they export some production to Mexico.

The production vector *P* for Bellamont has a first component equal one for the region of Canada and zero for the rest of the regions. The sales vector *S* for Bellamont is obtained by multiplying *P* and *D*:

$$S = P \cdot D = \begin{pmatrix} 1 & 0 & 0 & 0 & 0 & 0 & 0 \end{pmatrix} \begin{pmatrix} 0.37 & \cdots & 0.17 \\ \vdots & \ddots & \vdots \\ 0.00 & \cdots & 0.93 \end{pmatrix} = \begin{pmatrix} 0.37 & 0.15 & 0.16 & 0.15 & 0 & 0 & 0.17 \end{pmatrix}$$

The sales vectors for Stata and Northern O&G are computed similarly.

The cosine similarity and the scalar product of sales vectors (i.e. our standardized and unstandardized measures of the degree of competition, respectively) for each pair of firms 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**

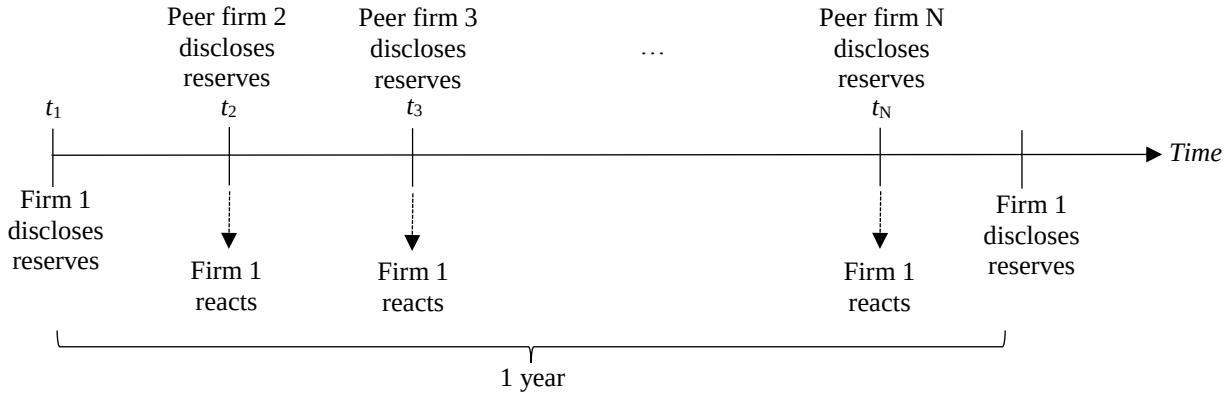
	Canada	Central	Midwest	Northeast	Southeast	Southwest	Western		
Bellamont Exploration Ltd.	0.37	0.15	0.16	0.15	0.00	0.00	0.17	**Cosine Similarity**	**0.51**
Northern Oil & Gas Company	0.09	0.11	0.68	0.11	0.01	0.00	0.00	**Scalar Product**	**0.18**

The two measures of degree of competition are higher for the pair Bellamont – Northern O&G (i.e., 0.51, 0.18) than for the pair Bellamont – Stata (i.e., 0.10, 0.03). That is, Bellamont and Northern O&G exhibit a higher degree of competition than Bellamont and Stata. Intuitively, firms in Canada and the Southwest region (such as Bellamont and Northern O&G) are more likely to compete because these two regions are directly connected by the gas pipeline network. In contrast, firms in Canada and the Southwest region (such as Bellamont and Stata) are unlikely to compete since no direct pipelines connect these two regions.

Appendix D. Variable Definitions

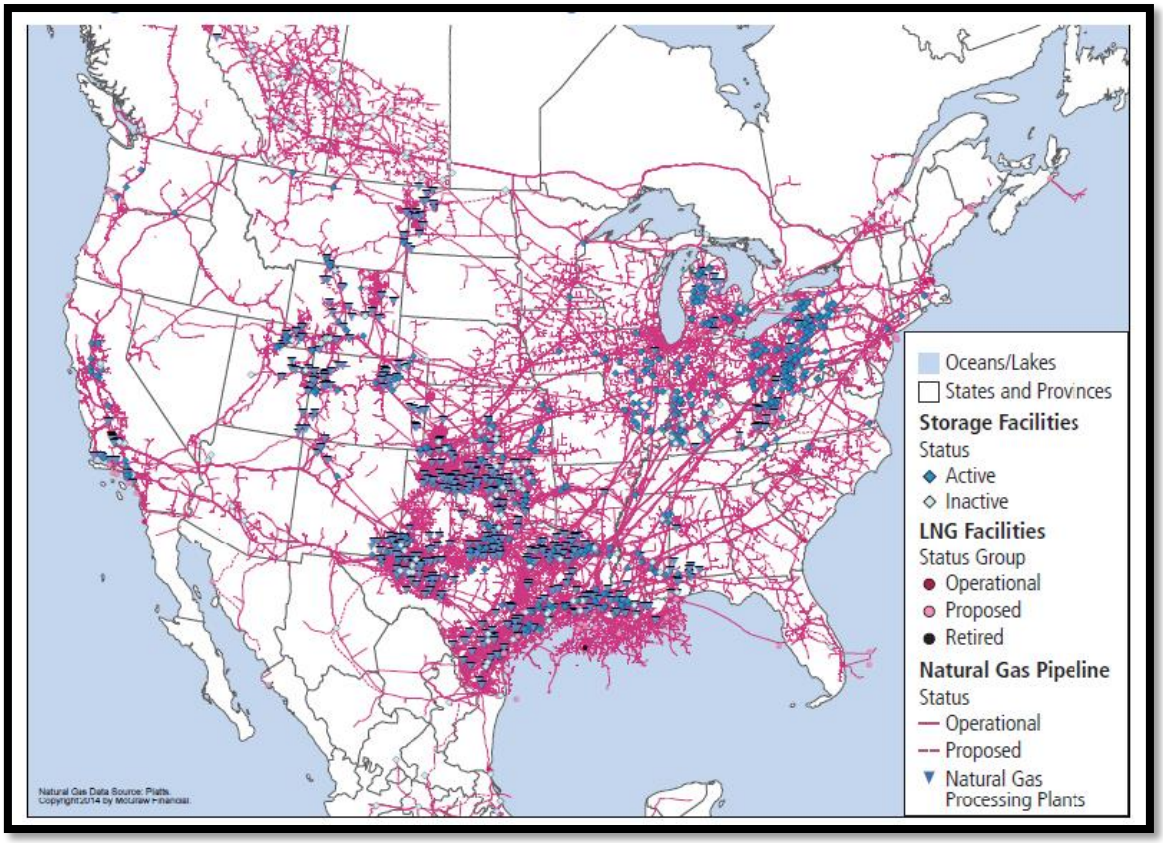
Abn_Return	Market-adjusted compounded stock return over the (−1, +1) day window around each peer firm's annual release of information about O&G reserves, expressed in %.
CAPEX	Capital expenditures scaled by total assets measured in the year of disclosure of reserves, expressed in %.
Δ_Reserves_Peer	Fractional 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, expressed in %.
ROA	Return on assets computed as earnings before extraordinary items, scaled by total assets at fiscal year-end.
Past_Return	Stock return compounded over the 365 days before the end of the fiscal year prior to the disclosure date.
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. Sample Construction Procedure



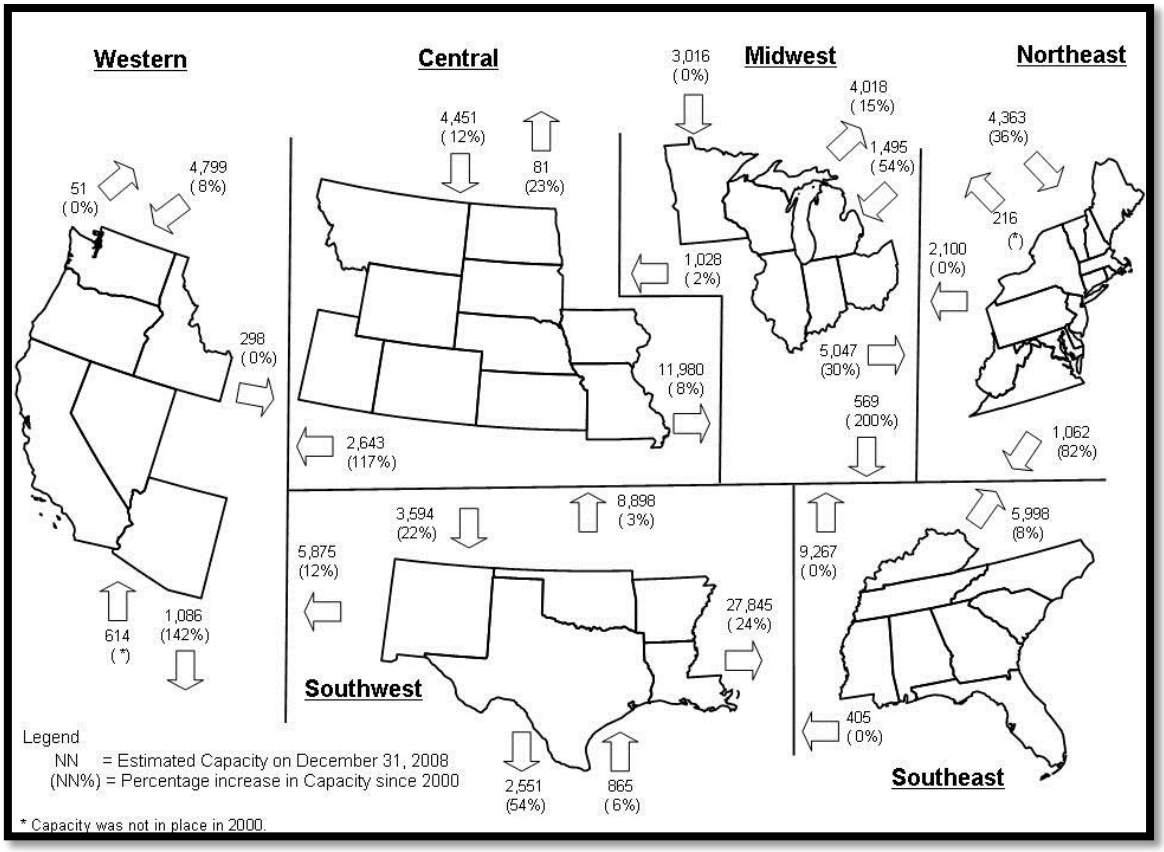
This figure illustrates the construction of our firm-peer-disclosure sample. For example, the observation (Firm 1, Peer firm 2, t_2) corresponds to the effect on Firm 1 of the disclosure of Peer firm 2 at t_2 (Peer firm 2's disclosure date) within 365 days after t_1 (Firm 1's disclosure date). Repeating this process for each firm in every period results in a sample of 395,968 firm-peer-disclosure observations.

Figure 2. North-American Gas Pipeline Infrastructure



This figure depicts the North-American gas pipeline infrastructure in 2015. Source: US Energy Department (http://energy.gov/sites/prod/files/2015/06/f22/Appendix%20B-%20Natural%20Gas_1.pdf).

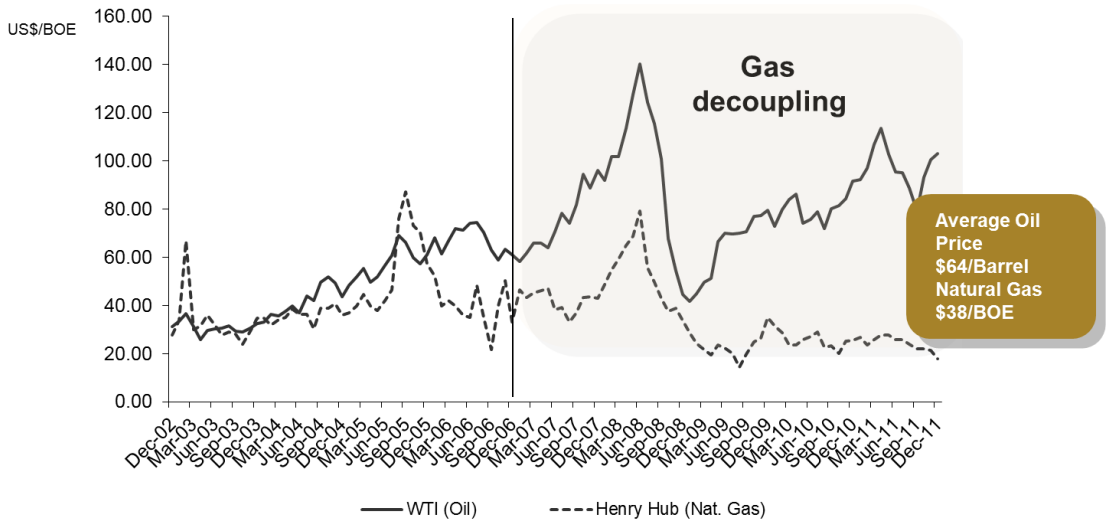
Figure 3. US Interregional Natural Gas Transmission Pipeline Capacity



This figure depicts the natural gas US regional capacity flows in 2008. Amounts of gas are expressed in million cubic feet per day. Figures in parentheses are percentage increases in pipeline capacity from 2000). Source: US Energy Department

(https://www.eia.gov/pub/oil_gas/natural_gas/analysis_publications/ngpipeline/RegiontoRegionMap.html)

Figure 4. Fracking Technology and O&G Prices



This figure illustrates the decoupling of the natural gas and oil prices traditional behavior since the shale gas expansion in 2007. Before 2007, the correlation between natural gas and oil prices was very high. However, around 2007, technological changes—notably the pairing of horizontal drilling with hydraulic fracturing (i.e., "fracking")—brought on significant quantities of natural gas from previously low-producing gas deposits in North America. The uneven impact of these technological changes on the oil and gas markets caused a significant price decoupling. Prices (left axis) are expressed in dollars per barrel.

Figure 5. Changes in Reserves Disclosure Rules and Reserves Revisions

Figure 5.a. Canada

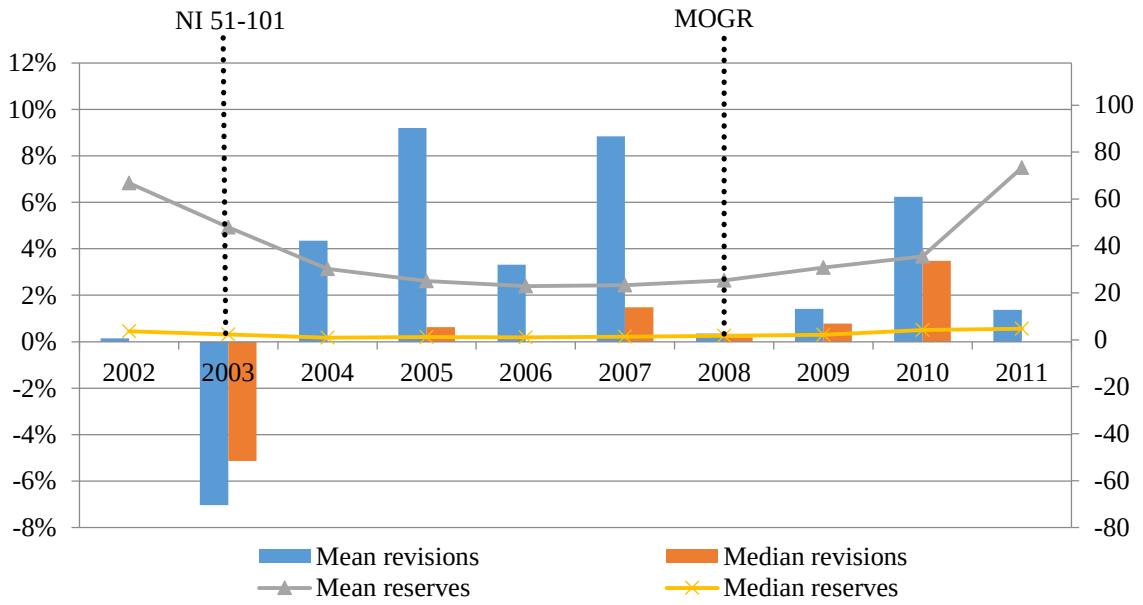


Figure 5a presents annual mean and median amounts of reserves revisions and proved reserves reported by Canadian O&G firms during the sample period. *Revisions* (left axis) is the amount of reserves revisions scaled by the amount of proved reserves corresponding to the revision, expressed in %. *Reserves* (right axis) is the reserve amounts classified as "proved" measured in millions of barrels of oil equivalent (BOE). Source: Badia et al. (2017).

Figure 5.b. United States

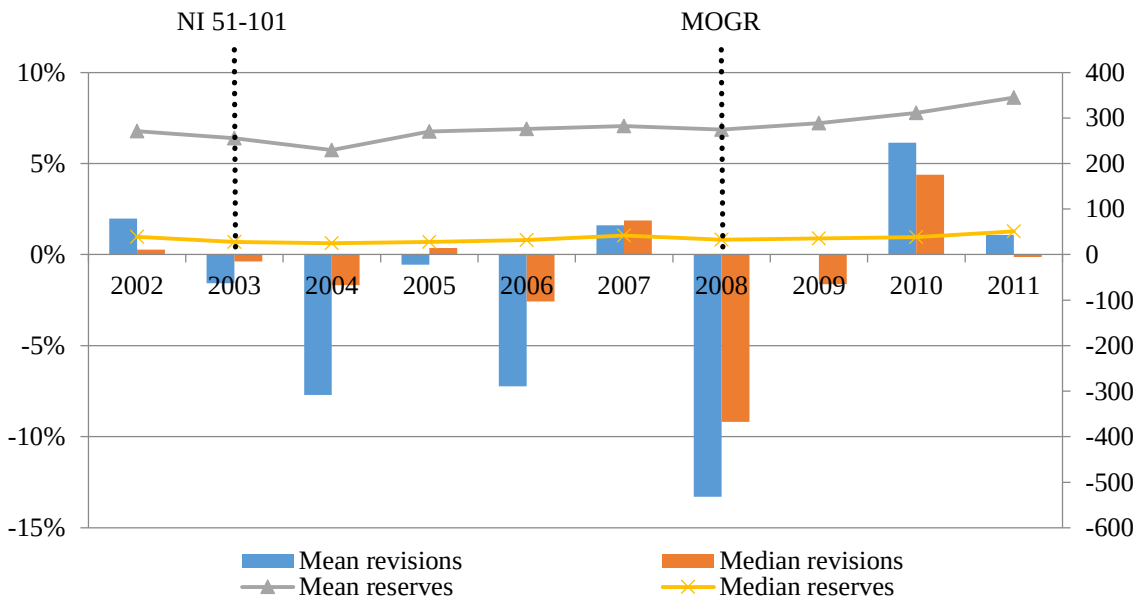


Figure 5b presents annual mean and median amounts of reserves revisions and proved reserves reported by US O&G firms during the sample period. *Revisions* (left axis) is the amount of reserves revisions scaled by the amount of proved reserves corresponding to the revision, expressed in %. *Reserves* (right axis) is the reserve amounts classified as "proved" measured in millions of barrels of oil equivalent (BOE). Source: Badia et al. (2017).

Table 1. Descriptive Statistics

This table presents descriptive statistics for our sample of North-American 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, expressed in %. *CAPEX* is capital expenditures scaled by total assets, expressed in %. The measures of degree of competition are defined in section 3.3. See Appendix D for other variable definitions.

Variables	Mean	Median	St.dev.
At firm-disclosure level (1,843 obs.):			
Δ_Reserves	0.59	0.09	2.29
Abn_Return (to own disclosures, in %)	0.46	0.00	12.96
CAPEX (in %)	23.14	19.74	21.65
Size	5.00	5.12	2.44
BM	0.91	0.54	1.15
Past_Return	0.30	0.08	1.14
Leverage (in %)	23.97	22.16	20.91
ROA	0.04	0.00	0.98
At firm-peer-disclosure level (395,968 obs.):			
Abn_Return (to peer disclosures, in %)	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

This table reports results of estimating the stock price reaction and investment decisions around peer firms' releases of information about O&G reserves. 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, expressed in %. In Panel B, the dependent variable, *CAPEX*, is capital expenditures in the year of disclosure of reserves scaled by total assets, expressed in %. *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. Results are based on a sample of 395,968 firm-peer-disclosure observations. 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

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	0.54***	0.54***	0.37***
	(13.45)	(13.45)	(9.35)
Abn_Return_Peer		0.001	0.01***
		(0.03)	(2.10)
Size			−4.96***
			(−4.25)
BM			−5.62***
			(−6.70)
Past_Return			1.63***
			(2.57)
Leverage			−0.48***
			(−9.38)
ROA			4.93***
			(2.50)
Firm-Peer Fixed Effects	YES	YES	YES
R^2	0.38	0.38	0.48

Table 3. Partitioning by 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 degree of competition between pair firms, measured as explained in section 3.3 (standardized and unstandardized measure). 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. 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, expressed in %. In Panel B, the dependent variable, *CAPEX*, is capital expenditures in the year of disclosure of reserves scaled by total assets scaled by total assets, expressed in %. Results are based on a sample of 395,968 firm-peer-disclosure observations. Standard errors are double-clustered by firm and disclosure date. *, ** and *** denote statistical significance at the 10%, 5% and 1% (two-tail) levels, respectively. *p*-values at the bottom correspond to testing the null hypothesis of equality of the coefficients on *Δ_Reserves_Peer* (β) in the two subsamples (i.e., *High* and *Low*).

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	β	−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
H_o: $\beta_{High} = \beta_{Low}$		*p*-value = 0.051		*p*-value = 0.097	

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	β	0.50***	0.21***	0.51***	0.23***
		(10.20)	(4.91)	(10.22)	(5.43)
Controls		YES	YES	YES	YES
Firm-Peer Fixed Effects		YES	YES	YES	YES
R^2		0.49	0.49	0.49	0.48
H_o: $\beta_{High} = \beta_{Low}$		*p*-value < 0.001		*p*-value < 0.001	

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 degree of competition between pair firms, measured as explained in section 3.3 (standardized measure). *Post_Fracking* equals one if the peer's disclosure is in year 2007 or later, and zero otherwise. In Panel B, *Gas_Producer* equals one if more than 50% of the peer firm's production is gas, and zero otherwise. The dependent variable, *Abn_Return*, is the market-adjusted stock return in the (−1, +1) window around each peer's disclosure date, expressed in %. The rest of the variables are defined in Appendix D. Results are based on a sample of 395,968 firm-peer-disclosure observations. 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

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

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 degree of competition between pair firms, measured as explained in section 3.3 (standardized measure). *Post_Fracking* equals one if the peer's disclosure is in year 2007 or later, and zero otherwise. In Panel B, *Gas_Producer* equals one if more than 50% of the peer firm's production is gas, and zero otherwise. The dependent variable, *CAPEX*, is capital expenditures in the year of disclosure of reserves scaled by total assets, expressed in %. The rest of the variables are defined in Appendix D. Results are based on a sample of 395,968 firm-peer-disclosure observations. 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*	0.54***	0.04
	(7.28)	(0.69)
Δ_Reserves_Peer	0.01	0.16***
	(0.26)	(3.80)
Post_Fracking	−7.15***	−6.54***
	(−5.67)	(−5.26)
Controls	YES	YES
Firm-Peer Fixed Effects	YES	YES
R^2	0.51	0.52

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

Panel B. Partitioning by Degree of Competition

	Dependent variable: *CAPEX*	
Independent variables:	*High* degree of competition	*Low* degree of competition
*Δ_Reserves_Peer*Gas_Producer*Post_Fracking*	0.60***	0.11
	(6.56)	(1.57)
*Δ_Reserves_Peer*Gas_Producer*	0.02	−0.12***
	(0.44)	(−2.55)
*Δ_Reserves_Peer*Post_Fracking*	−0.06	0.40***
	(−0.83)	(4.26)
*Gas_Producer*Post_Fracking*	0.64***	−0.79***
	(3.21)	(−4.69)
Δ_Reserves_Peer	0.17***	−0.09
	(2.94)	(−1.33)
Gas_Producer	0.74***	0.77***
	(3.03)	(4.63)
Post_Fracking	−9.75***	−4.89***
	(−6.49)	(−4.26)
Controls	YES	YES
Firm-Peer Fixed Effects	YES	YES
R^2	0.51	0.50

Table 6. Tightening Reserves Disclosure Rules

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 degree of competition between pair firms, measured as explained in section 3.3 (standardized measure). Panel A analyzes stock market reactions to peers' reserves disclosures. Panel B analyzes firms' investment decisions around peers' reserves disclosures. 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, expressed in %. In Panel B, the dependent variable, *CAPEX*, is capital expenditures in the year of disclosure of reserves scaled by total assets, expressed in %. Results are based on a sample of 395,968 firm-peer-disclosure observations. 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

Panel B. Investment Decisions

	Dependent variable: *CAPEX*	
Independent variables:	*High* degree of competition	*Low* degree of competition
*Δ_Reserves_Peer*New_Rule*	0.36***	−0.01
	(3.64)	(−0.15)
Δ_Reserves_Peer	0.19**	0.25***
	(2.29)	(3.32)
New_Rule	−4.09***	−13.15***
	(−3.05)	(−8.87)
Controls	YES	YES
Firm-Peer Fixed Effects	YES	YES
R^2	0.49	0.53

Table 7. Tightening Reserves Disclosure Rules. Placebo Tests

This table presents placebo tests on the effect of tightening reserves disclosure rules on firms' reaction to peer firms' releases of information about O&G reserves. *p*-values (in brackets) correspond to testing the hypothesis that the coefficients obtained in Table 6 for the subsample of firms with high degree of competition (i.e., β) are equal to the mean of the empirical distribution of coefficients computed by two randomization procedures (i.e., $E[\beta]$). Panel A presents results from randomizing the year of the introduction of NI 51-101 and MOGR. Panel B presents results from randomizing the home country of the disclosing peer. *p*-values are obtained from *t*-tests (two-tail). *, ** and *** denote statistical significance at the 10%, 5% and 1% (two-tail) levels, respectively.

Panel A. Randomizing Regulatory Dates

	Dependent variable: *Abn_Return*			Dependent variable: *CAPEX*		
Independent variables:	(1) Real dates β	(2) Random dates $E[\beta]$	(3) *p-value* H_o: $\beta = E[\beta]$	(4) Real dates β	(5) Random dates $E[\beta]$	(6) *p-value* H_o: $\beta = E[\beta]$
*Δ_Reserves_Peer*New_Rule*	-0.07^{***}	−0.02	[0.017]	0.36^{***}	0.02	[<0.001]
Δ_Reserves_Peer	−0.04	-0.06^{***}	[0.205]	0.19^{**}	0.28^{***}	[<0.001]
New_Rule	1.16	0.30^{***}	[<0.001]	-4.09^{***}	-9.01^{***}	[<0.001]
Controls	YES	YES	YES	YES	YES	YES
Firm-Peer Fixed Effects	YES	YES	YES	YES	YES	YES

Panel B. Randomizing Peers' Home Country

	Dependent variable: *Abn_Return*			Dependent variable: *CAPEX*		
Independent variables:	(1) Real countries β	(2) Random countries $E[\beta]$	(3) *p-value* H_o: $\beta = E[\beta]$	(4) Real countries β	(5) Random countries $E[\beta]$	(6) *p-value* H_o: $\beta = E[\beta]$
*Δ_Reserves_Peer*New_Rule*	-0.07^{***}	−0.001	[<0.001]	0.36^{***}	0.11^{***}	[<0.001]
Δ_Reserves_Peer	−0.04	-0.10^{***}	[<0.001]	0.19^{**}	0.38^{***}	[<0.001]
New_Rule	1.16	-0.38^{***}	[<0.001]	-4.09^{***}	10.71^{***}	[<0.001]
Controls	YES	YES	YES	YES	YES	YES
Firm-Peer Fixed Effects	YES	YES	YES	YES	YES	YES

Table 8. 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 degree of competition between pair firms, measured as explained in section 3.3 (standardized measure). 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, expressed in %. In Panel B, the dependent variable, *CAPEX*, is capital expenditures in the year of disclosure of reserves scaled by total assets, expressed in %. See Appendix D for other variable definitions. Results are based on a sample of 395,968 firm-peer-disclosure observations. 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

Panel B. Investment Decisions

	Dependent variable: *CAPEX*	
Independent variables:	*High* degree of competition	*Low* degree of competition
Δ_Reserves_Peer	0.50***	0.22***
	(10.26)	(4.83)
Δ_Earnings_Peer	0.24**	0.04
	(2.01)	(0.24)
Controls	YES	YES
Firm-Peer Fixed Effects	YES	YES
R^2	0.49	0.49